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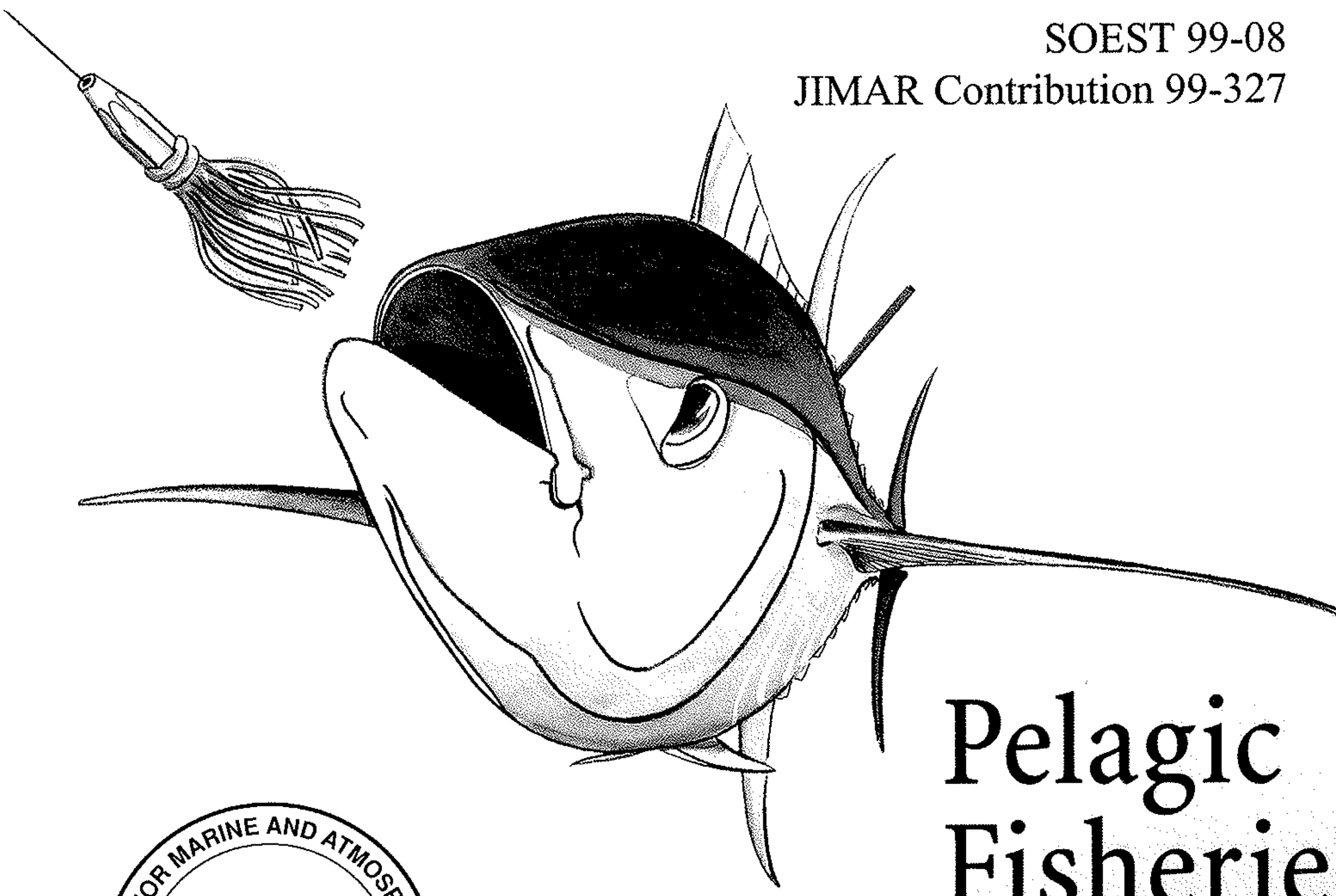
SOEST 99-08
JIMAR Contribution 99-327



Pelagic Fisheries Research Program

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ACKNOWLEDGMENTS

We would like to thank Hawaii Fishing Industry and Vessel Economics (HIFIVE) project team for providing the cost-earnings data of various Hawaii's fisheries. We are particularly thankful to Marcia Hamilton for not only giving us many insights to the cost-earnings surveys but also for collecting the necessary information from fishery dealers and suppliers and providing valuable inputs during the course of this study. We are also grateful to K. McConnell for providing the survey data for pelagic recreational fishing in Hawaii and to Xijun Tian, Hawaii Department of Business, Economic Development and Tourism for providing the updated 1992 Hawaii input-output table.

This study was funded by cooperative agreement # NA67RJ0154 between the Joint Institute of Marine and Atmospheric Research (JIMAR) and the National Oceanic and Atmospheric Administration (NOAA). The views expressed herein are those of the authors and do not necessarily reflect the view of NOAA or any of its subagencies.

ABSTRACT

The purpose of this study was to integrate all the baseline cost-earnings data of Hawaii's commercial, recreational/expense, and charter fleets being gathered by the Hawaii Fishing Industry and Vessel Economics (HIFIVE) project under the Pelagic Fisheries Research Program (PFRP) into the 1992 Hawaii Input-Output (I-O) model; to compute output, income, and employment multipliers for Hawaii's fishery sectors; and to estimate their output, income, and employment contributions to the state economy. The modified I-O table contained 72 industry sectors, including 4 fishery sectors, namely longline, other commercial (troll and handline, aku boats, bottomfish, lobster, and others), charter, and recreational/expense and 68 non-fishery sectors. The detailed 72-sector I-O model is not included in this report. However, those interested can obtain it from the authors. In 1992, altogether Hawaii's fisheries generated $98.2 million of output, $33.2 million of labor income, and $37.1 million of value added. Hawaii's fisheries also generated 1,426 jobs. When fishery trade and distribution margins were also included, fisheries contributed to about $118.8 million of output, $34.3 million of labor income, $45.1 million of value added, and 1,469 jobs.

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1. BACKGROUND

Expansion of commercial fisheries activities, especially longline activities in the early 1990s, heightened the conflicts between longliners and the troll and handline fisheries in Hawaii. In addition, concern over impacts on endangered species and the possibility of localized over-fishing led to tighter regulations for the domestic longline fishery in 1990 and subsequent regulations for longliners under the Pelagic Fishery Management Plan. Currently, fishery management entities in Hawaii are considering additional forms of limited entry programs for the pelagic fishery. However, there is a lack of certain critical information when considering alternative management options and predicting their economic consequences for individual fishing firms, fishery sectors, and the overall economy as well as biological consequences for fish stocks.

At the macro-policy level, one type of information that is useful is a description of economic contributions of fisheries. This permits evaluation of the economic consequences – in terms of output, income, value added, and employment - of changes in fishing activities. Such changes might stem from natural increases or decreases in fish stocks and catches; from state, national or international policies to encourage or discourage fishing activities; or from other programs such as stock enhancement efforts.

There are three major components of Hawaii's marine fisheries: commercial fishing boats, charter boats, and recreational and expense boats. Commercial fishing boats can further be divided into longliners, troll and handline, and others (e.g., aku boats, bottomfish, and lobster). For this study, troll and handline and other fisheries are designated as other commercial fishery sector. In 1992, ex-vessel revenues from Hawaii's fisheries have been estimated at $63.1 million, including $43.9 million from longliners, $13.9 million from other commercial boats, $3.9 million from expense boats, and $1.4 million from charter boats. The charter boats also generated $15.1 million in direct revenues from patrons' fees in addition to fish sales. The total gross input purchases by Hawaii's fisheries were estimated to be $98.2 million, including $49.8 million of input purchases from Hawaii's industries, $33.2 million of payments to households (labor income), $4 million of other value added (profit, indirect business taxes, etc.), and $11.2 million of imports. The year 1992 is selected to correspond to the most recent Hawaii State input-output table which depicts the economic conditions in 1992.

However, the above values reflect only the direct revenues and expenditures of fisheries activities. A change in any part of the economy, such as fishing, leads to changes in other sectors of the economy. Fishery sectors have two kinds of effects on the economy. First, an increase (decrease) in fisheries output means there will be increased (decreased) demands for inputs by the fishery sectors on other sectors whose products are used as inputs in fisheries production. This is generally referred to as the backward linkage where the direction of causation is the response to changes in final demand. Second, an increase (decrease) in fisheries output also means there will be additional (reduced) amounts of fisheries output that are available to be used as inputs to other sectors for their own production. This is generally termed as the forward linkage where the direction of causation is the usual supply response. Consequently, the measurement of the contribution of fisheries requires a tracing of these linkages that exist

between fisheries and other sectors in the economy. Input-output (I-O) models provide a comprehensive approach in estimating these economic linkages and hence the total contributions of fisheries to the economy in terms of business sales, employment, and household income.

Except for Maharaj and Carpenter (1996) I-O models have not been applied to Hawaii's fisheries. Maharaj and Carpenter (1996), based on a national sample of 233 U.S. anglers involved in sport fishing in Hawaii, estimated that, in 1996, a total of 260,000 U.S. anglers (of which 50% were assumed to be from the mainland U.S.) participated in a total of 2.5 million of recreational fishing trips (~ 6,820 trips/day) in Hawaii. The total expenditures for sport fishing in Hawaii during 1996 were estimated to be $130 million, comprising $96 million for trip-related expenses ($37 million for food and lodging, $33 million for transportation, and $27 million for bait, fuel, and equipment rental), $33 million for fishery and related equipment, and $949 thousand for other items (magazines, permits, membership dues, etc.). Using an input-output model (RIMS II), developed by Bureau of Economic Analysis (BEA), the economic impacts of these expenditures were estimated to be $238 million of output, $70 million of income, and 3,080 jobs. Although no other detailed impact analyses exist for Hawaii's fisheries, compared to other available sources, these estimates may have grossly overstated the expenditure-induced economic impacts of Hawaii's recreational fisheries.[1] This may perhaps be attributed to several reasons, including possibly sampling bias, lack of a clear-cut distinction between recreational fishing trips and other trips (such as charter fishing and non-fishing trips), overestimation of fishing trips, and the attribution of these expenses entirely to Hawaii's industries although a significant portion of trip-related and equipment supplies are imported.

The fishery sector was not explicitly represented in the 1987 Hawaii state I-O model but was instead aggregated in the "Fishing and Forestry" sector. Even at the national level, forestry and fishery products have remained combined as one industry because of lack of sufficient input information to separate the two. This deficiency has been corrected in the most recent (1992) Hawaii I-O model by disaggregating the "Fishing and Forestry" sector to "Commercial Fishing" and "Forestry and Forest Products" sectors. However, economic contributions of the individual fisheries (such as longliners, other commercial boats, charter boats, and recreational boats) cannot be estimated from the 1992 model directly without substantial modification. The recently completed cost-earnings surveys of various Hawaii's fisheries provide necessary information for further refinement of the 1992 I-O model in order to assess fisheries' linkages and economic contributions to the state economy. This information will be highly critical in assessing the economic impacts of fishery regulations on various sectors of the economy as well as the impacts on fishery sectors themselves.

[1]Meyer (1987) estimated the market value of fish sold by subsistence and recreational fishermen and their direct expenditures for 1985 to be $30 and 33 million (adjusted for inflation to 1990 prices), respectively. The annual figure of 0.5 million recreational trips as estimated by the NMFS Marine Recreational Fishing Statistical Survey (MRFSS) during 1979-81 is considered to be excessive (Pooley, 1993). Moreover, although commercial fisheries have experienced a significant expansion since the late 1980s, the extent of recreational fishing has perhaps changed very little since the 1980s.

2. STUDY OBJECTIVES

The purpose of this research is to integrate the cost-earnings information for the various commercial (longline, troll and handline, and others) and charter boat fleets, and estimated expenditure patterns of the recreational/expense fishing boats into the input-output framework to measure the economic contributions of Hawaii's fisheries to the state economy. The study will also provide information on the linkages of fishery sectors to the other sectors of the economy, and their relative importance compared to the other sectors in terms of outputs, household income, value added , and employment. Specific objectives include as follows:

1. Systematically integrate all the baseline cost-earnings data of Hawaii's commercial, recreational/expense, and charter fleets being gathered by recent Pelagic Fisheries Research Program (PFRP) projects into the 1992 Hawaii State Input-Output (I-O) model, the latest table available for the state;

2. Estimate output, income, and employment multipliers for each fishery sector;

3. Provide information on forward and backward linkages of fishery sectors vis-a-vis the other sectors of the economy; and

4. Provide information on economic importance and value of the various fishery sectors to Hawaii's economy in terms of their contributions to output, household income, and employment.

Originally, this research also proposed to extend the state I-O model to include a social accounting matrix (SAM). SAM presents an unified account of the circular flow of goods and money in the economy and hence provides a consistent representation of the flows-of-funds accounts of the separate institutions or "actors" in the economy (such as industries, households, government, trade, etc.) that one may wish to distinguish, to reflect the complexities of the income distribution process. However, due to a lack of relevant information SAM analysis could not be carried out at this point.

3. INPUT-OUTPUT (I-O) ANALYSIS

3.1. Introduction to I-O analysis

An input-output (I-O) model depicts a comprehensive and detailed set of accounts of sales and purchases of goods and services among producers (industries), final consumers (households, visitors, exports, government, etc.), and resource owners (labor, capital, land) in an economy during a particular time period (usually a year). The I-O table can simply be described in terms of three major components. These are inter-industry transaction, final demand, and value added as described and illustrated next using an 8-sector 1992 I-O model for Hawaii, including 4 fishery and 4 non-fishery sectors.

The inter-industry transaction portion of an I-O table shows the summary account of intermediate sales and purchases of goods and services among the industries. Reading across a row of the transaction table gives the inter-industry sales by the industry named at the beginning of the row to the other industries. Similarly, reading down a column shows the purchases of goods and services of other industries by the industry named at the top of the column. The inter-industry table is often constructed based on partial-survey or non-survey methods. For example, sales and purchases for the four fishery sectors in this study are based on their recent cost earnings surveys, while the transactions for the non-fisheries sectors are based on secondary sources and previous I-O tables. The final demand portion of an I-O table shows the sales of commodities by each industry to final users, namely households (personal consumption expenditures or PCE), federal, state and local government units (government expenditures), visitors (visitor expenditures), investors (private investment), and exports. The value added portion of the table shows purchases of primary or non-industry inputs of production – labor, capital, land, and indirect business tax payments (value added) along with imports of goods and services for intermediate use.

The input-output analysis follows a financial T-Accounts procedure in which the receipts must balance the expenditures as in any double entry bookkeeping system. By that convention, total output (sales, including final demands) is equal to total input (purchases, including final payments and imports) for each industry sector in the economy.

One of the most important functions of input-output analysis is to assess the economic impacts of changes that are exogenous to the economy. I-O models are driven by exogenous final consumption (or final demand). Various I-O multipliers are derived and can be used to estimate various economic effects of a change in an industry's final demand. Three of the most commonly used I-O multipliers are output, income, and employment multipliers. Besides the impacts of exogenous changes, I-O models can also be used in assessing economic contributions of an industry sector or a group of sectors to the economy. The estimation of economic impacts or contributions using I-O analysis begins with the calculation of I-O multipliers.

I-O multipliers are derived based on direct and indirect effects resulting from changes in or existing levels of industries' final demands. The direct effects measure the initial effects, while the indirect components measure the subsequent intra- and inter-industry purchases of inputs as a result of initial changes in outputs of the directly affected industries. If labor income and personal consumption expenditures (PCE) are included in the model similar to other industries, multipliers can also measure the effects of demand changes on household spending that result from changes in household income through direct and indirect effects. These additional effects are known as the induced effects. Depending upon whether the household sector is included in the model or not, there are two types of multipliers, namely Type I and Type II. These are calculated as follows:

$$\text{Type I multiplier} = \frac{(\text{Direct effect} + \text{Indirect effect})}{\text{Direct effect}}$$

$$\text{Type II multiplier} = \frac{(\text{Direct effect} + \text{Indirect effect} + \text{Induced effect})}{\text{Direct effect}}$$

The calculation of multipliers begins with the transactions table. The direct requirements table, also known as the technical coefficients matrix, is created by dividing each element of the inter-industry transactions table by its corresponding column sum or total of industry inputs (purchases). This direct requirements table is subtracted from an identity matrix and then inverted. The resultant matrix is the total requirements table or the Leontief's inverse which gives the direct and indirect effects of a dollar change in final demand.

3.2. Illustration of I-O modeling

For illustrative purposes, an aggregated version of the 1992 Hawaii inter-industry transactions table, with the addition of 4 fisheries sectors is shown in Table 1. The table shows the following:

- Eight industry groups
  - Longline fishery
  - Other commercial fishery (troll and handline, aku boats, bottomfish, lobster, etc.)
  - Charter fishery
  - Recreational/expense fishery
  - Agriculture
  - Construction and manufacturing (including mining)
  - Transportation, utilities and trade
  - Finance, services and government (including insurance and real estate)

- Two final demand sectors
  - Personal consumption expenditures (PCE)
  - Other final demand (government, visitors, exports and investment)

- Two final payment sectors
  - Value added
    - Labor income
    - Other
  - Imports

All transactions in Table 1 are expressed in million of 1992 dollars since the latest available comprehensive I-O table for Hawaii is for 1992. The cost-earnings information collected from various fisheries in recent years is converted to 1992 dollars using appropriate price indices. Although it is not a technical component of the I-O model, the last row of the table shows employment data by industry for calculating employment multipliers. Employment is defined as the total number of wage, salary, and self-employed jobs in each industry.

Table 1. Transaction table (millions of 1992$) and total employment (jobs)

	Longline fishery	Other commercial fishery	Charter fishery	Recreational /expense fishery	Agriculture	Construction & manufacturing	Transportation, utilities & trade	Finance, services & government	Total intermediate demand	Personal consumption expenditures	Other final demand	Total industry output
Longline fishery	0.0	0.0	0.0	0.0	0.0	3.1	12.8	6.4	22.4	4.1	17.4	43.9
Other commercial fishery	0.0	0.0	0.0	0.0	0.0	3.1	2.3	1.1	6.5	5.2	2.2	13.9
Charter fishery	0.0	0.0	0.0	0.0	0.0	0.3	0.4	0.0	0.7	4.4	11.4	16.5
Recreational/expense fishery	0.0	0.0	0.0	0.0	0.0	1.8	0.8	0.4	3.1	20.6	0.2	23.9
Agriculture	0.0	0.0	0.0	0.0	75.8	297.8	8.9	116.7	499.2	58.2	211.4	768.8
Construction & manufacturing	9.8	4.7	2.9	12.6	42.6	489.2	938.4	682.2	2,182.4	752.8	4,850.1	7,785.3
Transportation, utility & trade	3.8	1.3	2.9	4.2	39.4	540.7	1,054.1	1,122.9	2,769.3	3,909.0	5,946.7	12,625.0
Finance, services & government	1.8	0.7	3.1	2.0	32.5	414.1	1,158.0	3,285.6	4,897.8	9,444.0	11,794.7	26,136.4
Total intermediate purchases	15.4	6.7	8.9	18.8	190.3	1,750.1	3,175.7	5,215.5	10,381.4	14,198.3	22,834.1	47,413.7
Value added	23.7	6.2	7.2	0.0	469.4	3,368.6	7,796.3	18,889.4	30,560.9	0.0	0.0	30,560.9
Labor income	21.2	5.5	6.4	0.0	323.4	2,653.2	4,869.0	12,297.3	20,176.1	0.0	0.0	20,176.1
Other value added	2.5	0.7	0.8	0.0	146.0	715.4	2,927.3	6,592.1	10,384.8	0.0	0.0	10,384.8
Total direct imports	4.7	1.0	0.4	5.1	109.1	2,666.6	1,653.0	2,031.5	6,471.5	4,303.7	4,322.3	15,097.5
Total industry purchases	43.9	13.9	16.5	23.9	768.8	7,785.3	12,625.0	26,136.4	47,413.7	18,501.9	27,156.4	93,072.0
Total employment	652	357	417	0	21,107	63,555	207,143	463,901	757,132			

The sales and payments among various sectors are summarized in Table 1. Reading across a row (sector) shows sales by that sector to other sectors (columns), including industry and final demand. Reading down a column (sector) shows the purchases by that sector from the various industry and final payment sectors (rows). Because an input-output transactions table is a double entry bookkeeping set of accounts, total output (row total) is equal to total purchases (column total) for each industry. For example, in terms of 1992 dollars total output or sales of longline fishery amounted to $43.9 million, of which total inter-industry sales to other industries amounted to $22.4 million and sales to final demand sectors to $21.5 million, including $4.1 million to Hawaii residents and $17.4 million to other final demand sectors (mainly visitors and exports). Similarly, total purchases by longline fishery included $15.4 million worth of goods and services from other industries, $23.7 as value added (including $21.2 million as payments to households, i.e., labor income and $2.5 million as other value added, i.e., profit), and $4.7 million worth of imported commodities. Altogether, total purchases from the longline fishery added to $43.9 million exactly equal to total sales. The longline fishery accounted for a total of 652 jobs in the state of Hawaii.

Inter-industry flows of sales and purchases in Table 1 can be expressed as a system of 8 equations, each representing distribution of each sector's total output (sales) among various industry (producing) and final demand sectors as:

$X_1 = Z_{11} + Z_{12} + \dots + Z_{18} + Y_1$	Longline fishery
$X_2 = Z_{21} + Z_{22} + \dots + Z_{28} + Y_2$	Other commercial fishery
$\cdot \quad \cdot \quad \cdot \quad \dots \quad \cdot \quad \cdot$	.
$\cdot \quad \cdot \quad \cdot \quad \dots \quad \cdot \quad \cdot$	.
$\cdot \quad \cdot \quad \cdot \quad \dots \quad \cdot \quad \cdot$	.
$X_8 = Z_{81} + Z_{82} + \dots + Z_{88} + Y_8$	Finance, services and government

where X's represent total industry outputs, Z's are sales to endogenous or producing sectors, and Y's are total sales to final demand, including personal consumption and other final demand sectors.

3.2.1 Direct requirements table

The next step in input-output analysis is the derivation of the direct requirements table. Elements in each column of the direct requirements table are obtained by expressing each column entry of the transactions table as a proportion (coefficient) of the corresponding column total. The coefficients of the direct requirements table indicate the amount of input from each of the row sectors required by the column sector to produce one dollar's worth of output of the column sector. In mathematical terms, each coefficient of the direct requirements table, usually designated as a_{ij}, shows the purchase of column sector j from row sector i required to produce a dollar of output in sector j. The a_{ij}'s are derived by dividing each column entry of the transaction table, Z_{ij} by the corresponding column total, X_j, or

$$a_{ij} = Z_{ij}/X_j$$

Using this definition of a_{ij}, the previous system of inter-industry equations can be rewritten as

$$
\begin{array}{ll}
X_1 = a_{11}X_1 + a_{12}X_2 + \ldots + a_{18}X_8 + Y_1 & 1 = \text{Longline fishery} \\
X_2 = a_{21}X_1 + a_{22}X_2 + \ldots + a_{28}X_8 + Y_2 & 2 = \text{Other commercial fishery} \\
\vdots & \vdots \\
X_8 = a_{81}X_1 + a_{82}X_2 + \ldots + a_{88}X_8 + Y_8 & 8 = \text{Finance, services and government}
\end{array}
$$

In matrix notation, the above system of equations can be written as:

$$
\begin{bmatrix} X_1 \\ X_2 \\ \cdot \\ \cdot \\ \cdot \\ X_8 \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} & \cdot & \cdot & \cdot & a_{18} \\ a_{21} & a_{22} & \cdot & \cdot & \cdot & a_{28} \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ a_{81} & a_{82} & \cdot & \cdot & \cdot & a_{88} \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ \cdot \\ \cdot \\ \cdot \\ X_8 \end{bmatrix} + \begin{bmatrix} Y_1 \\ Y_2 \\ \cdot \\ \cdot \\ \cdot \\ Y_8 \end{bmatrix}
$$

The matrix of direct input coefficients, a_{ij}'s, designated by A, is known as the technology matrix. Each column of this matrix represents a production function for the corresponding producing sector. The computation of the direct requirements table uses only the transactions table. Other final demand sectors are usually omitted while the household sector is sometimes treated as a producing sector to measure the induced effects as defined earlier. The direct requirements column for the household sector is obtained by dividing each entry in PCE column by total labor income in the economy.

The direct requirements table for the 8 endogenous sectors and the household sector is presented in Table 2. The 8 by 8 matrix of the double-lined rectangle of Table 2 shows the direct requirements table for the producing sectors. For example, the commercial longline fishery column of the direct requirements table shows various input requirements for producing each dollar worth of fish output of longline fishery. For example, among the producing sectors, longline fishery uses about 22 cents worth of commodities from construction and manufacturing sectors, about 9 cents from transportation, utilities and trade, about 4 cents from finance, services and government sectors, and pays 54 cents in value added (comprising 48 cents in labor costs and 6 cents in other value added) and about 11 cents for imported commodities to produce a dollar worth of fish output.

Table 2. Direct requirements table

	Longline fishery	Other commercial fishery	Charter fishery	Recreational/ expense fishery	Agriculture	Construc-tion & manufactu-ring	Transporta-tion, utilities & trade	Finance, services & government	Personal consumption expenditures
Longline fishery	0.0000	0.0000	0.0000	0.0000	0.0000	0.0004	0.0010	0.0002	0.0002
Other commercial fishery	0.0000	0.0000	0.0000	0.0000	0.0000	0.0004	0.0002	0.0000	0.0003
Charter fishery	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002
Recreational/expense fishery	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0001	0.0000	0.0010
Agriculture	0.0000	0.0000	0.0000	0.0000	0.0986	0.0382	0.0007	0.0045	0.0029
Construction & manufacturing	0.2238	0.3361	0.1772	0.5263	0.0554	0.0628	0.0743	0.0261	0.0373
Transportation, utility & trade	0.0874	0.0941	0.1750	0.1771	0.0512	0.0695	0.0835	0.0430	0.1937
Finance, services & government	0.0407	0.0492	0.1889	0.0829	0.0423	0.0532	0.0917	0.1257	0.4681
Value added	0.5411	0.4457	0.4369	0.0000	0.6106	0.4327	0.6175	0.7227	0.0000
Labor income	0.4841	0.3969	0.3882	0.0000	0.4207	0.3408	0.3857	0.4705	0.0000
Other value added	0.0570	0.0487	0.0488	0.0000	0.1899	0.0919	0.2319	0.2522	0.0000
Total direct imports	0.1070	0.0749	0.0219	0.2137	0.1419	0.3425	0.1309	0.0777	0.2133
Total industry purchases	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9170

Table 3. Total requirements table (Type I)

	Longline fishery	Other commercial fishery	Charter fishery	Recreational/ expense fishery	Agriculture	Construc-tion & manufactu-ring	Transporta-tion, utilities & trade	Finance, services & government
Longline fishery	1.0002	0.0003	0.0004	0.0005	0.0001	0.0005	0.0012	0.0004
Other commercial fishery	0.0001	1.0002	0.0001	0.0003	0.0000	0.0004	0.0002	0.0001
Charter fishery	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Recreational/expense fishery	0.0001	0.0001	0.0001	1.0002	0.0000	0.0003	0.0001	0.0000
Agriculture	0.0111	0.0164	0.0105	0.0259	1.1129	0.0463	0.0054	0.0073
Construction & manufacturing	0.2511	0.3733	0.2144	0.5874	0.0733	1.0794	0.0917	0.0372
Transportation, utility & trade	0.1185	0.1364	0.2197	0.2467	0.0709	0.0882	1.1042	0.0573
Finance, services & government	0.0748	0.0941	0.2527	0.1578	0.0657	0.0772	0.1218	1.1524
Output multiplier (Type I)	1.4560	1.6208	1.6979	2.0187	1.3230	1.2923	1.3246	1.2548

3.2.2. Total requirements table

The direct requirements table (Table 2) shows the direct or initial effects on all producing sectors due to a dollar change in final demand. These direct effects lead to a series of successive or indirect impacts on the producing sectors. For example, agriculture supplies about 4 cents worth of agricultural commodities for each dollar worth of output in construction and manufacturing final demand. Agriculture has to purchase inputs from various suppliers to produce that 4 cents of agricultural products. These suppliers, in turn, would need to purchase inputs to meet the demands for their commodities. The indirect impacts would continue through each of the various industries supplying inputs to construction and manufacturing, although each successive impact will be smaller than the preceding one due to the leakage of purchasing power from the economy in the form of imports. To capture all indirect effects of a dollar increase in construction and manufacturing output, this analysis needs to be applied to each of the sectors providing inputs to construction and manufacturing sector. Measuring total requirements this way would be exceedingly tedious, especially when the number of industry sectors is large. Fortunately, total requirements can be estimated easily using matrix algebra. The last expression of the inter-industry equations can be written in a more compact form as

$$X = AX + Y$$

where X represents the 8 by 1 vector of industry total outputs, A represents the 8 by 8 matrix of direct input coefficients (a_{ij}), and Y is the 8 by 1 vector of final demands. This can be generalized to any number of industries. Employing the use of the identity matrix and matrix algebra, the vector of total industry outputs can be solved as

$$X = (I - A)^{-1}Y = BY$$

where $(I - A)^{-1}$ or B is the 8 by 8 matrix of total input coefficients (b_{ij}), or simply the total requirements table, or Leontief's inverse. The total requirements table for the eight-industry input-output model is presented in Table 3. Each column of the total requirements table indicates the direct and indirect impacts on endogenous sectors of a dollar change in the column sector's final demand. For example, a $1 increase in final demand of the longline fishery increases output in the economy by about $1.46 (1.4560), of which $1.000 (1.0002) comes from longline fishery itself and the remaining 46 cents (0.456) from other endogenous sectors.

3.2.3. Type I output multipliers

Output multipliers for each sector are derived by summing the corresponding column entries of the total requirements table. The output multiplier for a particular industry represents total dollars of output generated in the economy per dollar of final demand in that industry. The output multipliers for the 8 producing sectors are shown in the last row of Table 3. These are Type I multipliers as the household sector is not included in the analysis. For example, the output multiplier for longline fishery is 1.456, which means that each $1 change in longline's final demand results in a change in the economy's total output by 1.456 dollars. In other words, each

$1 increase in final demand for output produced by the longline fishery requires $1.456 of inputs from all producing sectors in the region. This includes the initial dollar change in longline's final demand (direct effect) and changes in the outputs of the endogenous sectors to support the initial dollar change in longline output (indirect effects). The column totals of the total requirements table or output multipliers can be broken down into direct and indirect effects of changes in final demands as described below under the derivation of output multipliers. Direct and indirect effects of a dollar change in final demand of longline commercial fishery are shown in Table 4. Similar analyses can be done for other sectors as well.

Table 4. Direct, indirect, and total effect of Type I output multiplier for longline fishery

	Direct effect	Indirect effect	Total effect
Longline fishery	1.0000	0.0002	1.0002
Other commercial fishery	0.0000	0.0001	0.0001
Charter fishery	0.0000	0.0000	0.0000
Recreational/expense fishery	0.0000	0.0001	0.0001
Agriculture	0.0000	0.0111	0.0111
Construction & manufacturing	0.0000	0.2511	0.2511
Transportation, utility & trade	0.0000	0.1185	0.1185
Finance, services & government	0.0000	0.0748	0.0748
Total	1.0000	0.4560	1.4560

3.2.4. Type I income multipliers

The income multiplier can be expressed in two different ways as follows:

(a) First, it can be defined in terms of total labor income generated in the economy per dollar of final demand in an industry ($ income/$ final demand), which is also called the total income effect or Keynesian income multiplier. This income multiplier measures the economic impact of a change in an industry's final demand in terms of changes in the industry's payments (labor income) to households. Thus, in estimating the income impact of an exogenous change in the industry's final demand, the total income effect or Keynesian income multiplier should be used.

(b) Second, it can be expressed as the ratio of the total income effect to the direct income coefficient (or labor income to output ratio) ($ income/$ income). Thus this type of income multiplier is also referred to as ratio income multiplier, which shows the total labor income generated in the economy per $1 increase in income in an industry. When impacts of final demand changes are estimated in terms of I-O multipliers, the ratio income multiplier should not be used.

The Type I income multipliers are derived based on information contained in the direct requirements table (Table 2) and total requirements table (Table 3). The labor income row of Table 2 shows the labor income payments to households for every dollar worth of output produced by each sector. These are called direct income coefficients which are used to convert the total requirements of Table 3 to income equivalents by multiplying each row of the total

requirements table by the corresponding sector's direct income coefficient. The column totals of the resultant matrix give total income coefficients or Keynesian income multipliers. The ratio income multiplier is then computed by dividing the total sector income effect by the respective direct income coefficient. Table 5 shows the total income coefficients and the computation of income multipliers. For example, the total income effect or coefficient of a dollar change in longline fishery's final demand is 0.6554 (0.4841 as direct plus 0.1713 as indirect). Thus, the Type I ratio income multiplier for longline fishery sector is 1.354 (0.6554 ÷ 0.4841). Income multipliers for other sectors can be derived in a similar manner.

3.2.5. Type I employment multipliers

Similar to the income multiplier, the employment (wage and salary or total employment) multiplier can be summarized in two ways as follows:

(a) First, it can be defined in terms of the total number of jobs generated in the economy per million dollars of final demand in an industry (jobs/$ million final demand), which is also called the total employment effect or Keynesian employment multiplier. This employment multiplier should be used in impact analysis.

(b) Second, it can be expressed as the ratio of the total employment effect to the direct employment coefficient (or employment to output ratio) (jobs/job). This is the ratio form of employment multiplier, which shows the total number of jobs generated in the economy per job created in an industry.

Employment multipliers are derived in the same fashion as income multipliers. The only difference is that the direct income coefficients are replaced by the direct employment coefficients (or employment to output ratios), obtained by dividing the employment row of Table 1 by industry output. Employment coefficients thus indicate the number of jobs per million dollar of output, so employment impacts are measured in terms of a million dollar change in final demand. Computation of the Type I employment multipliers for 8 industry sectors is presented in Table 6. For example, the Type I ratio employment multiplier for longline fishery is 1.379 ((14.8587 + 5.6343) ÷ 14.8587).

3.2.6. Type II multipliers

Type II multipliers, showing the direct, indirect as well as induced effects of a change in an industry's final demand, are derived by adding the labor income row and personal consumption expenditures (PCE) column to the I-O model, i.e. including households as the ninth industry. The conceptual procedures are same as those described for Type I multipliers. Due to induced effects, Type II multipliers are higher than Type I multipliers. For comparison purposes, Type I and Type II output, income, and employment multipliers for 8 aggregated sectors are presented in Table 7.

Table 5. Total income coefficient matrix and calculation of Type I labor income multiplier

	Longline fishery	Other commercial fishery	Charter fishery	Recreational/ expense fishery	Agriculture	Construc-tion & manufactu-ring	Transporta-tion, utilities & trade	Finance, services & government
Longline fishery	0.4842	0.0002	0.0002	0.0003	0.0001	0.0003	0.0006	0.0002
Other commercial fishery	0.0000	0.3970	0.0001	0.0001	0.0000	0.0002	0.0001	0.0000
Charter fishery	0.0000	0.0000	0.3882	0.0000	0.0000	0.0000	0.0000	0.0000
Recreational/expense fishery	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Agriculture	0.0047	0.0069	0.0044	0.0109	0.4682	0.0195	0.0023	0.0031
Construction & manufacturing	0.0856	0.1272	0.0731	0.2002	0.0250	0.3678	0.0313	0.0127
Transportation, utility & trade	0.0457	0.0526	0.0848	0.0951	0.0273	0.0340	0.4259	0.0221
Finance, services & government	0.0352	0.0443	0.1189	0.0742	0.0309	0.0363	0.0573	0.5422
Total income effect ($ income/$ final demand)	0.6554	0.6281	0.6696	0.3808	0.5515	0.4581	0.5174	0.5803
Direct income effect ($ income/$ output)	0.4841	0.3969	0.3882	0.0000	0.4207	0.3408	0.3857	0.4705
Indirect income effect ($ income/$ final demand)	0.1713	0.2312	0.2814	0.3808	0.1309	0.1173	0.1317	0.1098
Income multiplier (Type I) ($ income/$ income)	1.3538	1.5825	1.7249	NA	1.3111	1.3442	1.3415	1.2333

Table 6. Total employment coefficient matrix and calculation of Type 1 job multiplier

	Longline fishery	Other commercial fishery	Charter fishery	Recreational/ expense fishery	Agriculture	Construc-tion & manufactu-ring	Transporta-tion, utilities & trade	Finance, services & government
Longline fishery	14.8623	0.0046	0.0055	0.0078	0.0018	0.0081	0.0177	0.0053
Other commercial fishery	0.0032	25.6511	0.0035	0.0073	0.0011	0.0115	0.0062	0.0019
Charter fishery	0.0003	0.0005	25.3312	0.0008	0.0001	0.0012	0.0009	0.0001
Recreational/expense fishery	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Agriculture	0.3052	0.4506	0.2888	0.7110	30.5536	1.2698	0.1470	0.2014
Construction & manufacturing	2.0499	3.0471	1.7502	4.7951	0.5987	8.8114	0.7487	0.3037
Transportation, utility & trade	1.9446	2.2379	3.6053	4.0475	1.1626	1.4464	18.1173	0.9402
Finance, services & government	1.3274	1.6703	4.4845	2.8005	1.1662	1.3708	2.1614	20.4549
Total job effect ($ job/$ final demand)	20.4930	33.0622	35.4691	12.3700	33.4842	12.9192	21.1991	21.9075
Direct job effect ($ job/$ output)	14.8587	25.6466	25.3309	0.0000	27.4545	8.1635	16.4074	17.7492
Indirect job effect ($ job/$ final demand)	5.6343	7.4156	10.1382	12.3700	6.0297	4.7557	4.7918	4.1583
Job multiplier (Type I) ($ job/$ job)	1.3792	1.2891	1.4002	0.0000	1.2196	1.5826	1.2921	1.2343

Table 7. Type and Type II input-output multipliers

Sector	Output		Income/income		Income/demand		Total job/job		Total job/demand	
	Type I	Type II	Type I	Type II	Type I	Type II	Type I	Type II	Type I	Type II
Longline fishery	1.456	2.424	1.354	2.224	0.655	1.077	1.379	2.464	20.493	36.619
Other commercial fishery	1.621	2.549	1.583	2.600	0.628	1.032	1.289	1.892	33.062	48.515
Charter fishery	1.698	2.687	1.725	2.834	0.670	1.100	1.400	2.050	35.469	51.940
Recreational/expense fishery	2.019	2.581	NA	NA	0.381	0.626	NA	NA	12.370	21.739
Agriculture	1.323	2.138	1.311	2.154	0.551	0.906	1.220	1.714	33.484	47.051
Construction & manufacturing	1.292	1.969	1.344	2.209	0.458	0.753	1.583	2.963	12.919	24.189
Transportation, utility & trade	1.325	2.089	1.341	2.204	0.517	0.850	1.292	2.068	21.199	33.927
Finance, services & government	1.255	2.112	1.233	2.026	0.580	0.953	1.234	2.039	21.907	36.184

3.2.7. Inter-industry linkages

In the input-output framework, production by a particular sector has two kinds of economic effects on other sectors in the economy. An increase in a sector's output will increase demand for outputs of other sectors from which that sector purchases inputs to its production. This demand-side interconnection of a particular sector to other sectors in the economy is known as backward linkage. This approach identifies the path back toward primary resources. On the other hand, increased output in a particular sector also means increased supply of its products to be used as inputs to the production of other sectors in the economy. Such supply-side interconnection of a particular sector to the economy is called a forward linkage. This approach leads forward toward the final consumer. Examination of these measures provides a method for identifying key or leading sectors in the economy. For example, if the backward linkage of sector i is larger than that of sector j, a dollar's worth of expansion of sector i's output would have larger impacts on the economy than an equivalent expansion in sector j's output, in terms of economic activities that would be generated by it. A larger forward linkage means larger impacts in terms of the overall productive activity that a given output expansion would support.

Various measures have been proposed to quantify such backward and forward linkages for the sectors in the economy. Following Miller and Blair (1985), the backward linkage of an industry is most easily measured in terms of direct purchases from other industries. Accordingly, a simplest measure of the strength of the backward linkage of a sector is obtained by the sum of the elements in the corresponding column of the direct-coefficients matrix, A. Since the coefficients in A are measures of direct effects only, this is usually known as the direct backward linkage. As discussed earlier, since the elements in the Leontief's matrix account for both direct and indirect linkages among sectors, the sum of elements in the Leontief's or total-requirements matrix gives a measure of the total backward linkage. In other words, output multipliers are measures of total backward linkages.

The estimation of an industry's forward linkages involves the direct-output and total-output coefficients matrices. The direct-output coefficients matrix is obtained by dividing the elements in the inter-industry transactions table by the corresponding row totals. The resultant Leontief's inverse becomes the total-output coefficients matrix. To distinguish this approach from the standard demand-side model, the direct-output coefficients matrix is denoted by $\vec{A}$ and the total-output coefficients matrix by $(I-\vec{A})^{-1}$. The row sums in $(I-\vec{A})^{-1}$ are called input multipliers, which represent the direct and indirect effects on total output in the economy associated with a dollar change in primary inputs for the corresponding column sectors. In other words, in this approach, also called supply-side I-O model, the Leontief's matrix relates sectoral gross production to the primary inputs, i.e., to a unit of value entering the inter-industry system at the beginning of the process. In the standard demand-side model, the Leontief's matrix relates sectoral gross outputs to the amount of final product, i.e., to a unit of product leaving the inter-industry system at the end of the process. Thus parallel to the backward linkages, the direct forward linkage of a particular sector is obtained as the sum of corresponding row elements in $\vec{A}$ and the total forward linkage is obtained as the sum of corresponding row elements in $(I-\vec{A})^{-1}$ (Miller and Blair, 1985). Both backward and forward linkages for the 8 industry sectors are

summarized in Table 8. A $1 increase in final demand of longline fishery would require $1.456 worth of output in the economy, i.e. the backward linkages. In terms of forward linkages, a $1 increase in output of longline fishery would support $1.654 worth of production activity in the economy. It should be noted that in terms of backward linkages all fisheries sectors are associated with greater economic impact than other sectors in the economy. However, in terms of forward linkages, the economic impact of output expansion will be highest for the agricultural sectors and lowest for charter fishery.

Table 8. Backward (input) and forward (output) linkages

	Backward linkages		Forward linkages	
	Direct	Total	Direct	Total
Longline fishery	0.352	1.456	0.511	1.654
Other commercial fishery	0.479	1.621	0.468	1.614
Charter fishery	0.541	1.698	0.041	1.054
Recreational/expense fishery	0.786	2.019	0.128	1.170
Agriculture	0.248	1.323	0.649	1.921
Construction & manufacturing	0.225	1.292	0.280	1.365
Transportation, utility & trade	0.252	1.325	0.219	1.283
Finance, services & government	0.200	1.255	0.187	1.237

4. USE OF I-O ANALYSIS IN FISHERIES

The Magnuson-Stevens Fishery Conservation and Management Act of 1976 (as amended through 1996) and other Federal Statutes[2] require 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. The two main approaches commonly used in assessing economic and welfare impacts of public policy are input-output (I-O) analysis and benefit-cost (B-C) analysis. In fisheries literature, the I-O analysis is also known as economic impact analysis (EIA). Edwards (1990), Herrick et al. (1994), and Hushak (1987) describe the use of I-O and B-C analyses in the context of fisheries management, including the strengths and weaknesses of the two approaches.

The purpose of I-O models is to show output (production), income and employment relationships that exist among the sectors or industries within a region and external trade links with other economies. These models are useful as policy tools in analyzing, for example, the effects of fishery regulations that would affect purchases of inputs and sales patterns in fisheries as well as other sectors linked with the fishery sectors. For example, I-O analysis can be used by manufacturers and local and state governments to determine how fishery regulations might affect their share of markets and revenues (i.e. production), including taxes. With the I-O approach,

[2] In particular, Executive Order 12866 (1993), Economic Analysis of Federal Regulations and the Regulatory Flexibility Act (1996).

new policies are evaluated in terms of net changes in economic activities (sales, labor income, employment, etc.) in the region for which the I-O model is constructed. Accordingly, policies that result in higher sales, income, and employment compared to status quo scenario and/or alternative policies may be favored.

The B-C approach is mandated for Federal regulations by EO12866 to demonstrate that policies are selected based on maximum net benefits to the nation, i.e., that the total economic value resulting after a regulation exceeds total resource costs irrespective of the source or distribution of those benefits or costs. In the B-C analysis literature, increases in net economic values are said to increase efficiency. Therefore, B-C analysis is used to determine whether a fishery regulation would increase or decrease economic efficiency.

Neither of these economic analysis tools provides complete information for policy decisions. Since different approaches provide different but important pieces of information, it would be better to use these approaches together than any method in isolation. However, there have hardly been any studies using all approaches simultaneously, perhaps due to the lack of necessary data. When the objectives involve the assessment of economic contributions of existing fisheries in terms of their linkages with the rest of the economy as in the present study, the I-O approach is an appropriate approach to use. Moreover, as noted by Hushak (1987) fishery officials are often interested as to how expenditures by commercial and recreational fishermen on equipment and trip-related supplies stimulate the economy in terms of sales, employment, and household income.

Several studies have applied I-O models in determining the overall economic value of fisheries. Harris and Norton (1978) illustrated the use of an I-O model to examine the income and employment effects of commercial fisheries. Briggs et al. (1982) applied the I-O framework in an analysis of Maine's fisheries. King and Shellhammer (1982a, 1982b) employed the I-O model to describe interdependencies between California fisheries and the rest of the state's economy and to determine the economic value of fishing industries in California. Hushak et al. (1986) applied an I-O model of Northern Ohio to examine the economic impacts of increased reallocation of Ohio's Lake Erie fishery from commercial fishing to sport fishing as well as to analyze the relative economic impacts of sport fishing and commercial fishing. The impacts of the North Pacific Fishery Management Council's (NPFMC) proposal of shifting a portion of walleye pollock and pacific cod quotas from the offshore to inshore harvesting sector in waters off Alaska were estimated using both I-O and B-C approaches (NPFMC, 1991; Herrick et al., 1994). More recently, Storey and Allen (1993) conducted I-O analysis to estimate the economic impact of marine recreational fishing in Massachusetts. Several other applications of I-O models to fisheries can be found in Andrews and Rossi (1986) and Hushak et al. (1986).

These I-O applications to fisheries have one common feature, i.e., the use of I-O multipliers in conjunction with policy-induced changes in direct sales in a fishing sector to compute direct, indirect, and induced impacts on output, household income, and employment in the economy. The estimated impacts thus capture the backward linkages of fishery sectors with the rest of the economy. However, for a more complete picture of fisheries' linkages and hence their contributions to the rest of the economy, it is imperative to estimate forward linkages as well.

Forward linkages measure the impacts on fishing industries of changes in direct sales/final demands on non-fishery sectors that procure inputs from the fishing industries.

Another concern with previous studies is a lack of distinction between the analysis of impacts of a change in final demand and an assessment of current contributions of fisheries to the economy. While the former is an ex-ante analysis where one examines new direct, indirect, and induced impacts of a change in final demand on output, income, value added, and employment (Siegel et al, 1995), the latter is an ex-post analysis where the industry's actual totals (output, income, value added, and employment) are decomposed to direct and indirect contributions attributed to various inter-industry linkages in the economy. In the latter approach, the calculation of induced effects is difficult unless there is enough information to decompose observed PCEs to subsistence needs and income effects.

5. METHODOLOGY

5.1. Incorporation of fisheries sectors in the 1992 Hawaii State I-O Table

The official 1992 Hawaii State I-O table originally contained 118 sectors, including one commercial fishing industry (sector # 14) capturing all commercial fisheries production activities in Hawaii, except fishery services which, following the previous I-O tables, were included in agricultural, forestry, and fishery services (sector # 17) and charter fleet, which was contained in the miscellaneous amusement services (sector # 97). For the purpose of estimating the economic contributions of Hawaii's fisheries and their linkages to the rest of the economy, the original model was first re-aggregated to 69 sectors, including a commercial fishing industry which was then disaggregated to two different sectors: longline fishery and other commercial fishery (i.e., comprising troll and handline, Aku boats, bottomfish, lobster, and others). Troll and handline, Aku, bottomfish, and lobster fisheries were combined to form one sector because these fisheries are quite small to be analyzed as separate sectors in themselves. Furthermore, there is a lack of cost-earnings information for Aku, bottomfish, and lobster fisheries to treat them as individual sectors. Since Aku, bottomfish, and lobster fisheries are believed to have fairly similar sales and expenditures patterns as troll and handline boats, it is sensible to combine them as one sector. Besides two commercial fishing sectors, two new fishery sectors, namely the charter and recreational/expense fisheries were inserted to the table. Recreational and expense fishing activities were combined into one sector, called recreational/expense fishery, since the primary motive for both recreational and expense fishing is recreational and their expenditure patterns are quite similar. Thus, the total number of sectors in the modified I-O table used in estimating the economic contributions of Hawaii's fisheries was 72.

5.2. Data sources

The most of the data needed to incorporate the four fishery sectors into the 1992 I-O model came from the cost-earnings surveys of various fishing boats, conducted between 1993 and 1997.

Table 9. Summary of cost-earnings surveys of Hawaii's fisheries

Fishery type	Survey period	Data period	No. of boats surveyed	No. of boats analyzed	Total boats in Hawaii[a]
Longline boats[b]	May – Dec. 1994	1993	101	95	122
Small boats[c]	Jan. – Nov. 1996	1995-96	625	569	3,823[d]
Commercial	Jan. – Nov. 1996	1995-96		184	381[d]
Expense	Jan. – Nov. 1996	1995-96		227	952[d]
Recreational	Jan. – Nov. 1996	1995-96		158	2,490[d]
Charter boats[e]	Sep. 97 – June 1998	1996-97	63	62	188

[a]Given the lack of accurate information on population of small boats in Hawaii, the total number of small boats (commercial, expense, and recreational) was based on Pan et al. (1999) as described below.
[b]Source: Hamilton, Curtis and Travis (1996)
[c]Source: Hamilton and Huffman (1997)
[d]Source: Pan et al. (1999)
[e]Source: Hamilton (1998)

Table 9 shows the timing and sample size for each of these surveys. Additionally, to cross-check information from the cost-earning surveys and to estimate exports as well as the leakage from each fishery sector, i.e., their imports, 2 fishing supply wholesalers, 25 fishing supply retailers, 6 repair and dry-dock facilities, and 7 fish seafood dealers and brokers on the islands of Oahu, Hawaii, and Maui were also surveyed during 1996/97.

5.3. Estimation of boat population for various fisheries

Since the purpose of this study is to estimate the total statewide contributions of all Hawaii's fishing boats rather than only those included in the surveys, the estimation of total number of boats for different fisheries was critical to convert the sample estimates of sales, expenditures, income, and employment to statewide totals. Furthermore, because the objective is to measure the actual contributions of Hawaii's fisheries to the state economy, only the population of active fishing boats is relevant for this study. However, for several reasons there is incomplete information on total number of boats in various fisheries, especially for other commercial and recreational/expense fisheries.

The total number of active longline vessels in Hawaii was 122 in 1992 (Dollar, 1993). The total number of active charter boats in Hawaii was estimated to be 188 in 1996 (Hamilton, 1998). Due to a lack of this information for 1992, the total number of active charter boats for 1992 was also assumed to be 188. Due to the lack of relevant information, the total numbers of other commercial and recreational/expense fishing boats were estimated based on Pan et al. (1999), as described next.

Pan et al. (1999) estimated total numbers of other commercial and expense boats in the state of Hawaii to be respectively 381 and 952 based on 1993 HDAR data, and the number of recreational boats to be 2,490 based on a 1984 study (Skillman and Louie, 1984). As an effort to revise these figures, an alternative procedure was tried based on the number of total commercial

fishing licenses and reports for 1997, distribution of commercial and recreational boats in the sample of small boats surveyed in 1997/1998 for a PFRP project "The Economics of Recreational Fishing for Pelagics in Hawaii" (McConnell) and Pan et al. (1999). Using this procedure the total numbers of other commercial, expense, and recreational boats in Hawaii were estimated to be 711, 1,775, and 1,820, respectively. However, based on these figures, the output estimate of other commercial fisheries (troll, handline, Aku, bottomfish, and lobster) appeared to be too high as compared to various secondary sources (such as WPRFMC, 1998; Hawaii Data Book, 1995; Department of Taxation, 1995). Thus, the total numbers of other commercial, expense, and recreational boats were adopted from Pan et al. (1999), as output estimates from HDAR numbers were more comparable to published sources and internally consistent.

5.4. Estimation of total fisheries sales (outputs), input purchases, income, and employment

The data on cost-earnings surveys were based on samples of boats. Therefore, one of the main tasks of this study was to estimate the total statewide outputs, inputs, labor income and employment for each of the four fishery sectors. Except for the sales (output) of the longline fishery, the statewide total sales, income, and employment were estimated based on sample averages from the cost-earnings surveys combined with the total number of fishing boats in Hawaii. For two reasons, the 1992 longline fishery sales (output) was based on secondary sources (WPRFMC, 1998) instead of the longline cost-earnings study. First, the 1992 longline fishery output if estimated in terms of sample averages from the cost-earnings survey and total number of longline boats would be much higher than that reported in several sources (such as WPRFMC, 1998; Hawaii Data Book, 1995; Department of Taxation, 1995). Second, since the analysis was based on the 1992 I-O table it was better to use the 1992 output wherever possible. However, this could not be done for other fishery sectors because of a lack of the 1992 output data for them, especially the charter and recreational/expense fisheries.

According to the Tax Department data the sales from all commercial fisheries (i.e., comprising longline, commercial troll and handline, Aku boats, bottomfish and lobster, and expense boats) in 1992 was $61.7 million. Of this, $43.9 million came from the longline fishery (WPRFMC, 1998), and the remainder $17.8 million was attributed to other fisheries (such as troll and handline, Aku boats, bottomfish, and lobster). In 1992, the total sales for commercial troll and handline and Aku boats were $7.2 million and $2.4 million, respectively (WPRFMC, 1998). This information for expense and other boats (lobster, bottomefish, and others) was not available. Because of this, the outputs for other commercial and expense fisheries were estimated based on cost-earnings surveys and total population of other commercial boats (381) and expense boats (952). Accordingly, in terms of 1992 dollars the total outputs (i.e., in the form of fish sales) of other commercial and expense fisheries were estimated to be $12.9 million and $3.6 million, respectively. Thus, the fish sales from all fisheries totaled $60.4 million ($43.9 million: longline + $12.9 million: other commercial + $3.6 million: expense), which is $1.3 million short of $61.7 million, the 1992 total commercial fisheries output from the Tax Department. The remainder $1.3 million was distributed among the other commercial and expense fisheries according to their shares in total estimated outputs of other commercial and expense fisheries. Accordingly, the final estimate for the ex-vessel sales (i.e., output) of other commercial fishery was $13.9 million and the estimate for the ex-vessel revenue of expense fishery was $3.9 million. In

addition to this $3.9 million of fish sales from expense boats, in 1992 dollars recreational/expense fishing accounted for $20.0 million of PCEs of Hawaii's industries supplying various inputs to fishing (such as fuel, food, ice, etc.). By combining these two, total output/sales of recreational/expense fishery for 1992 was estimated to be $23.9 million. Total output/sales for the charter boat fishery in 1992 dollars was estimated to be $16.5 million (including $15.1 million in direct revenues from patrons and $1.4 million from fish sales) based on mean annual sales for the sample charter boats and total charter boat population in Hawaii. Therefore, the total output of Hawaii's fishery sectors in 1992 was $98.2 million (Table 10).

Table 10. Sales (outputs) of Hawaii's fisheries (million of 1992 $)

Sector	Fish sales	Direct revenue	Expenditures (PCEs)	Total
Longline	43.9			43.9
Other commercial	13.9			13.9
Recreational/expense	3.9		20.0	23.9
Sub total (longline + other commercial + recreational/expense)	61.7			61.7
Charter	1.4	15.1		16.5
Total	63.1	15.1	20.0	98.2

Except for the longline fishery, input purchases were based on cost-earnings surveys and the total number of boats. Input purchases for the longline fishery were estimated based on the input-output ratios from the 1993 longline cost-earnings study and the 1992 longline output ($43.9 million) based on secondary sources, as mentioned above. For other fisheries, totals for various fixed expenses such as insurance, repairs/maintenance, loan payments and fees were estimated based on sample averages from the cost-earnings surveys and total boat population. Total operating or variable expenses such as food, fuel, bait, and other supplies were estimated in a slightly different manner. Since information for these expenses were collected on a per trip basis, the calculation of the statewide purchases of these inputs by fisheries sectors involved three components. These were average cost per trip for each of these inputs for sample boats, average number of annual trips for the sample boats, and the total number of boats. Because some fishing trips by other commercial boats were recreational, these trip costs were included under the recreational/expense fishery.

Total employment was based on average crew size and the total number of boats. Income was based on average crew size, mean annual income per crew member and total number of boats. For part-time other commercial fishermen, only 20% of their crew time was attributed to fisheries employment as, based on survey information, fishing accounted for about 20% of personal income of part-time fishermen.

5.5. The construction of the inter-industry transaction table and technical coefficients

Having estimated the total outputs and input purchases for the four fisheries, the next step was to construct the inter-industry transactions table for the modified I-O table. This involved the allocation of outputs and input purchases of the four fisheries sectors to relevant industries. The inter-industry portions of fishery sectors were constructed based on sales and expenditures patterns from the recent cost-earnings surveys, additional data obtained from fishery dealers and suppliers, and secondary sources, especially the row and column information of the commercial fishery sector in the original I-O model.

The distribution of fishery outputs or sales to inter-industry purchases and final demand sectors was based on information obtained from fishermen and fishery dealers and suppliers as well as information for the commercial fishing sector in the original I-O table. The allocation of expenditures to relevant industry sectors was less straightforward for several reasons. First, the fishing activity in Hawaii is based on several out-of-state imported inputs that should not be attributed to Hawaii's industries when estimating fisheries contributions to the local economy. Second, some inputs are fixed (such as insurance, interest payments, etc), while others are long-term investments (such as purchase of boats, electronic equipment, etc.) for which conventional I-O accounts may not hold. Third, the expenses incurred by fishermen are valued at purchaser's prices that need be broken down to producer's prices and trade and transportation margins.

Based on information obtained from fishery dealers and suppliers surveys and information for the commercial fishery in the original I-O table, only 10% of expenditures on fishing supplies, gears, baits, and boat and equipment was attributed to Hawaii industries and remaining 90% was attributed to imports. All expenditures on food, ice, and fuel were attributed to Hawaii's industries since imported inputs involved in the production of these commodities have already been included in the imports of corresponding production sectors, such as food processing and petroleum refinery and outputs. While insurance and interest payments are fixed from the fishermen's perspectives, in the context of overall economy during the year these are still inter-industry transactions between the fisheries sectors and insurance and finance industries. So insurance and interest payments were treated as direct purchases from the insurance and finance industries. However, for long-term capital investments (e.g., purchases of boat, electronic equipment, trailer, etc.) only a annualized portion was included. The economic life of fishery equipment was assumed to be 20 years. Fishermen's retail expenses on various inputs were allocated to relevant producing sectors (e.g., food processing, petroleum refinery, manufactured ice, transportation equipment, etc.) and trade (wholesale and retail) and distribution (water transportation, air transportation, ground transportation, etc.) margins.[3]

Accordingly, production relationship for the longline fishery was estimated based on the 1993 cost-earnings study, fishing suppliers and dealers surveys, and technical coefficients of the commercial fishery in the original table. To calculate the actual input purchases for the longline

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[3] Given a lack of information to break retail expenses to expenses in producer's prices and trade and distribution margins, this was done based on the 1987 national input-output composition of personal consumption expenditures (PCE) in the national income and products accounts (NIPA).

fishery for 1992, the 1993 estimated production relationship was then applied to the 1992 longline output obtained from secondary sources. Input purchases and output sales for other commercial fishery were primarily based on cost-earnings data of small commercial boats (troll, handline, and others), fishery dealers and suppliers surveys, and information on the commercial fishing sector in the original I-O table. The production and sales patterns for the charter boat fishery were estimated using the information contained in the charter boat cost-earnings survey. Since charter boat activities were subsumed under the miscellaneous amusement services sector in the original model, inputs and outputs thus estimated for charter boat fishery were deducted from the amusement sector in the modified table.

The construction of the recreational/expense fishery sector was somewhat trickier compared to other fisheries. Although the expense fishing boats do sell some of their catch to recover part of their fishing expenses, relative to their total expenditures their total sales are much smaller than for commercial fishing sectors. Furthermore, recreational fishing boats do not sell their catch and hence incur only expenses in the form of fuel, bait, supplies, etc. Thus, the standard I-O convention of equality between total sales or outputs and total purchases or inputs does not hold in the case of recreational/expense fishery. Various expenses (e.g. fuel, bait, supplies, etc) incurred by local residents for recreational and expense activities are personal consumption expenditures (PCE) on goods and services produced from other industries in the economy (such as petroleum refinery and products, manufacturing, trade, etc). Thus, it seems logical to represent these activities in terms of a vector of final sales of goods and services of various industry sectors to households for recreational fishing purposes. In other words, the PCE vector can be decomposed into two vectors, one accounting for the expenses on the recreational/expense fishing and the other for the remainder of PCE. However, this approach poses two problems. First, the sales/output of the expense fishery in the form of fish sales could not accounted for. Second, treating recreational/expense fishing expenses as one of the final demand sectors precludes the possibility of estimating I-O multipliers for the recreational/expense fishery. For these reasons, recreational and expense fishery was defined as another endogenous or producing industry sector. The column entries of the proposed sector are the input purchases of goods and services from various row sectors by recreational/expense fishermen. To eliminate double counting, final demands in the original model were adjusted by subtracting these quantities from the PCEs of industries supplying inputs to recreational/expense fishery. The row shows the intermediate and final sales of fish output and a lump sum of PCE, which is equal to total input purchases (column total) minus value of fish sold by expense fishermen.

The modified I-O table was then rebalanced. The balancing was done using specifically designed macros in Microsoft Excel. The underlying technical details are presented in the 1992 Hawaii state I-O studies (DBEDT, 1998; Sharma et al., 1997). The details involved in the estimation of technical coefficients, Leontief's inverse, and various I-O multipliers have been presented in an earlier section.

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

Fisheries are linked with other industry sectors in two ways. First, they procure various inputs (e.g., bait, fuel, supplies, etc) from the economy. Thus, the final demands for fishery products and services contribute to output, value added, income, and employment in sectors that supply inputs to fisheries. The measures of such impacts on the economy arising from the need to deliver fishery products and services to final consumers are referred to as backward linkages. Second, fisheries provide inputs to non-fishery sectors and non-fishery final demands contribute to the output, value added, income, and employment in fisheries. Such effects are called forward linkages. Measures of these backward and forward linkages show the inter-dependence between the fishery sectors and rest of the economy. I-O analysis is an appropriate economic model to trace these backward and forward linkages among the economic activities. There are various approaches to estimate industry's linkages using the I-O framework, as discussed by Sharma et al. (1999). Of these approaches, the final demand-based approach is used to measure fisheries' contributions and linkages to Hawaii's economy. Sharma et al. (1999) have used this approach to estimating linkages of agricultural production, processing, and distribution sectors in Hawaii.

6.1 Model

Let's define

$$B = (I - A)^{-1}$$

where A is an n by n matrix of technical or direct requirements coefficients and B is an n by n Leontief's inverse or total requirements matrix containing the direct and indirect effects of every dollar of all final demands in the economy. For a given vector of exogenous final demands, the vector of industry outputs can be derived using the Leontief's inverse matrix as

$$X = BY$$

where X is an n by 1 vector of industry outputs and Y is an n by 1 vector of final demands. In order to empirically estimate the value of output generated by fishery sectors to support the input requirements of final demands of other sectors and the value of output by other sectors to support final demand of fishery products, the last equation can be partitioned as (Mattas and Shrestha, 1989)

$$\begin{bmatrix} X_f \\ X_m \\ X_o \end{bmatrix} = \begin{bmatrix} B_{ff} & B_{fm} & B_{fo} \\ B_{mf} & B_{mm} & B_{mo} \\ B_{of} & B_{om} & B_{oo} \end{bmatrix} \begin{bmatrix} Y_f \\ Y_{mf} + Y_{mo} \\ Y_o \end{bmatrix}$$

where f represents fishery sectors, m represents trade and distribution sectors, o represents other sectors in the economy, f + m + o = n or the total sectors in the economy, Y_{mf} denotes the final

demand for trade and distribution services involved in the delivery of fishery products and services to final consumers, and Y_{mo} denotes the final demand of trade and distribution services associated with the delivery of other final products to the consumers. Separating the final demand for trade and distribution services into fishery and non-fishery components allows for the estimation of the contributions of trade and distribution services involved in the delivery of fishery products to final consumers.

Income effects could be estimated in the same manner as output except that the total requirements coefficients in B are converted to total income coefficients as

$$V = \Lambda BY$$

where V is an n by 1 vector of labor income and Λ is an n by n diagonal matrix of labor income coefficients (labor income to output ratios). Similarly, to compute value added effects, total requirements coefficients in B are converted to value added terms. This is easily accomplished by replacing labor income coefficients Λ in the above equation by value added to output ratios. Employment effects are computed by converting total requirements coefficients in B to employment coefficients as

$$E = \Gamma BY$$

where E is an n by 1 vector of employment and Γ is an n by n diagonal matrix of direct employment coefficients (employment to output ratios).

The fishery's total output, X_f, can be decomposed as

$$X_f = B_{ff} Y_f + B_{fm} Y_{mf} + B_{fm} Y_{mo} + B_{fo} Y_o$$

where $B_{ff}Y_f$ is the fishery output required to support final demand of fishery products, $B_{fo}Y_o$ is the fishery output required to provide inputs for non-fishery final demands, and the remaining two terms in the middle indicate the fishery output needed to support final demands for and trade and distribution services, including those involved in the delivery of fishery products to final consumers. The total fishery output attributed to support its own final demand, $B_{ff}Y_f$, can further be decomposed to direct effect, Y_f, and indirect effect, $(B_{ff} - I)Y_f$.

Likewise, the contribution of final demand of fishery products to the total economy's output can be derived as

$$Q_f = B_{ff} Y_f + B_{mf} Y_f + B_{of} Y_f$$

where Q_f is total economy's output generated by fishery final demands, of which the first term is the output of fishery sector itself, the second term is the output of trade and distribution sectors, and the last term is the output of the rest of the sectors in the economy. The contributions of fishery distribution services can also be determined in a similar manner. Labor income, value

added and employment total coefficient matrices can be partitioned in the same manner as Leontief's matrix to derive fisheries backward and forward linkages in terms of labor income, value added, and employment.

6.2. Fisheries' inter-industry transactions, payments, and sales

In terms of 1992 dollars, Hawaii's fisheries purchased $98.2 million worth of inputs from the economy, including $43.9 million by the longline fishery, $13.9 million by small commercial boats, $16.5 million by charter boats, and $23.9 million by recreational and expense boats (Table 11). Of this, intermediate inputs from Hawaii's industries constituted $49.8 million (or 51%), labor income $33.2 million (or 34%), other value added $4.0 million (or 4%), and imports $11.2 million (or 11%). Considering fishery sectors individually, intermediate inputs accounted respectively for 35%, 48%, 54%, and 79% of total inputs for the longline, other commercial, charter, and recreational/expense fisheries. The figure for the recreational/expense fishery is high due to the lack of direct valued added. Major sectors supplying inputs to Hawaii's fisheries were petroleum refining and products ($13.7 million), other food and tobacco products ($10.1 million), finance and insurance ($5.9 million), transportation equipment ($5.7 million), and wholesale trade ($5.7 million).

As shown in Table 12, Hawaii's fisheries also play an important role in the economy as source of production inputs for other industries. Fisheries' intermediate sales to other industries consist primarily of fish sales. In terms of 1992 dollars, inter-industry sales from Hawaii's fisheries totaled $32.7 million, including $22.4 million from the longline fishery, $6.51 million from other commercial boats, and $3.1 million from recreational and expense boats. Total intermediate sales accounted for 33.3% of total fishery output. Of the total inter-industry sales of fisheries, 50% went to eating and drinking places, 25.6% to other food and tobacco products, and remaining 24.4% to hotel and lodging places. For individual fisheries, the share of total-intermediate sales in total output varied from 4.1% for the charter fishery to 51.1% for the longline fishery. For the charter fishery the value of fish landed is small relative to total sales and hence its inter-industry sales is rather small. Most of the intermediate sales of other commercial and recreational/expense fisheries went to other food and tobacco processing sectors, while that of longline fishery mostly went to eating and drinking places.

Besides intermediate demand, Hawaii's fisheries also serve final demand sectors of the economy. As shown in Table12, about $65.5 million or 66.7% of total output from Hawaii's fisheries went to final consumers. Of total fisheries' final demand, PCE accounted for 52.4%, exports 28.8%, and visitors' expenditures 18.9%. The composition of final demand differed significantly among the four fishery sectors. For example, exports accounted for nearly four-fifths of total final demand for the longline fishery, while visitors' expenditures accounted for 71% of final demand for the charter fishery. Likewise, for recreational/expense and other commercial fisheries PCE was dominant, accounting for 99% and 71% of their total final demands, respectively. Forward-linked trade and distribution services involved in the delivery of fishery products to final consumers amounted to $4.9 million. Most of these margins are associated with final demands from commercial fisheries. Since most of the final demands for charter and recreational/expense fisheries are services, the contribution of distribution margins is very little in these fisheries.

Table 11. Input purchases by Hawaii's fisheries (millions of 1992$)

Sectors	Longline fishery	Other commercial fishery	Charter fishery	Recreationa/ expense fishery	Total fishery
Other food and tobacco products	5.30	1.65	0.38	2.75	10.08
Petroleum refining & products	3.81	2.13	1.57	6.20	13.71
Transportation equipment	0.51	0.83	0.88	3.44	5.67
Misc. manufacturing products	0.20	0.06	0.09	0.18	0.54
Taxies, limousines, buses	0.00	0.00	0.18	0.00	0.18
Motor freight transportation & warehousing	0.08	0.04	0.03	0.13	0.28
Water transportation	1.02	0.08	1.80	0.40	3.30
Air transportation	0.05	0.03	0.01	0.07	0.17
Communications	0.00	0.00	0.30	0.00	0.30
Wholesale trade	2.07	0.77	0.44	2.42	5.70
Eating and drinking	0.33	0.16	0.06	0.52	1.08
Retail Trade	0.28	0.22	0.05	0.69	1.25
Finance and insurance	1.78	0.68	1.47	1.98	5.92
Hotels and lodging places	0.00	0.00	0.93	0.00	0.93
Business services	0.00	0.00	0.68	0.00	0.68
Amusement services	0.00	0.00	0.02	0.00	0.02
Total intermediate inputs	15.44	6.67	8.91	18.78	49.81
Value added	23.74	6.20	7.19	0.00	37.14
Labor income	21.24	5.53	6.39	0.00	33.16
Other value added	2.50	0.68	0.80	0.00	3.98
Imports	4.70	1.04	0.36	5.11	11.21
Total inputs	43.88	13.92	16.46	23.89	98.15

Thus, according to the inter-industry transaction patterns, although small relative to most other industries, Hawaii's fisheries are important contributors to the local economy, both as destination of inputs from and source of inputs for other industry sectors. Because of this interdependence between fishery and non-fishery sectors, the changes in input requirements and final demands in the fisheries lead to output, income, and employment changes in the non-fishery sectors and vice versa. Such interdependencies are analyzed next.

6.3. Decomposition of fishery output, income, value added, and employment

In terms of 1992 dollars, Hawaii's fisheries contributed $98.2 million or 0.21 % of Hawaii's total output. Similarly, fishery sectors provided $37.1 million in value added, $33.2 million in labor income and 1,736 jobs, which were each less than 0.2% of their respective totals (Table 13).

Table 12. Output sales from Hawaii fisheries to various industry and final demand sectors (millions of 1992$)

Fishery sectors	Other food and tobacco products	Eating and drinking	Hotels and lodging places	Total intermediate sales	Personal consumption expenditures	Visitor expenditures	Exports	Total final demand	Total industry output
Longline fishery	3.15	12.85	6.42	22.41	4.06	0.45	16.96	21.47	43.88
Other commercial fishery	3.10	2.27	1.14	6.51	5.25	0.58	1.58	7.41	13.92
Charter fishery	0.32	0.35	0.00	0.68	4.36	11.26	0.16	15.79	16.46
Recreational/expense fishery	1.79	0.85	0.42	3.06	20.63	0.07	0.13	20.83	23.89
Total	8.36	16.32	7.98	32.66	34.30	12.37	18.83	65.49	98.15

Table 13. Decomposition of output, income, value added and employment of Hawaii's fisheries sectors

	Direct effect	Indirect effects from					Total	% of Hawaii total
		Longline fishery	Other commercial fishery	Charter fishery	Recreational/ expense fishery	Rest of economy		
Output (millions of 1992$)								
Longline fishery	21.47	0.05	0.02	0.01	0.05	22.28	43.88	0.09
Other commercial fishery	7.41	0.05	0.02	0.01	0.05	6.39	13.92	0.03
Charter fishery	15.79	0.01	0.00	0.00	0.00	0.66	16.46	0.03
Recreational/expense fishery	20.83	0.03	0.01	0.00	0.03	2.99	23.89	0.05
Total	65.49	0.14	0.05	0.02	0.13	32.32	98.15	0.21
Labor income (millions of 1992$)								
Longline fishery	10.39	0.03	0.01	0.01	0.02	10.79	21.24	0.11
Other commercial fishery	2.94	0.02	0.01	0.00	0.02	2.53	5.53	0.03
Charter fishery	6.13	0.00	0.00	0.00	0.00	0.26	6.39	0.03
Recreational/expense fishery	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	19.46	0.05	0.02	0.01	0.05	13.58	33.16	0.16
Value added (millions of 1992$)								
Longline fishery	11.62	0.02	0.01	0.01	0.03	12.06	23.74	0.08
Other commercial fishery	3.30	0.02	0.01	0.00	0.02	2.85	6.20	0.02
Charter fishery	6.90	0.00	0.00	0.00	0.00	0.29	7.19	0.02
Recreational/expense fishery	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	21.82	0.04	0.02	0.01	0.05	15.19	37.14	0.12
Total employment (No. of jobs)								
Longline fishery	319	1	0	0	1	331	652	0.09
Other commercial fishery	190	1	0	0	1	164	357	0.05
Charter fishery	400	0	0	0	0	17	417	0.06
Recreational/expense fishery	0	0	0	0	0	0	0	0.00
Total	909	2	1	0	2	512	1,426	0.19

Using the analytical framework presented above, the total fishery outputs, value added, labor income, and employment were decomposed to direct and indirect effects of fishery own final demands and indirect effects of non-fishery final demands. These results are presented in Table 13. For the ease of presentation of results, non-fishery sectors are aggregated to one 'rest of economy' sector. Overall, the direct effects of fishery final demands generated two-thirds and the indirect effects of final demands of the rest of economy generated one-third of total fishery output. Eating and drinking places, other food and tobacco products, and hotels and lodging places were the three leading indirect contributors to fishery outputs. The indirect effects of fishery own final demands generated less than 1% of fishery output due to very little inter-industry transactions among the fishery sectors themselves. The share of direct contributions of own final demand and that of indirect contributions of non-fishery final demands to output are quite different for individual fisheries. For example, direct effect of own final demand was dominant for charter and recreational/expense fisheries, accounting for 96% and 87.5% of their total outputs, respectively. The shares of direct and indirect effects were about the same for outputs of the commercial fisheries. These differences can be explained in terms of differences in intermediate demands. For example, inter-industry demand accounted for 51% and 47% of total outputs of longline and other commercial fisheries, compared to 4% for the charter fishery and 12.5% for recreational/expense fisheries. Similarly, the indirect effects of non-fishery final demands generated about 41% each of value added and labor income and 36% of employment of fisheries.

It should be noted that Table 13 does not reveal the output, labor income, value added, and employment for fishery trade and distribution sectors because these sectors in the original I-O table were aggregated to general trade and distribution sectors involving both fishery and non-fishery sectors. Furthermore, there is a lack of information to separate the actual output, value added, income, and employment for fishery distribution sectors from the collective totals of the general trade and distribution sectors. The omission of fishery distribution sectors may underestimate the importance of fisheries to the economy when its linkages are measured in terms of direct and indirect components of actual output, labor income, value added, and employment. This problem could be overcome by calculating the output, value added, labor income, and employment contributions of fishery final demands, including the final demands for fishery trade and distribution services represented by forward-linked trade and distribution margins of final demands for fishery products. The estimated contributions of fishery final demands and related trade and distribution services are discussed next.

6.4. Output, labor income, value added, and employment contributions of fishery final demands

Direct and indirect output, labor income, value added, and employment generated by fishery final demands and related forward-linked trade and distribution sectors are presented in Table 14. In terms of 1992 dollars, fishery final demands and their forward-linked distribution sectors generated \$118.8 million or 0.25% of total output in Hawaii's economy. The total indirect effects (i.e., backward linkage) constituted \$48.0 million or 40.4% of the total output generated by fishery final demands and related trade and distribution services. Non-fishery sectors that benefited most from fishery final demands and related margins were petroleum refining and

products ($10.5 million), other food and related products ($6.4 million), finance and insurance ($6.2 million), retail trade ($5.2 million), wholesale trade ($5.0 million), transportation equipment ($4.7 million), and water transportation ($4.2 million). Fishery final demands and related trade and distribution services contributed $34.3 million of labor income, $45.1 million of value added, and 1,469 jobs, which were respectively 0.17%, 0.15% and 0.19% of total labor income, value added, and employment in the economy. The indirect effects on non-fishery sectors constituted about 36.4% of total labor income, 43.6% of value added, and 30.3% of employment generated by fishery final demands and related distribution sectors.

Comparing the four fishery sectors and distribution margins, total output contribution was highest for the recreational/expense fishery ($41.2 million or 34.7%), labor income and value added contributions were highest for the longline fishery ($12.8 million or 37.4% and $15.5 million or 34.3%, respectively), employment contribution was highest for charter fishery (525 jobs or 35.7%). In terms of indirect impacts on non-fishery sectors, recreational/expense fishery accounted for about two-thirds each of total indirect non-fishery output labor income, value added, and employment generated by four fishery final demands and related distribution sectors combined. Thus relative to direct effects, recreational/expense fishery showed largest indirect effects on the economy. The total output contribution of actual expenses on recreational/expense fishing ($41.2) may be regarded as the lower bound for the value of recreational/expense fishing estimated using other valuation methods, such as contingent valuation and hedonic approaches.

Results presented in Tables 13 and 14 provide two alternative measures of fisheries' contributions to the economy. In Table 13, fisheries' contributions are expressed in terms of actual output, labor income, value added, and employment, including the indirect effects from non-fisheries final demands on fisheries sectors. Table 14, on the other hand, shows the output, income, value added, and employment contributions of fishery final demands and related trade and distribution sectors, including their indirect impacts on non-fishery sectors. Total fisheries' contributions are somewhat higher in Table 14 than Table 13. This difference is mainly due to the fact that Table 13 does not include fisheries trade and distribution sectors for the reasons mentioned earlier. The authors believe that the estimates of collective fisheries' contributions would be very similar between the two tables if fisheries trade and distribution services were also included in Table 13, although individual contributions would be quite different. Thus, the results indicate that in this case either measure provides similar estimates of the contribution of fisheries sectors combined, but information presented in the two tables are equally important to fully understand fisheries' linkages to rest of the economy.

Table 14. Output, income, value added and employment contributions of fisheries final demands and distribution margins

	Direct effect	Indirect effects to					Total	% of Hawaii total
		Longline fishery	Other commercial fishery	Charter fishery	Recreational/ expense fishery	Rest of economy		
Output (millions of 1992$)								
Longline fishery	21.47	0.05	0.05	0.01	0.03	10.05	31.66	0.07
Other commercial fishery	7.41	0.02	0.02	0.00	0.01	4.47	11.93	0.03
Charter fishery	15.79	0.01	0.01	0.00	0.00	11.67	27.48	0.06
Recreational/expense fishery	20.83	0.05	0.05	0.00	0.03	20.26	41.22	0.09
Fisheries distribution margins	4.92	0.00	0.00	0.00	0.00	1.58	6.50	0.01
Total	70.42	0.13	0.13	0.01	0.07	48.04	118.79	0.25
Labor income (millions of 1992$)								
Longline fishery	10.39	0.03	0.02	0.00	0.00	2.39	12.83	0.06
Other commercial fishery	2.94	0.01	0.01	0.00	0.00	1.07	4.02	0.02
Charter fishery	6.13	0.01	0.00	0.00	0.00	3.38	9.51	0.05
Recreational/expense fishery	0.00	0.02	0.02	0.00	0.00	5.09	5.14	0.03
Fisheries distribution margins	2.24	0.00	0.00	0.00	0.00	0.55	2.79	0.01
Total	21.70	0.07	0.05	0.00	0.00	12.47	34.29	0.17
Value added (millions of 1992$)								
Longline fishery	11.62	0.02	0.02	0.00	0.00	3.80	15.47	0.05
Other commercial fishery	3.30	0.01	0.01	0.00	0.00	1.70	5.02	0.02
Charter fishery	6.90	0.01	0.00	0.00	0.00	5.21	12.12	0.04
Recreational/expense fishery	0.00	0.03	0.02	0.00	0.00	8.05	8.10	0.03
Fisheries distribution margins	3.48	0.00	0.00	0.00	0.00	0.89	4.37	0.01
Total	25.30	0.06	0.06	0.01	0.00	19.64	45.07	0.15
Total employment (No. of jobs)								
Longline fishery	319	1	1	0	0	88	409	0.05
Other commercial fishery	190	0	0	0	0	38	229	0.03
Charter fishery	400	0	0	0	0	125	525	0.07
Recreational/expense fishery	0	1	1	0	0	175	178	0.02
Fisheries distribution margins	109	0	0	0	0	19	128	0.02
Total	1,018	2	3	0	0	445	1,469	0.19

6.5. Contributions of Hawaii's fisheries relative to production agriculture

Agricultural and fishery sectors have a few similarities. First, both are natural resource-based industries. Second, they are relatively more labor-intensive compared to most other non-service producing sectors in the economy. Third, both play an important role in local food supply and culture and subsistence of local communities. Lastly, both sectors are subject to resource limitations and increasing environmental scrutiny. For these reasons, information on their relative importance in the state economy can be of some interest in policy decisions concerning allocation of fiscal resources.

In terms of 1992 dollars, Hawaii's agricultural and fishery production sectors combined accounted for $867 million of output and $356.6 million of labor income to the state economy. Likewise agricultural and fishery sectors employed 22,533 people. These are respectively 1.8% of total state output ($47.4 billion), 1.8% of labor income ($20.2 billion), and 3.0% of employment (757,132 jobs). Hawaii's fishery sectors accounted for about 11.3 %, 9.3%, and 6.3% of combined agricultural and fishery output, labor income and, employment, respectively.

More than 55% of total sales of agricultural sectors was used as intermediate inputs in other sectors compared to 33% for fishery sectors. Thus, relative to total output, impacts of forward linkages of agricultural sectors would be higher than those for fishery sectors. However, intermediate input purchases accounted for about 50% of total inputs for fishery sectors compared to about 25% for agricultural sectors, thus implying higher backward linkages in fisheries than in agriculture. Although, on average, direct income coefficients were higher for the agricultural than the fishery sectors (0.42 versus 0.33), annual income per worker was lower in agriculture ($15,322 vs. $23,282). Every $1 million of agricultural output generated 17 jobs while for fisheries the corresponding figure was 15 jobs for all four fishery sectors and 19 jobs for the two commercial and charter fisheries. In other words, employment to output ratios were quite similar for agricultural and fishery sectors.

Various Type I and Type II backward multipliers from the 72-sector I-O model for 4 fishery sectors and 17 agricultural sectors are shown in Table 15. Note that the multipliers in Table 15 are slightly different from those presented earlier in Table 8 due to different levels of aggregation in the two tables. Overall, fisheries's multipliers compared favorably well with agricultural multipliers, especially income and job multipliers. The Type I output multipliers were higher for fisheries than 12 of 17 agricultural sectors and the Type II output multipliers were higher in fisheries than 15 of 17 agricultural sectors. Among both agricultural and fishery sectors, the Type I output multiplier was the highest for the recreational/expense fishery and the Type II output multiplier was highest for the charter fishery. Comparing Type I and Type II output multipliers, induced effects were mostly higher for fisheries except for recreational/expense fishing. Total income and employment effects of changes in final demand were lowest for the recreational/expense fishery due to the absence of direct income and employment effects for recreational/expense fishing. However, for other fishery sectors total income effects were mostly higher than for most agricultural sectors and total employment effects were more or less similar between the two groups of activities.

Table 15. Type I and Type II output, income, and employment multipliers for Hawaii's fisheries and agricultural sectors

	$Output/$final demand		$Income/$income		$Income/$final demand		Job/Job		Job/$ million final demand	
	Type I	Type II	Type I	Type II	Type I	Type II	Type I	Type II	Type I	Type II
Fisheries sectors										
Longline fishery	1.47	2.32	1.23	1.88	0.60	0.91	1.28	2.08	19.07	30.87
Other commercial fishery	1.61	2.38	1.37	2.08	0.54	0.83	1.20	1.62	30.89	41.61
Charter fishery	1.74	2.59	1.55	2.36	0.60	0.92	1.31	1.78	33.24	45.14
Recreational/expense fishery	1.98	2.33	NA	NA	0.25	0.37	NA	NA	8.52	13.39
Agricultural (production) sectors										
Sugar crops	1.33	2.17	1.21	1.83	0.59	0.90	1.19	1.72	25.96	37.62
Vegetables	1.26	1.86	1.40	2.12	0.42	0.64	1.14	1.33	49.56	57.92
Tree nuts	1.39	2.10	1.56	2.38	0.50	0.77	1.22	1.45	53.09	63.06
Pineapple	1.25	1.87	1.32	2.01	0.43	0.66	1.35	1.93	20.03	28.60
Other fruits	1.33	1.97	1.51	2.29	0.46	0.69	1.15	1.31	62.81	71.82
Coffee	1.46	2.20	1.68	2.56	0.52	0.79	1.29	1.57	48.63	58.91
Greenhouse and nursery products	1.35	2.10	1.47	2.23	0.52	0.79	1.32	1.69	36.31	46.64
Dairy farm products	1.64	2.17	1.63	2.48	0.37	0.56	1.24	1.53	30.72	38.05
Poultry and eggs	1.51	2.19	1.82	2.77	0.48	0.73	1.61	2.14	28.95	38.41
Cattle and calves	1.53	2.11	1.54	2.34	0.41	0.62	1.26	1.54	35.88	43.99
Hogs, pigs, & swine	1.73	2.37	1.73	2.63	0.45	0.69	1.34	1.53	61.66	70.61
Misc. livestock	1.10	1.53	1.14	1.74	0.30	0.45	1.04	1.20	37.02	42.93
Aquaculture	1.04	1.49	1.06	1.61	0.31	0.48	1.03	1.28	24.85	31.06
Forestry and forest products	1.00	1.24	1.00	1.52	0.17	0.25	1.00	1.24	14.00	17.29
Other agricultural products	1.52	2.24	1.66	2.53	0.51	0.77	1.36	1.74	35.60	45.61
Agricultural, forestry and fishery services	1.16	2.05	1.13	1.71	0.63	0.95	1.10	1.49	34.89	47.29
Landscape and horticultural services	1.29	2.23	1.20	1.83	0.67	1.02	1.15	1.61	32.46	45.66

Note. Income (income/income) and employment (job/job) ratio multipliers could not computed for recreational and expense fishery due to the absence of direct income and employment effects.

7. COMPARISON WITH OTHER FISHERIES STUDIES IN THE U.S.

The purpose of this section is to compare estimated I-O multipliers for Hawaii's fisheries and those from the mainland U.S.. However, caution should be exercised in comparing the multipliers for a particular industry sector or group of sectors across geographical regions. Besides the variations in an industry's structure, the multipliers can be different across regions for several other reasons, such as differences in data sources and measurements, year of analysis, methodology, and sector specifications. Despite these, multipliers serve as a good means of comparing industries across regions.

Although I-O models have been widely applied to fisheries, the number of such applications that can be found in the literature is quite limited. A few fisheries with information that can be compared with Hawaii's fisheries are listed in Table 16. In mainland studies, commercial fisheries are often defined in terms of species. Similarly, information on recreational fishery is often presented in terms of residents and non-residents. For these reasons, figures presented in Table 16 are average estimates of original studies to make them comparable with Hawaii's fisheries. For example, output and income multipliers for Southern New England, Cape Cod, Rhode Island, Ocean County, and Maine commercial fisheries are averages for two or more species. Likewise, multipliers for recreational fishery in Massachusetts are averages over residents and non-residents and over trip-related and non-trip related expenses. Furthermore, to ensure comparability longline and other commercial fisheries in Hawaii are combined to form a single commercial fishery sector and charter fishery and recreational and expense fisheries are combined to form a single recreational fishery. Virtually in all cases, the year of analysis is different.

Despite the above concerns, comparing multipliers for Hawaii's fisheries with those for mainland fisheries can be useful, particularly for federal fishery agencies in allocating resources and in considering nation-wide fishery management regulations. This will also provide researchers with some sense of accuracy and confidence in their results, although differences among studies can be attributed to several factors as mentioned above. For that reason, there is no way one could adequately explain as to why the multipliers for Hawaii's fisheries are different from those in the mainland U.S.. However, major differences or similarities are highlighted below.

In general, the multipliers for Hawaii's fisheries compare fairly well with those from the mainland U.S.. Compared to Hawaii's longline fishery, California's pelagic fisheries have higher Type II output multipliers (especially tuna purse-seiners and jigboats) and, except for tuna purse-seiners, higher total employment effects (jobs/million of final demand). Income multipliers are quite similar for Hawaii's longline and California's fisheries, except for higher ratio income multiplier ($income/$income) for jigboats. For commercial fisheries, income multipliers tend to be higher for Hawaii's fisheries than those from the mainland. Except higher employment effects for Ohio Lake Erie, multipliers for Hawaii's charter fishery are fairly comparable with those from the mainland charter fisheries. In case of recreational fisheries (i.e., aggregating charter and recreational), multipliers are consistently higher for Hawaii (Table 16).

Table 16. Comparison of I-O multipliers between Hawaii's fisheries and fisheries in the mainland U.S.

	$Output/$final demand		$Income/$income		$Income/$final demand		Job/Job		Job/$million final demand	
	Type I	Type II	Type I	Type II	Type I	Type II	Type I	Type II	Type I	Type II
Pelagic fisheries										
Hawaii (longline)	1.47	2.32	1.23	1.88	0.60	0.91	1.28	2.08	19.07	30.87
California[a]										
Tuna purse-seiners	1.51	3.66	1.23	1.70	0.75	1.04	1.98	4.67	11.90	28.01
Baitboats (tuna)	1.38	2.53	1.16	1.61	0.75	1.04	1.10	1.46	48.90	65.00
Jigboats (tuna)	2.05	3.75	2.12	2.95	0.60	0.83	1.28	1.55	61.70	74.50
Harpoon (billfish)	1.80	2.53	1.63	2.26	0.60	0.84	1.11	1.25	99.14	112.10
Commercial fisheries										
Hawaii (longline + other commercial)	1.51	2.34	1.26	1.92	0.58		1.26		21.91	
Southern New England[b]		3.37		1.83						
Cape Cod, Massachusetts[c]		2.89		1.33						
Rhode Island[d]		2.61		1.41						
Ocean County, New Jersey[e]		1.96		1.21						
Maine[f]		3.18		1.47						
Ohio Lake Erie Fishery[g]	1.65		1.52		0.24		1.37		28.48	
Charter fisheries										
Hawaii	1.74	2.59	1.55	2.36	0.60		1.31		33.24	
Southern New England[b]		2.98		2.18						
Cape Cod, Massachusetts[c]		2.82		1.52						
Ohio Lake Erie Fishery[g]	1.91		1.76		0.62		2.69		56.44	
Recreational fisheries										
Hawaii (Charter + expense + recreational)	1.88		2.47				1.80			
Massachusetts[h] (charter + recreational)	1.50		1.70				1.59			

Source: [a] King and Shellhammer (1982a, 1982b), [b] Grigalunas and Ascarl (1982), [c] King and Storey (1974), [d] Callaghan and Comeford (1978), [e] Rossi et al. (1985), [f] Briggs et al. (1982), [g] Hushak (1987), and [h] Storey and Allen (1993). Figures for Southern New England, Cape Cod, Rhode Island, and Maine are taken from Andrews and Rossi (1986) due to the lack of access to original studies.

8. CONCLUDING REMARKS

The purpose of this research was to incorporate recent cost-earnings information of Hawaii's commercial, charter, and recreational/expense fisheries into the 1992 Hawaii state input-output table, to compute output, income, and employment multipliers for each of these fishery sectors, and to estimate their direct and indirect output, income, and employment contributions to the state economy. The modified I-O table and information presented in this study can be useful in assessing the significance of fishery sectors to the state economy and in determining the economic impacts of new fishery regulations (such as area closure and reallocation of commercial catch to recreational fishing) on fishery sectors themselves as well as on other sectors that are related to fisheries activities. However, for several reasons, as described below, one has to be cautious in interpreting the results and in using the model for policy purposes.

The results should be used in view of inherent limitations of the I-O approach, which is just one of several economic tools used in valuation of fishery resources and formulation of fishery policy decisions. Most information involved in the analysis came from sample surveys, meaning that the results are dependent on sampling procedures, interview techniques and related estimation issues. Assuming that inter-industry transactions patterns remained constant or changed very little over time, the fisheries cost-earnings data collected in various years were incorporated into the 1992 I-O table. Aggregating the data for different years involved an assumption of constant cost-earnings structure over time, particularly between 1992 and 1997 during which the surveys were conducted.

The results indicate that, in 1992 dollars, Hawaii's fisheries (comprising longline boats, other commercial boats, charter boats, and recreational/expense boats) generated about $98.2 million of output, $33.2 million of labor income, and $37.1 million of value added. Hawaii's fisheries also generated 1,426 jobs. When fishery trade and distribution margins were also included, fisheries contributed to about $118.8 million of output, $34.3 million of labor income, 45.1 million of value added, and 1,469 jobs.

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