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Description of the Input-Output Model for Pacific Coast Fisheries

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Description of the Input-Output Model for Pacific Coast Fisheries

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Executive Summary

The input-output model for Pacific Coast Fisheries (IO-PAC) is designed to estimate the gross changes in economic contributions and economic impacts resulting from policy, environmental, or other changes that affect fishery harvest. IO-PAC was constructed by customizing Impact Analysis for Planning (IMPLAN) regional input-output software. The methodology employed in this model is similar to that used in the Northeast Region Commercial Fishing Input-output Model. IO-PAC is designed to estimate the economic effects of changes in fishing harvest for various types of vessels and fish species over multiple geographic areas along the Pacific Coast. Economic impact estimates in IO-PAC include the effects of changes in fish harvest to harvesting vessels, seafood wholesalers, and processors, and they can be exhibited as a change in total economic output, income, or employment.

Data used to develop the fishing sectors were obtained from Pacific Fisheries Information Network (PacFIN) fish ticket data maintained by the Pacific States Marine Fisheries Commission, the Northwest Fisheries Science Center's (NWFSC) cost earnings surveys, moorage rates from 19 ports along the West Coast, and collection statistics for the Washington Enhanced Food Fish Tax. PacFIN data include fish ticket and vessel registration information that are supplied by the California Department of Fish and Game, Oregon Department of Fish and Wildlife, and Washington Department of Fish and Wildlife. The 2006 PacFIN fish ticket data, when aggregated into vessel classifications and commodity types, comprise the sales estimates that are included in the model. Default IMPLAN 2006 data are used in IO-PAC for the regional nonfishing economy such as the agricultural, manufacturing, trade, and service sectors, as well as the various institutions in the region such as households and governments. NWFSC cost earnings surveys provide the majority of data necessary to construct the production functions in IO-PAC. Data on Washington Enhanced Food Fish Tax collections in 2006 are used to estimate the flow of fish landings.

IO-PAC covers the commercial groundfish, salmon, crab, highly migratory species, coastal pelagic species, lobster, and shrimp fisheries on the West Coast. Commercial fishing vessel categories are classified by type using the 19 sector scheme. These 19 vessel categories are added as industry sectors into IMPLAN and they produce 32 unique species and gear commodity outputs. Because the 19 vessel industry sectors produce a variety of species and gear commodities, economic impact estimates can be made on both an industry and commodity basis.

The IO-PAC approach to study area for impact estimation is to use a collection of region-specific models. There are models for the entire West Coast and the states of Washington, Oregon, and California. Additionally, there are models for port areas that correspond to the port groups analyzed in the 2005–2006 Pacific Coast groundfish environmental impact statement. The IO-PAC approach of region-specific models is intended to be flexible enough to provide impact estimates for a wide variety of policy situations and analysis goals. It can provide coast-wide, statewide, and port-area impacts.

Information on product flow from IMPLAN and data on Washington Enhanced Food Fish Tax collections in 2006 were used to broaden the economic effects beyond the harvesting vessels and include seafood wholesalers and processors. IMPLAN provides estimates of the flow of fish from harvesters to processors in all IO-PAC study areas. The amount of fish that flows to wholesalers was assumed to be a fixed percent of landings in all study areas and is based on Washington Enhanced Food Fish Tax collections data supplied by the Washington Department of Revenue.

Production functions for the harvesting sectors included in the model were constructed primarily through the use of NWFSC cost earnings surveys data. The surveys were conducted for the limited entry trawl, limited entry fixed gear, and open access fleets. Data for 2004 were used from the limited entry surveys and data for 2005 were used from the open access survey. The production functions in the IO-PAC were developed by weighting the results of the three different NWFSC cost earnings surveys and incorporating information on landings taxes and moorage rates. Because the cost earnings surveys did not collect data on vessel moorage expenditures, these were estimated using 2009 data on moorage rates from 19 West Coast ports. Landings taxes paid by harvesters were estimated by applying the tax rate by state to the value of taxable landings in 2006. The cost earnings surveys do not cover all 19 vessel classification categories. Those vessel categories that lack direct survey coverage were given a weighted average production function of all categories with direct survey coverage.

The use of IO-PAC is demonstrated with two examples of estimated changes in sablefish landings on the West Coast. The first example shows the change in economic output, income, and employment that results from a $500,000 decrease in landings by sablefish fixed gear vessels, which respectively are –$2,065,243, –$1,006,939 and –23 jobs. The second example also uses a decrease in sablefish landings of $500,000. However, the decrease in landings was not entered into the model as a change to only sablefish fixed gear vessels as classified by H. D. Radtke and S. W. Davis. Rather the effect was entered into the model as a change in the sablefish fixed gear commodity. Vessels in numerous classification categories have sablefish landings using fixed gear. The results of the commodity approach differ because the change in landings affects vessels in numerous classification categories. The change in output, income, and employment in the commodity approach are –$2,055,027, –$982,317 and –28.7 jobs, respectively.

There are several areas where IO-PAC can potentially be improved. First, some simplifying assumptions were made regarding product flow and the wholesale seafood dealer markup and production function. Future research efforts will attempt to obtain better information about these components. Second, IO-PAC relies on economic relationships that existed in 2006; however, technology and prices change at relatively slow rates, so the model can likely be used for subsequent years with minimal error. Third, IO-PAC relies on a generic production function for all commercial vessels on the West Coast that is currently not covered by NWFSC cost earnings surveys. As a result, the model is likely more accurate for those sectors that have direct survey coverage. NWFSC is planning data collections that will reach vessels in classifications that currently lack coverage. As cost earnings data from these vessel classifications become available, they will be incorporated into the model.

Acknowledgments

There are numerous individuals to thank for their contributions to this effort. We thank Brad Stenberg, Pacific Fisheries Information Network (PacFIN), who supplied fish ticket landings data and consultations about PacFIN related data issues; Dave Colpo, Pacific States Marine Fisheries Commission (PSMFC), who provided guidance on PacFIN data and landings taxes; Doreen Hansen, natural resources economist, who provided information about the proportion of groundfish landings made directly to the public in California; Greg Konkel, Washington Department of Fish and Wildlife (WDFW), who provided insight into Washington tribal landings; Lee Hoines, WDFW, who provided knowledge of commercial fishing in Washington; Marlene Bellman, PSMFC, who provided guidance with PacFIN data and constructed maps; Michelle Grooms, Oregon Department of Fish and Wildlife, who provided insight and data regarding landing fees and knowledge of commercial fishing in Oregon; Natalia Smagina, Jason Sayer, Julie Hoke, and Beth Leech, Washington Department of Revenue, for insight and data regarding the Washington Enhanced Food Fish Tax; Scott Steinback, Northeast Fisheries Science Center, who provided invaluable advice on how to construct a fisheries specific input-output model using IMPLAN software; Steve Freese, National Marine Fisheries Service, who provided project insight into federal excise taxes; and Terry Tillman and Gerry Kobylinski, California Department of Fish and Game, who provided insight into landings taxes and knowledge of commercial fishing in California.

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Abbreviations and Acronyms

BEA	U.S. Bureau of Economic Analysis
CDFG	California Department of Fish and Game
CGE	computable general equilibrium
FEAM	Fisheries Economic Assessment Model
IMPLAN	Impact Analysis for Planning (regional input-output software)
IO	input-output
IO-PAC	input-output model for Pacific Coast fisheries
NAICS	North American Industry Classification System
NERIOM	Northeast Region Commercial Fishing Input-Output Model
NMFS	National Marine Fisheries Service
NWFSC	Northwest Fisheries Science Center
ODFW	Oregon Department of Fish and Wildlife
PacFIN	Pacific Fisheries Information Network
RPC	regional purchase coefficient
SAM	social accounting matrix
WDFW	Washington Department of Fish and Wildlife
WDOR	Washington Department of Revenue

1. Introduction

When making decisions, federal fishery managers are required to consider the importance of fishery resources to fishing communities. National Standard 8 of the Magnuson-Stevens Fishery Conservation and Management Act (as amended through 12 January 2007) specifies that such considerations utilize economic and social data based on the best scientific information available to provide for sustained participation, and to the extent practicable, minimize adverse economic impacts on fishing communities. Policy changes involving fishery harvest affect individuals and businesses directly involved in the fishing industry. These decisions also affect gas stations that supply fuel to fishing vessels, grocery stores that supply provisions to vessel crew members, health care providers who service communities in which crew families reside, and even teachers whose salaries depend partially on sales and property taxes generated by fishing activity. This paper describes a new model developed by the Northwest Fisheries Science Center (NWFSC) to estimate these effects and provide information about the effects of fishing on regional economies.

The NWFSC input-output model for Pacific Coast fisheries (IO-PAC) was designed to estimate the gross changes in economic contributions and economic impacts resulting from policy, environmental, or other changes that affect fishery harvest. The IO-PAC was constructed by customizing Impact Analysis for Planning (IMPLAN) regional input-output (IO) software (Minnesota IMPLAN Group Inc., Hudson, Wisconsin). The methodology employed in developing this model is similar to that used in Northeast Fisheries Science Center's Northeast Region Commercial Fishing Input-Output Model (NERIOM) (Steinback and Thunberg 2006).

The IO-PAC model was designed to estimate the economic effects of changes in fishing harvest for many types of vessels and fish species over multiple geographic areas along the Pacific Coast. Commercial fishing vessels are classified by type using the 19 sector scheme developed by Radtke and Davis (2000). Vessels produce 32 unique species/gear outputs in the model. Estimates are spatially flexible and can be calculated for the entire West Coast; the states of Washington, Oregon, and California and the port study areas are displayed in Figure 1.

Data used to customize IMPLAN were derived from Pacific Fisheries Information Network (PacFIN) fish ticket data maintained by the Pacific States Marine Fisheries Commission; the NWFSC limited entry fixed gear, limited entry trawl, and open access surveys; and information obtained from the California Department of Fish and Game (CDFG), the Oregon Department of Fish and Wildlife (ODFW), and the Washington Department of Fish and Wildlife (WDFW). A critical component of IO-PAC is the estimation of unique production functions for each of the 19 vessel classifications included in the model. NWFSC cost earnings surveys were the primary source of information used to estimate these production functions. Because the surveys targeted vessels that had a minimum threshold of groundfish or troll-caught salmon landings, the model is likely most accurate for the groundfish-related and salmon-troll-related contribution and impact estimates. However, the surveys provided enough cost earnings data to build unique production functions for some vessel classification sectors that are not designated as

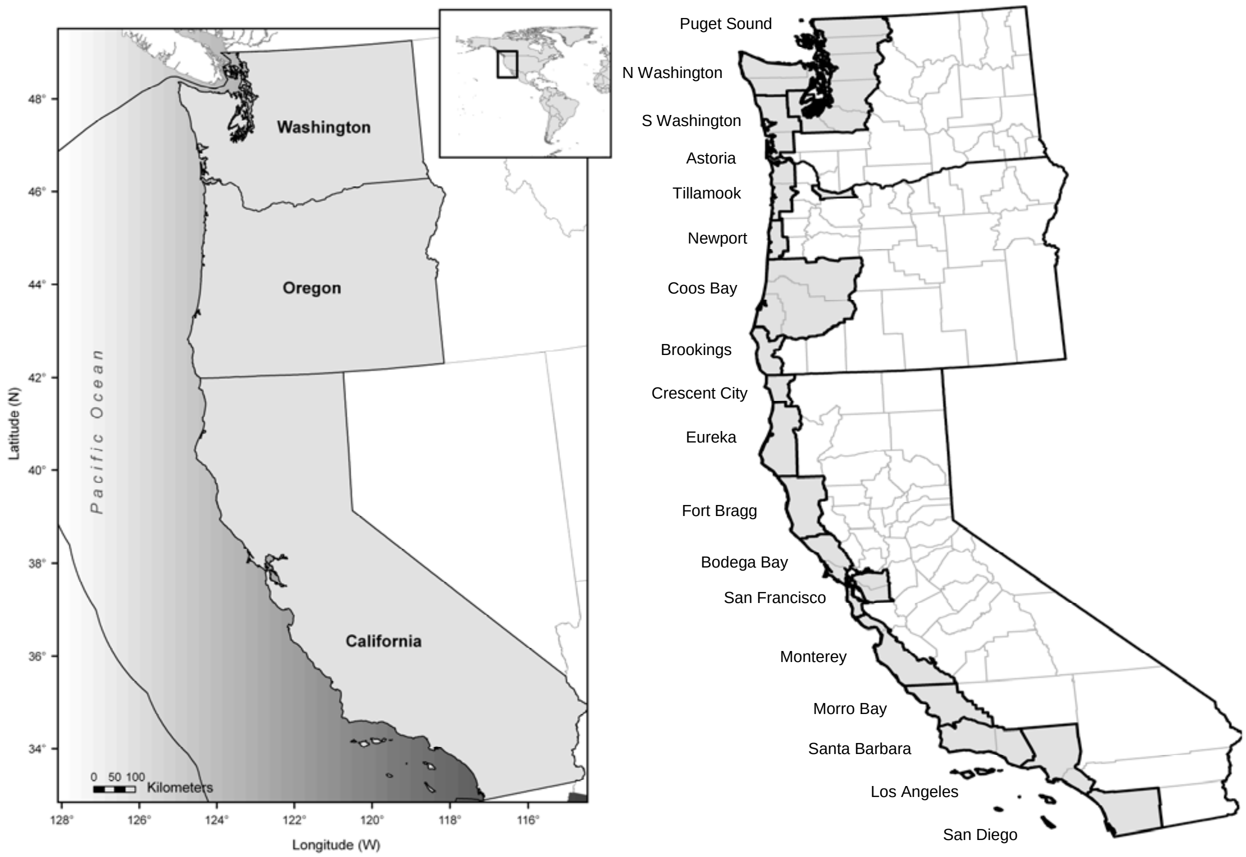

Figure 1. West Coast, state, and port study areas in IO-PAC.

groundfish or salmon-troll related. Other vessel classification sectors included in the model did not have sufficient data to estimate unique production functions. For these sectors, a weighted average production function was used. NWFSC plans to survey these vessel categories in the near future and the data will be incorporated into the model as it becomes available. In addition, NWFSC plans to add additional sectors (e.g., private recreational and charter recreational) in future versions of the model.

This paper provides an overview of the IO-PAC model design, explains its operation, and displays the outputs generated by its use. The paper proceeds as follows. Section 2, Elements of IO Analysis, summarizes the procedures used in IO modeling and the required considerations for its use in a fishery management setting. Section 3, Data, presents the data used in building the customized sectors contained in the model. Section 4, The IO-PAC Model, describes the model in detail. Section 5, Model Construction, discusses the model's incorporation into the default IMPLAN system. Section 6, Impact Estimation, explains application of the model to generate impact assessments and offers two hypothetical examples. Section 7, Discussion, reviews the IO-PAC model, discusses its limitations, and makes suggestions for further improvement.

2. Elements of IO Analysis

When a business or firm expands or contracts, there is a ripple effect through the economy. For example, when fishing vessels increase their landings, they purchase more fuel and increase payments to labor. This new economic activity also generates activity in related businesses that sell to the fishing fleet. The related businesses then buy more inputs and hire more labor. Some of the additional labor income is subsequently spent on goods and services in the community. Change in one industry, therefore, is multiplied throughout the economy following its linkages to other businesses and payments to workers. To capture these effects, it is necessary to use an economic model that contains these linkages. IO analysis is a method of modeling relationships among businesses and between businesses and consumers.

The short discussion of IO models that follows is by no means exhaustive. More detailed descriptions of IO analysis are in Miller and Blair (1985) and Hewings (1985). A survey of IO studies is in Richardson (1985).

2.1. IO Fundamentals

The underpinning of IO analysis is a double-entry accounting framework that tracks the flow of dollars in the economy. Expenditures and receipts of businesses and households are tracked. The sum of all expenditures made by businesses and households in the economy must equal the sum of all income received. These transactions are expressed in matrix form, and IO multipliers are derived through the manipulation of this matrix as shown below.

The multipliers in IO models describe the “backward” linkages among industries. As some exogenous economic event affects an industry under investigation, economic activity is then affected in input supply industries and from changes in personal income. Any economic changes found downstream, “stemming from” effects, must be exogenously incorporated into the model (Watson et. al 2008).

The multipliers in IO models are separated into three types of effects.

1. Direct effect refers to the production change associated with a variation in final demand for the good itself. It is the initial activity that occurs in the economy, which is exogenous to the model.
2. Indirect effect refers to secondary activity caused by changing input needs of directly affected industries (e.g., additional input purchases to produce additional output).
3. Induced effect is caused by changes in household spending due to additional employment generated by direct and indirect effects.

The fundamental equation of IO analysis, central to understanding multipliers, is

$$X = (I\text{-}A)^{-1}Y \qquad (1)$$

where X is a J × 1 vector of industry outputs, or sales, for each of J sectors, $(I\text{-}A)^{-1}$ is collectively referred to as the Leontief inverse, with I being a J × J identity matrix, while Y is a J × 1 vector of final demands for all J sectors' production. A is the matrix of technical coefficients, which describes the flow of inputs from sector i to sector j. For a simple two sector economy, the A matrix of interindustry linkages would be

$$A = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \qquad (2)$$

with a_{11} showing purchases by industry 1 from firms in the same sector, while a_{21} represents inputs that industry 1 buys from industry 2. The other elements are defined accordingly (These values are usually reported per dollar of sales. Thus $a_{21} = 0.15$ means that for each dollar of sales by sector 1, sector 1 would purchase \$0.15 worth of inputs from sector 2). The Leontief inverse of the A matrix is represented as

$$(I\text{-}A)^{-1} = \begin{bmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \end{bmatrix} \qquad (3)$$

The elements in the Leontief inverse matrix represent the total direct and indirect changes in output (in dollars) within the row industry resulting from an additional dollar's worth of final demand initiated in the column industry. To calculate an output multiplier for a region, a change in final demand for a given sector is hypothesized, which can come from added spending by consumers, exporters, investors, or government. (For simplicity, we calculate the total effect of a \$1 change in final demand for a given industry.) This is calculated as

$$\Delta X_1 = (I\text{-}A)^{-1}\Delta Y_{1j} = \begin{bmatrix} \alpha_{11} \\ \alpha_{21} \end{bmatrix} \qquad (4)$$

where ΔX_1 is a vector of changes in total industry output from a \$1 change in final demand for sector 1, $(I\text{-}A)^{-1}$ is the Leontief inverse, and ΔY_{1j} is a column vector that contains a 1 in the first row to show the dollar change in final demand for sector 1 and 0 in all other positions. The result is equal to the first column of the Leontief inverse. The direct effect is α_{11}, while indirect effects relate to the off-diagonal elements, which is α_{21} in this case. The total output multiplier then is the sum of all changes in output that result from the increase in final demand for industry j and is calculated as

$$O_j = \sum_{i=1}^{n} \alpha_{ij} \qquad (5)$$

for all j, where O_j is the output multiplier for industry j, which comes from the column sum of the α_{ij} values in the Leontief inverse.

The types of multipliers in IO models differ depending on what parts of the economy are endogenous in the A matrix. For a Type I multiplier, only interindustry linkages are included, so, as in the example above, only direct effects of the change in final demand for industry j and the indirect effects on other sectors are included. The effects that arise as employees receive increased income and spend it are not included in the Type I multiplier. Thus the Type I multiplier is defined as: Type I = (direct effects + indirect effects) / direct effects.

Type II multipliers make household spending and wages endogenous. In this case, the modified A matrix is

$$\overline{\mathrm{A}} = \left[\begin{array}{cc|c} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ \hline a_{31} & a_{32} & a_{33} \end{array}\right] \tag{6}$$

The new third column adds households as an endogenous sector that purchases products and services from other sectors, based on their increased wages that are found in the added third row (a_{33} shows the hiring of laborers directly by households, which might be a variety of personal services).

The additional spending that occurs in the economy due to new household income is called an induced effect. The direct, indirect, and induced effects together yield a "Type II" multiplier. The Type II multiplier is defined as follows: Type II = (direct effects + indirect effects + induced effects) / direct effects.[1]

Social accounting matrix (SAM) multipliers allow for further endogenization of accounts such as state and local government, federal government, savings and investment, corporations, and commuting patterns. In IMPLAN the difference between the Type II multiplier and the type SAM multiplier that is only closed with respect to households is that the SAM multiplier accounts for commuting patterns where labor's place of residence and place of occupation differ. In IO-PAC the models for the substate regions use SAM multipliers that endogenize only households. For the state and West Coast models, households and state and local government are also endogenized.

2.2. IO Model Assumptions

There are several key assumptions of IO models. First, IO models are demand driven and assume that the supply of outputs is unlimited. As a result, an increase in demand is always met by an increase in supply. Second, IO models assume that commodity and factor prices are fixed regardless of any change in demand. Due to these assumptions, IO models tend to overestimate the effects of policy changes (Miller and Blair 1985). Third, IO models assume zero substitution elasticities in production and consumption. For producers, the technical coefficients (a_{ij}) are fixed. For consumers, the proportions of their total expenditures made on different commodities are fixed. As a result of the fixed factor ratios, IO models are less appropriate for studying

[1] Other multipliers, such as social accounting matrix (SAM) multipliers, endogenize additional sectors, such as government expenditure or other institutions.

economies that are facing factor constraints or changes in production technology (Seung and Waters 2005).

2.3. Study Area Considerations

Selection of the appropriate study area is an important dimension in IO analysis. Generally, larger geographic areas have larger multipliers in an IO model. The level of economic interdependence among entities in larger geographic areas is greater than that in smaller geographic areas. Smaller geographic areas tend to have lower economic diversity and must import a larger portion of goods and services (Miller and Blair 1985). Consequently, businesses in larger geographic areas likely derive a higher proportion of their inputs from within the area than businesses in smaller geographic areas. Likewise, households in larger geographic areas likely source a higher share of consumed goods and services from within the area than households in smaller geographic areas. Thus in IO models, greater interdependence among entities results in larger multipliers.

While choosing a larger study area will likely produce larger multipliers, it also may reduce the relative importance of a particular industry. The larger the study area, the more likely the effects of a change in economic activity will be masked by other activity that is occurring within the area; hence, the relative importance of a particular industry will be diluted (Watson et al. 2007).

The appropriate size of the analysis region depends heavily on the purpose of the analysis and the particular policy issue being addressed. For example, if the question is how the output from the fishing industry in a small port in Oregon ripples through the Oregon economy, then a statewide study area is appropriate. However, if the question is how a change in fishing regulations will affect the income of inhabitants of the same small port, then a smaller, port-level study area is more appropriate.

2.4. Trade Flow Considerations

Location quotients, supply-demand pooling, and regional purchase coefficients (RPCs) are the varieties of methods used to estimate trade flows into and out of a study region. The IO-PAC model uses an RPC approach to estimate regional trade flows. Using RPCs is the approach generally suggested by makers of IMPLAN.[2] The RPCs used in the model are generated by IMPLAN software through a series of econometric equations. An RPC for a given commodity indicates the proportion of local demand for the commodity that is met by local production.

2.5. IO Models in a Fishery Context

There are numerous studies that examine the economic contribution and impacts of recreational and commercial fisheries. Seung and Waters (2006) provided a detailed overview of the use of IO models in a fisheries context.

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[2] See the IMPLAN professional software, analysis, and data guide, online at http://www.implan.com.

Steinback (2004) points out an important consideration that IO models must address before they are appropriate for use in a fishery management context. IO models are designed to estimate the backward linked effects of an exogenous change in final demand. However, fishery managers do not control the sale of fishery resources in final markets such as grocery stores, restaurants, etc. Rather, fishery managers control harvest of fishery resources. Management is imposed at the point of production. If the standard IO framework is not modified to account for this and changes in production are entered as if they were changes in final demand, the estimates of economic impacts will be overstated.

There are several approaches to handling production changes rather than final demand changes in an IO framework. The approach in the IO-PAC model is the same as that used by Steinback and Thunberg (2006). The RPCs of the directly impacted sectors are set to zero, then production changes are modeled as if they originated from final demand. This approach permits the utilization of the ready-made IO system IMPLAN. The directly impacted sectors added to IMPLAN are all given an RPC of 0 except for the bait supplying sector. The bait sector supplies the commodity of bait to the fish harvesters that are added to the model. No other sector purchases bait in the model. As a result, not setting the RPC to 0 for the bait supplying sector avoids the feedback effect that necessitates the RPCs be set to 0 as discussed in Steinback (2004). By setting the RPCs to 1 for the bait sector, we are assuming that harvesters will purchase 100% of bait from suppliers within the study area. The wholesale seafood trade sector that is added to the model is also assigned an RPC of 0. The default fish processing sector (IMPLAN Sector 71) is assigned an RPC of 0 because it will be modeled as a directly impacted sector in the same manner as the harvesting sectors. The default fishing sector in IMPLAN (Sector 16) is assigned an RPC of 0 to avoid double counting of harvester-level impacts when impacts on the seafood processing sector are entered.

2.6. IMPLAN

IMPLAN is a commercially available data collection and regional modeling system that was developed by the U.S. Forest Service with cooperation of the Federal Emergency Management Agency and the U.S. Bureau of Land Management for use in land and resource management planning. It has been in use since 1979. The IMPLAN system has appeal due to its widespread use and availability of support literature. Integrating gear-specific and species-specific commercial fishing data into the IMPLAN framework permits anyone with knowledge of how to use IMPLAN to assess the impact of fishery specific management actions. Additionally, by using IMPLAN, the interrelationships among newly created fishing-related sectors and other industrial sectors are explicitly detailed.

3. Data

Data for the model come from three primary sources: IMPLAN, PacFIN, and the NWFSC cost earnings surveys. In addition to these primary data sources, data on landing tax rates and moorage rates are described at the end of the section.

3.1. IMPLAN Data

IMPLAN collects, organizes, and econometrically estimates the data that are necessary to construct regional economic impact models.[3] These data, collectively referred to as the region's social accounts, consist of purchases of inputs, labor, and capital by the respective sectors of the economy, the output production of each sector, household demands in the region, sources of income of households in the region, taxes paid and government spending in the region, and the region's imports and exports.

IMPLAN constructs county-level social accounts based on a variety of data sources including the U.S. Census Bureau, U.S. Bureau of Economic Analysis (BEA), and ES-202 employment data. The procedure that IMPLAN uses to generate the social accounts consists of two main components. The first is national make and use transaction tables and the second is county specific data on industry output, employment, income, and final demands. Final demands in turn consist of household, government, and export purchases. The national make and use transaction tables are based on the 1997 Benchmark Input-Output Study conducted by BEA.

An absorption table is then created by dividing each of the elements of the use matrix by the respective industry's total output. This yields the percent of each dollar of output spent on intermediate inputs from other sectors. A column, then, represents the industry's production function or the proportion of intermediate inputs used to produce $1 of output.

The actual industry mix or the size of each industry in a region is specific to the study area. IMPLAN uses county specific ES-202 data, county business patterns data from the U.S. Census Bureau, Bureau of Labor Statistics, and BEA's Regional Economic Information System data to estimate employment for every sector in the region. Value-added components such as employee compensation, proprietor's income, and other property income are derived from BEA's National Income and Product Accounts data. Estimates of total industry output primarily come from BEA's output series and from its Annual Survey of Manufacturers.

The default IMPLAN 2006 data are used to characterize the nonfishing economy of the regions such as the agricultural, manufacturing, trade, and service sectors, as well as the various institutions in the region such as households and governments.

[3] See footnote 2.

3.2. PacFIN Data

IO-PAC utilizes 2006 fish ticket data from PacFIN.[4] PacFIN data include fish ticket and vessel registration information that is supplied by CDFG, ODFW, and WDFW. Each time a commercial fishing vessel lands fish along the West Coast, it is documented on a fish ticket. For all commercial landings sold to wholesale fish dealers or processors, the fish buyers are required to fill out a fish ticket that describes the species, weight, and total price paid for the fish purchased. It also contains information on the vessel identification of the seller, gear type used to catch the fish, date of transaction, and port where the fish were landed. If a commercial fishing harvester sells directly to consumers, the harvester is responsible for recording the receipts, filling out fish tickets, and remitting the information to the appropriate state agency. Vessel registration information supplied by the states includes some physical characteristics such as length and engine horsepower. For this project, PacFIN personnel supplied data on pounds landed and revenue received by species, gear type, and port for each vessel that landed more than $1,000 in 2006.

These data, when aggregated into vessel classifications and commodity types, comprise the sales estimates that are included in the model. The vessel classification scheme and commodity types are discussed further in the IO-PAC Model section. PacFIN contains shoreside landings along the West Coast. There are no landings data for two of the vessel classifications: Alaska fisheries vessels and mother ship catcher/processors. As a result, the current version of IO-PAC cannot be used for estimating impacts resulting from harvest changes in these sectors.

In addition to landings data, PacFIN data contain vessel physical characteristics and permit information. The physical characteristics that come from vessel registrations include length and engine horsepower. Special endorsements and permit information such as federal limited entry trawl and limited entry fixed gear are also included. Vessel length information is used in calculating moorage rates.

A PacFIN vessel identification issue affects some estimates in IO-PAC. Fish ticket data are linked to individual vessels through an identification variable called Derived ID in PacFIN. Derived ID is generated primarily through the use of U.S. Coast Guard and state agency registration numbers. There are some instances when a fish ticket contains a vessel identifier that does not have a valid Coast Guard or state registration identification. These records are assigned a Derived ID that begins with "ZZZ." In 2006, 9% of landings by value on the West Coast were attributable to fish tickets with a ZZZ identifier. This percentage is substantially higher when narrowing the scope to Washington alone. In Washington, fish tickets with a Derived ID beginning with ZZZ are almost entirely tribal fishing vessels. In 2006, 91% of fish tickets with ZZZ IDs were from Indian tribal vessels in Washington.[5]

In a given year, ZZZ identifiers are intended to be unique to an individual vessel. Every fish ticket with the same vessel identification number that is not a valid Coast Guard or state registration number is given a single, consistent ZZZ ID. However, uniquely identifying an individual vessel is problematic for tribal vessels. Each fish ticket from a tribal vessel in

[4] See http://pacfin.psmfc.org/index.php.
[5] Based on a PacFIN data query.

Washington has a unique tribe identifier in the first two digits of the tribal ID that is remitted to PacFIN. Following the first two digits, some tribal IDs have a number for an individual member of the tribe. Some tribe IDs do not include a number for an individual tribe member. When tribe IDs do not include a number for individual tribe member following the first two digits, a single ZZZ value within PacFIN can represent more than one vessel. Even in cases when the tribe IDs do include a number for individual tribe members, a single ZZZ ID in PacFIN is sometimes attributable to more than one vessel because an individual fisherman within a tribe may operate more than one vessel.[6]

IO-PAC does not exclude the fish ticket data from vessels with ZZZ IDs. Vessels with ZZZ IDs are important for estimates of commercial fishing revenue, especially in Washington. In instances where a unique ZZZ identifier represents more than one vessel, vessel classification as displayed in Table 1 may be affected; however, in IO-PAC it is assumed that misclassifying revenue by type of vessel is less problematic than excluding the revenue altogether. Additionally, failure to uniquely identify vessels results in a different approach to employment estimates in Washington, which is discussed in greater detail in the IO-PAC Model section.

3.3. NWFSC Cost Earnings Survey Data

NWFSC cost earning surveys provide the data necessary to construct the production functions in IO-PAC. Three cost earning surveys were used in developing the production functions: the limited entry trawl survey, the limited entry fixed gear survey, and the open access survey. The costs categories from the surveys that were used in the model include fuel and oil; food and provisions; ice; bait; repairs, maintenance, and improvements; insurance; leased permits; purchased permits; interest; crew expense; captain expense; vessel length; and vessel market value. Responses to the surveys can be easily matched to vessel landings by species, gear type, physical characteristics, and permit information contained in PacFIN. A short description of the surveys follows. For a more detailed description of the survey programs and summary statistics used in constructing the production functions, see Lian.[7]

The survey population for the limited entry trawl survey consisted of all vessels with a limited entry trawl permit and at least $5,000 in landings in 2004. The survey collected information for 2003 and 2004 through in person interviews. There were 91 completed responses out of a total of 143 vessels for a response rate of 64%. Using the vessel classification scheme suggested by Radtke and Davis (2000), shown in Table 1, the principle classification of respondents was large groundfish trawler, with a sizable number of responses among vessels classified as whiting and crabber. There were five responses from vessels classified as small groundfish trawler and a few responses classified as Alaska fisheries vessel, shrimper, and other.

The survey population for the limited entry fixed gear survey consisted of all vessels with a limited entry fixed gear permit and at least $1,000 in landings in 2004. This survey also collected information for 2003 and 2004, and used in person interviews. There were 61 completed responses out of a total of 121 vessels for a response rate of 51%. The principle

[6] G. Konkel, WDFW, Olympia. Pers. commun., 14 July 2009.
[7] See tables 4, 5, 6, 10, 11, and 12 in Lian 2010, tables 3, 4, 5, and 6 in Lian in press.

Table 1. Vessel sectors used in the IO-PAC (Radtke and Davis 2000).

Order	Vessel sector	Rule description
1	Mother ship catcher/processor	Identified by vessel documentation.
2	Alaska fisheries vessel	Alaska revenue is > 50% of vessel's total revenue.
3	Pacific whiting offshore and onshore trawler	Pacific whiting (*Merluccius productus*) PacFIN revenue plus U.S. West Coast offshore revenue is > 33% of vessel total revenue and total revenue is > $100,000.
4	Large groundfish trawler	Groundfish (including sablefish, halibut, and California halibut [*Paralichthys californicus*]) revenue from other than fixed gear is > 33% of vessel total revenue and total revenue is > $100,000.
5	Small groundfish trawler	Groundfish (including sablefish, halibut, and California halibut) revenue from other than fixed gear is > 33% of vessel total revenue and total revenue is > $15,000.
6	Sablefish fixed gear	Sablefish revenue from fixed gear is > 33% of vessel total revenue and total revenue is > $15,000.
7	Other groundfish fixed gear	Groundfish (including halibut and California halibut), other than sablefish, revenue from fixed gear is > 33% of vessel total revenue and total revenue is > $15,000.
8	Pelagic netter	Pelagic species revenue is > 33% of vessel total revenue and total revenue is > than $15,000.
9	Migratory netter	Highly migratory species revenue from gear other than troll or line gear is > 33% of vessel total revenue and total revenue is > $15,000.
10	Migratory liner	Highly migratory species revenue from troll or line gear is > 33% of vessel total revenue and total revenue is > $15,000.
11	Shrimper	Shrimp revenue is > 33% of vessel total revenue and total revenue is > $15,000.
12	Crabber	Crab revenue is > 33% of vessel total revenue and total revenue is > $15,000.
13	Salmon troller	Salmon revenue from troll gear is > 33% of vessel total revenue and total revenue is > $5,000.
14	Salmon netter	Salmon revenue from gill or purse seine gear is > 33% of vessel total revenue and total revenue is > $5,000.
15	Other netter	Other species revenue from net gear is > 33% of vessel total revenue and total revenue is > $15,000.
16	Lobster vessel	Lobster revenue is > 33% of vessel total revenue and total revenue is > $15,000.
17	Diver vessel	Revenue from sea urchins, geoduck (*Panopea abrupta*), or other species by diver gear is > 33% of vessel total revenue and total revenue is > $5,000.
18	Other > $15,000	All other vessels not above with total revenue > $15,000.
19	Other ≤ $15,000	All other vessels not above with total revenue ≤ $15,000.

classification of respondents was sablefish (*Anoplopoma fimbria*) fixed gear, with a sizable number of responses from vessels classified as crabber and other groundfish fixed gear.

The survey population for the open access survey consisted of all active commercial fishing vessels that 1) landed at least $1,000 of salmon and groundfish at West Coast ports during 2005 and 2006, 2) had at least one trip on which groundfish and salmon accounted for a majority of revenue from landings, and 3) did not hold a limited entry permit. All survey data were collected by in person or telephone interviews. There were 532 vessels that met the above three requirements for which a telephone number was obtainable. This survey collected information for years 2005 and 2006. There were 168 completed responses out of a total of 532 vessels for a response rate of 32%. Responses came from vessels classified as crabber, sablefish fixed gear, other less than $15,000, other greater than $15,000, other groundfish fixed gear, and salmon trollers.

The production functions in IO-PAC rely on only the 2004 data from the limited entry trawl and fixed gear surveys and only on the 2005 data from the open access survey. The survey results differ considerably depending on which year is chosen for several reasons.

In the limited entry trawl sector, differences between 2003 and 2004 reflect the implementation of the groundfish fishing capacity reduction program Congress enacted in 2003. The National Marine Fisheries Service (NMFS) invited program bids in July 2003. Bids were accepted during August 2003. Bids were submitted by 108 groundfish permit owners and NMFS accepted bids involving 92 vessels. On 4 December 2003, accepted bidders were required to permanently stop all further commercial fishing with their vessels and permits (Federal Register 2003).

The reduction in capacity had a sizable impact on average vessel costs and revenue. For the purposes of IO-PAC, it is assumed that the survey results from 2004 are more representative of current operations and are therefore used to construct the production functions.

Differences in open access survey results between 2005 and 2006 reflect the fishery failure for Pacific salmon. In August 2006 the Secretary of Commerce declared a fishery resource disaster for the California and Oregon salmon fisheries, pursuant to section 312(a) of the Magnuson-Stevens Fishery Conservation and Management Act (Upton 2008). The Pacific salmon fisheries failure had a sizable impact on average vessel revenue for some vessel classifications. The change in revenue is relatively the greatest for vessels classified as sablefish fixed gear, other less than $15,000, and other greater than $15,000. Because of the salmon failure, 2006 is a major transitional year for open access fishing vessels. A high percentage of vessels classified as salmon trollers in 2005 shift into other vessel categories in 2006. It is unknown whether the transitional changes experienced in 2006 will become the new standard. For the purposes of IO-PAC, it is assumed that the nonfailure year provides better representation of the status quo for average costs and revenues of the open access fleet, hence the 2005 results are used to develop the production functions.[8]

3.4. Landings Taxes and Moorage Rates

The voluntary cost earnings surveys listed above were not designed to capture all possible cost sources that commercial fishing vessels encounter. Attempting to capture all potential costs would have resulted in more lengthy questionnaires and possibly lower response

[8] An updated cost earnings survey for the open access fleet is under way to collect data for years 2008 and 2009. This assumption will be analyzed when 2008 and 2009 data become available.

rates. To improve response rates and data accuracy, some cost categories were not captured. Two such categories are moorage and landings taxes. As a result, they were estimated with data obtained from other sources.

Commercial fishing moorage rates for vessels of various lengths were obtained from numerous West Coast ports. Annual moorage rates for 2009 are displayed in Table 2. Ports often handle moorage costs differently. Some charge a straight cost per foot, while others charge an increasing cost per foot as the vessel surpasses specified thresholds. Some ports charge by the length of slip, regardless of the length of the vessel. If available information indicated that the maximum slip length in a port is smaller than a given vessel size, no rate is reported in the table. An average for each vessel size in each state is developed by calculating the mean of ports with values displayed in the table. The West Coast average is the mean of the California, Oregon, and Washington averages. Because California has noticeably more harbors listed, taking the mean of all the harbors would increase the influence of the California harbors on the overall total. By using the mean of the California, Oregon, and Washington averages, each has the same weight in the West Coast average.

Table 2. Moorage rates, 2009 ($ per year).

	Length of vessel (feet)							
	85	**80**	**70**	**65**	**60**	**50**	**40**	**30**
California								
Crescent City	—	—	2,381	2,381	2,041	1,706	1,450	1,195
Humboldt Bay	3,315	3,120	2,730	2,535	2,340	1,950	1,560	1,170
Port of Los Angeles	4,325	4,070	3,562	3,307	3,053	2,544	2,035	1,526
San Francisco Fisherman’s Wharf	—	—	—	—	—	1,065	959	639
San Francisco Hyde Street	—	4,688	4,688	4,688	4,688	2,930	2,344	2,344
Half Moon Bay	—	—	—	6,677	6,178	5,178	4,178	3,179
Morro Bay	—	—	2,797	2,597	2,398	1,998	1,598	1,439
Moss Landing	5,523	5,198	4,549	4,224	3,899	3,249	2,599	1,949
San Diego B Street Pier	3,258	3,066	2,683	2,491	2,300	1,916	1,533	1,150
Bodega Bay	—	5,659	4,952	4,598	4,244	3,537	2,830	2,122
California average	4,105	4,300	3,543	3,722	3,460	2,607	2,109	1,671
Oregon								
Astoria	2,295	2,160	1,890	1,755	1,620	1,350	1,080	810
Newport	3,304	3,128	2,583	2,420	2,145	1,701	1,306	1,056
Coos Bay	2,295	2,160	1,890	1,755	1,620	1,350	1,080	827
Oregon average	2,631	2,483	2,121	1,977	1,795	1,467	1,155	898
Washington								
Westport Grays Harbor	3,146	2,961	2,591	2,406	2,221	1,851	1,480	1,110
Seattle Fishermen’s Terminal	9,792	9,216	4,544	4,220	3,895	3,246	2,597	1,948
Ilwaco	1,597	1,503	1,315	1,221	1,127	635	508	381
Bellingham Squalicum Harbor	—	—	—	—	—	3,967	3,174	2,380
Bellingham Blaine Harbor	—	—	—	—	4,760	3,967	3,174	2,380
Washington average	4,845	4,560	2,817	2,616	3,001	2,733	2,186	1,640
West Coast average	**3,860**	**3,781**	**2,827**	**2,771**	**2,752**	**2,269**	**1,817**	**1,403**

Commercial fishing vessels also incur federal and state taxes. These rates are presented in Table 3. Landings taxes at the federal level partially fund the groundfish fishing capacity reduction program. Tax programs in the three states differ in how they are administered and the rates that are levied by species. These taxes are referred to as landings taxes in California and landing fees in Oregon. The tax program in Washington is referred to as the enhanced food fish tax. Technically, the levy in Washington is on the first commercial possession by an owner of fish within the state. For the purposes of this discussion, all of these levies are referred to as

Table 3. Taxes on commercial fishing vessel landings (see Table 7 for species scientific names).

Jurisdiction and species taxed	**Rate/pound ($)**
California (levied on landing pounds)	
All species of fish and shellfish unless otherwise specified	0.0013
Mollusks and crustaceans, excluding squid and crab	0.0125
Crab	0.0019
Squid	0.0019
Salmon, based only on weight in the round	0.0500
Lobster	0.0125
Abalone	0.0125
Anchovy	0.0013
Sardine	0.0063
Mackerel	0.0013
Halibut	0.0125
Angel shark, based only on weight in the round	0.0113
Swordfish, based only on weight in the round	0.0125
Thresher shark, based only on weight in the round	0.0113
Bonito shark, based only on weight in the round	0.0113
Herring	0.0125
Sea urchin	0.0013
Barracuda, flying fish, frogs, giant sea bass, saltwater worms, white sea bass, yellowtail (*Seriola lalandi*)	0.0125
Oregon (levied on landing dollars)	**Rate/dollar (%)**
All species of fish and shellfish unless otherwise specified	1.09
Salmon and steelhead	3.15
Black/blue rockfish and nearshore fish	5.00
Washington (levied on landing dollars)	
Food fish or eggs unless otherwise specified	2.30
Chinook, coho, and chum salmon, anadromous game fish and eggs	5.60
Sea urchins and cucumbers	4.90
Pink and sockeye salmon fish or eggs	3.40
Oysters	0.10
Federal (levied on landing dollars)	
Pacific coast groundfish (using trawl gear)	5.00
California coastal Dungeness crab	1.24
California pink shrimp	5.00
Oregon coastal Dungeness crab	0.55
Oregon pink shrimp	4.70
Washington coastal Dungeness crab	0.16
Washington pink shrimp	1.50

landings taxes. Information on landings taxes was obtained from the ODFW, CDFG, and the Washington Department of Revenue (WDOR). In Washington, the taxes are administered by WDOR with some assistance by WDFW.

Landings taxes are typically paid by individuals or companies licensed as commercial fish receivers. These licensed fish receivers include wholesale fish dealers, seafood processors, and in the case of Oregon, licensed bait dealers. However, in all three states, in the event that a commercial fisherman sells fish directly to the ultimate consumer, thereby bypassing the transfer of fish to a licensed receiver, the commercial fisherman becomes liable for the tax (ODFW 2006, California Codes 2009, RCW 2009).

In addition to landings tax liabilities for selling directly to the final consumer, it is common in Washington for fish receivers to shift some of the tax liability they face back to commercial fishermen. It is written in the Washington tax code (RCW 2009) that fish receivers can shift half of the landings tax back to fish sellers. As a result, fishermen and receivers typically negotiate the price that appears on the fish ticket that is the basis of the revenue in PacFIN. However, when receivers pay fishermen, one half of the receivers' tax liabilities are deducted from the amount paid. This does not happen in every transaction, but it is reported to occur in a substantial majority of cases.[9]

Neither the Oregon tax code (ORS 2009) nor the California tax code (California Codes 2009) include the provision to shift some of the tax back to harvesters. It may occur in some cases, but according to ODFW and CDFG personnel, the price paid to fish harvester by receivers that appears on the fish ticket is net of any tax agreement.[10] As a result, the revenue received by harvesters that is reflected in fish tickets is considered net of tax in California and Oregon. For California and Oregon, the only occurrence of state-level landings taxes paid by fish harvesters is when sales are made to the final consumer.

As noted, the federal government also places fees on certain fish landings to partially fund the groundfish fishing capacity reduction program. The fees are legally placed on the fish harvesters who sell the fish (CFR 2009), but fish buyers are directed to collect the fee and deduct it from the net trip proceeds that fish buyers pay to the fish sellers. The letter sent out to fish buyers (NMFS 2009) clearly indicates that the full amount of the tax should be paid by fish sellers. We therefore assume that fish harvesters pay the full amount of the federal landings fee and harvester proceeds on fish tickets are not net of these fees.

[9] L. Hoines, WDFW, Olympia. Pers. commun., 8 July 2009.

[10] T. Tillman, CDFG, Woodland. Pers. commun., 14 July 2009. M. Grooms, ODFW, Salem. Pers. commun., 14 July 2009. Both Tillman and Grooms indicated that this is not fully understood, but their understanding combined with that of the authors supported this assumption.

4. The IO-PAC Model

The IO-PAC model is a fisheries-specific IO model, where 19 unique vessel classification sectors, one wholesale seafood dealer sector, and one bait supplying sector are incorporated into IMPLAN regional IO software. The 19 fishing vessel classifications (Table 1) are based on rules developed by Radtke and Davis (2000). The vessel sectors produce 32 unique species/gear commodity outputs. The bait sector produces a single commodity, bait. The methodology employed to develop IO-PAC is modified from the Northeast Fisheries Science Center's NERIOM, developed by Steinback and Thunberg (2006). The approach differs from that of the Fisheries Economic Assessment Model (FEAM) currently being used in fisheries management along the West Coast.

FEAM is also based on an underlying IMPLAN IO model and begins by extracting the regional economic multipliers from a pregenerated IMPLAN model. The IMPLAN multipliers are then applied to the estimates of the expenditures made by the respective fishing sectors to determine the total economic impact of the fishing sectors. In this way, the ripple effects of expenditures made by the fishing vessel sectors are accounted for by externally multiplying the expenditures by their regional and industry specific multipliers. A similar process is used in FEAM to determine the economic impacts of the seafood processing sectors. This method is similar to the method used by Kirkley (2004) in the mid-Atlantic regional impact model. When the multipliers are calculated through the regional absorption table inversion, the fishing sectors are not present in the model. This method requires relatively less effort to construct than the NERIOM approach. However, because this approach does not internalize the fishery sectors into the IO model framework, it does not explicitly detail the relationships between the fishery-related sectors and other industrial sectors (Seung and Waters 2006).

The method employed by NERIOM and IO-PAC is to directly modify the sectors contained within the IMPLAN system. The regional linkages between the customized fishery sectors are established before the regional absorption table is inverted and the IO model is calculated. This method fully takes into account the effects of personal income generated by the fishing industry and the feedback interactions in the regional economy. Additionally, the approach of building the model in IMPLAN will also aid in the construction of a computable general equilibrium (CGE) model in the future. Information contained in the underlying SAM in IMPLAN can be used as the starting point for building a CGE model.

The IO-PAC model is constructed by first generating a default IMPLAN model based on the geographical area to be analyzed. New data for the 21 new industry sectors, 32 species/gear commodity outputs, and a single bait commodity are entered into the model. Next the model is rerun with the new data to generate the fully customized regional IO model. The model is then ready to complete economic impact estimates.

4.1. Industry Additions

The industrial sectors added to IMPLAN include 19 vessel sectors, a single bait sector, and a wholesale seafood dealers sector. The vessel sectors entered in the model follow the vessel classification scheme of Radtke and Davis (2000). Each vessel was assigned to 1 of the 19 vessel sectors based on Table 1 criteria. The classifications are rank dependent so that a vessel is classified into the highest ranking sector in which it meets the classification rule. For example, if a vessel meets the rule to be classified as Sector 1 (mother ship catcher/processor), then it is classified as mother ship catcher/processor regardless of whether it meets any additional classifications. Likewise, if a vessel satisfies the classification rule for Sector 4, Sector 12, and Sector 18, then the vessel would be classified as Sector 4 because that is the highest ranking vessel sector to which it belongs. Classification of vessels was performed by PacFIN personnel and appended to the fish ticket data that were supplied for the purposes of this project.

Alternative categorization schemes were considered, but this scheme has some historical precedence, so there is general familiarity with it by fishery managers on the West Coast. Additionally, it is a classification scheme that can be used with data from a variety of different sources with relative ease.

A wholesale seafood dealers sector is included in the model to account for economic effects of changes in the flow of fish to wholesale seafood dealers. Some fish flows from fish harvesters to parties other than seafood processors. This is necessary because some fish flows to wholesale seafood dealers, where it subsequently flows to restaurants, retailers, seafood processors, or is exported. In the default IMPLAN, wholesale seafood dealers are included in the default wholesale trade sector (Sector 390). Wholesale seafood dealers comprise a small portion of all wholesale dealers that are included in this IMPLAN sector. Consequently, the production functions, trade flows, and income estimates in the default wholesale trade sector, which includes everything from electronics to lumber, could differ from those of wholesales seafood dealers (Steinback and Thunberg 2006). Hence a wholesale seafood dealer sector was developed. The amount of fish that is expected to flow from harvesters to wholesale seafood dealers is detailed in the Product Flow subsection.

A bait supplying sector is included in the model to provide a sector to allocate bait purchases made by fish harvesters. Recall that the RPCs of all directly impacted sectors are set to 0 in IO-PAC, so directing bait purchases to any of these sectors would have effectively forced bait purchases to be sourced from outside the study area. The bait supplying sector that is included is a stand-alone sector that only supplies bait to fish harvesters. No other sector purchases bait. As a result, the sector avoids the feedback problems that necessitate setting the RPC to 0 (see discussion in Steinback 2004). The inclusion of a stand-alone bait supplying sector enables bait purchases to be sourced from within the study area while avoiding the feedback effects.

Vessel classifications along with the bait and wholesale seafood dealer sectors represent the industries added to IMPLAN. The IMPLAN codes for these classifications are displayed in Table 4.

Table 4. Industry categories and associated IMPLAN codes.

IMPLAN code	Category description
510	Mother ship catcher/processor
511	Alaska fisheries vessel
512	Pacific whiting trawler
513	Large groundfish trawler
514	Small groundfish trawler
515	Sablefish fixed gear
516	Other groundfish fixed gear
517	Pelagic netter
518	Migratory netter
519	Migratory liner
520	Shrimper
521	Crabber
522	Salmon troller
523	Salmon netter
524	Other netter
525	Lobster vessel
526	Diver vessel
527	Other, more than $15,000
528	Other, less than $15,000
561	Bait ship
563	Wholesale seafood dealers

4.2. Commodity Additions

The commodities added to IMPLAN include 32 different species/gear combinations and one bait commodity. The commodities are displayed in Table 5. The gear type portion of the commodity classification was made by grouping PacFIN fish ticket data along the gear categories presented in Table 6. The species classifications portion of the commodity classification was made by grouping the PacFIN data into the categories displayed in Table 7.

The total landings by vessel type and species/gear combinations are displayed in Table 8. Landings are classified in the species/gear classifications even if species for particular gear types are considered bycatch.

Use of species/gear combinations increases the flexibility of IO-PAC, permitting impact estimates to be made for harvest changes on a commodity basis. In practice, most impact estimates will likely be desired for particular gear classifications because regulations are often made based on vessels with particular permit authorization or gear type. However, there may be instances when impacts on a commodity basis will be preferable.

Impacts on a commodity basis, unlike impact estimates on a vessel classification basis, will affect all vessels with landings of a particular species, regardless of vessel classifications. For example, suppose there is an area closure or some other regulation change that is expected to reduce fixed gear sablefish landings. Vessels classified in several categories have appreciable fixed gear sablefish landings. In 2006 these included sablefish fixed gear (51%), crabbers

Table 5. Commodities added to IMPLAN and associated codes.

IMPLAN code	Species and gear combinations
529	Whiting, at sea
530	Whiting, trawl
531	Whiting, fixed gear
532	Sablefish, trawl
533	Sablefish, fixed gear
534	Dover/thornyhead, trawl
535	Dover/thornyhead, fixed gear
536	Other groundfish, trawl
537	Other groundfish, fixed gear
538	Other groundfish, net
539	Crab, trawl
540	Crab, fixed gear
541	Crab, net
542	Crab, other gear
543	Shrimp, trawl
544	Shrimp, fixed gear
545	Salmon, trawl
546	Salmon, fixed gear
547	Salmon, net
548	Highly migratory species, fixed gear
549	Highly migratory species, net
550	Coastal pelagic species, trawl
551	Coastal pelagic species, fixed gear
552	Coastal pelagic species, net
553	Coastal pelagic species, other gear
554	Halibut, trawl
555	Halibut, fixed gear
556	Halibut, net
557	Other species, trawl
558	Other species, fixed gear
559	Other species, net
560	Other species, other gear
562	Bait

Table 6. Gear groupings and associated PacFIN variables.

IO-PAC	Gear ID	Description
Trawl	TWL	Trawls except shrimp trawls
Trawl	TWS	Shrimp trawls
Fixed gear	NTW	Nontrawl gear
Fixed gear	HKL	Hook and line gear except troll
Fixed gear	TLS	Troll gear
Fixed gear	POT	Pot and trap gear
Net	NET	Net gear except trawl
Other gear	MSC	Other miscellaneous gear
Other gear	DRG	Dredge gear

Table 7. IO-PAC commodity groupings. SPID = species identification, NA = not applicable, Nom. = nominal.

IO-PAC	SPID	Common name	Scientific name
CPS	CMCK	Pacific mackerel	*Scomber japonicus*
CPS	JMCK	Jack mackerel	*Trachurus symmetricus*
CPS	MSQD	Market squid	*Loligo opalescens*
CPS	NANC	Northern anchovy	*Engraulis mordax*
CPS	PBNT	Pacific bonito	*Sarda chiliensis*
CPS	PSDN	Pacific sardine	*Sardinops sagax*
CPS	UMCK	Mackerel, unspecified	NA
Crab	BTCR	Bairdi tanner crab	*Chionoecetes bairdi*
Crab	DCRB	Dungeness crab	*Cancer magister*
Crab	OCRB	Other crab	NA
Crab	RCRB	Red rock crab	*Cancer productus*
Crab	UCRB	Crab, unspecified	NA
Crab	UKCR	King crab, unspecified	NA
Dover/thornyhead	DOVR	Dover sole	*Microstomus pacificus*
Dover/thornyhead	LSP1	Nom. longspine thornyhead	NA
Dover/thornyhead	SSP1	Nom. shortspine thornyhead	NA
Dover/thornyhead	THDS	Thornyheads, mixed	*Sebastolobus* spp.
Other groundfish	ARR1	Nom. aurora rockfish	NA
Other groundfish	ART1	Nom. arrowtooth flounder	NA
Other groundfish	ARTH	Arrowtooth flounder	*Atheresthes stomias*
Other groundfish	BCC1	Nom. bocaccio	NA
Other groundfish	BGL1	Nom. blackgill rockfish	NA
Other groundfish	BLK1	Nom. black rockfish	NA
Other groundfish	BLU1	Nom. blue rockfish	NA
Other groundfish	BNK1	Nom. bank rockfish	NA
Other groundfish	BRW1	Nom. brown rockfish	NA
Other groundfish	BRZ1	Nom. bronzespotted rockfish	NA
Other groundfish	BSOL	Butter sole	*Isopsetta isolepis*
Other groundfish	BYL1	Nom. black and yellow rockfish	NA
Other groundfish	CBZ1	Nom. cabezon	NA
Other groundfish	CBZN	Cabezon	*Scorpaenichthys marmoratus*
Other groundfish	CHN1	Nom. china rockfish	NA
Other groundfish	CLP1	Nom. chilipepper	NA
Other groundfish	CNR1	Nom. canary rockfish	NA
Other groundfish	COP1	Nom. copper rockfish	NA
Other groundfish	CSOL	Curlfin sole	*Pleuronichthys decurrens*
Other groundfish	CWC1	Nom. cowcod rockfish	NA
Other groundfish	DBR1	Nom. darkblotched rockfish	NA
Other groundfish	DSRK	Spiny dogfish	*Squalus acanthias*
Other groundfish	DVR1	Nom. Dover sole	NA
Other groundfish	EGL1	Nom. English sole	NA
Other groundfish	EGLS	English sole	*Parophrys vetulus*
Other groundfish	FLG1	Nom. flag rockfish	NA
Other groundfish	FSOL	Flathead sole	*Hippoglossoides elassodon*
Other groundfish	GBL1	Nom. greenblotched rockfish	NA
Other groundfish	GPH1	Nom. gopher rockfish	NA
Other groundfish	GRDR	Grenadier, unspecified	NA

Table 7 continued. IO-PAC commodity groupings. SPID = species identification, Nom. = nominal, NA = not applicable, Nor. = northern.

IO-PAC	SPID	Common name	Scientific name
Other groundfish	GRS1	Nom. grass rockfish	NA
Other groundfish	GSP1	Nom. greenspotted rockfish	NA
Other groundfish	GSR1	Nom. greenstriped rockfish	NA
Other groundfish	HNY1	Nom. honeycomb rockfish	NA
Other groundfish	KGL1	Nom. kelp greenling	NA
Other groundfish	KLP1	Nom. kelp rockfish	NA
Other groundfish	LCOD	Lingcod	*Ophiodon elongatus*
Other groundfish	LCD1	Nom. lingcod	NA
Other groundfish	LSRK	Leopard shark	*Triakis semifasciata*
Other groundfish	MXR1	Nom. Mexican rockfish	NA
Other groundfish	NUSF	Nor. shelf rockfish, unspecified	NA
Other groundfish	NUSP	Nor. slope rockfish, unspecified	NA
Other groundfish	NUSR	Nor. nearshore rockfish, unspecified	NA
Other groundfish	OFLT	Other flatfish	NA
Other groundfish	OGRN	Other groundfish	NA
Other groundfish	OLV1	Nom. olive rockfish	NA
Other groundfish	PCOD	Pacific cod	*Gadus macrocephalus*
Other groundfish	PDAB	Pacific sanddab	*Citharichthys sordidus*
Other groundfish	PDB1	Nom. Pacific sanddab	*Citharichthys* spp.
Other groundfish	PLCK	Walleye pollock	*Theragra chalcogramma*
Other groundfish	PNK1	Nom. pink rockfish	NA
Other groundfish	POP2	Nom. Pacific ocean perch	NA
Other groundfish	PTR1	Nom. petrale sole	NA
Other groundfish	PTRL	Petrale sole	*Eopsetta jordani*
Other groundfish	QLB1	Nom. quillback rockfish	NA
Other groundfish	RATF	Spotted ratfish	*Hydrolagus colliei*
Other groundfish	RCK2	Bolina rockfish, unspecified	NA
Other groundfish	RCK4	Reds rockfish, unspecified	NA
Other groundfish	RCK5	Sm. red rockfish, unspecified	NA
Other groundfish	RCK6	Rosefish rockfish, unspecified	NA
Other groundfish	RCK7	Gopher rockfish, unspecified	NA
Other groundfish	RDB1	Nom. redbanded rockfish	NA
Other groundfish	REX	Rex sole	*Glyptocephalus zachirus*
Other groundfish	REX1	Nom. rex sole	NA
Other groundfish	ROS1	Nom. rosy rockfish	NA
Other groundfish	RSOL	Rock sole	*Lepidopsetta bilineata*
Other groundfish	RST1	Nom. rosethorn rockfish	NA
Other groundfish	SBL1	Nom. shortbelly rockfish	NA
Other groundfish	SCR1	Nom. California scorpionfish	NA
Other groundfish	SFL1	Nom. starry flounder	NA
Other groundfish	SNS1	Nom. splitnose rockfish	NA
Other groundfish	SPK1	Nom. speckled rockfish	NA
Other groundfish	SSO1	Nom. sand sole	NA
Other groundfish	SSOL	Pacific sand sole	*Psettichthys melanostictus*
Other groundfish	SSRK	Soupfin shark	*Galeorhinus galeus*
Other groundfish	STR1	Nom. starry rockfish	NA
Other groundfish	STRY	Starry flounder	*Platichthys stellatus*

Table 7 continued. IO-PAC commodity groupings. SPID = species identification, Nom. = nominal, NA = not applicable.

IO-PAC	SPID	Common name	Scientific name
Other groundfish	SWS1	Nom. swordspine rockfish	NA
Other groundfish	TGR1	Nom. tiger rockfish	NA
Other groundfish	TRE1	Nom. treefish	NA
Other groundfish	UDAB	Sanddabs, unspecified	*Citharichthys* spp.
Other groundfish	UDNR	Deep nearshore rockfish, unspecified	NA
Other groundfish	UFLT	Flatfish, unspecified	NA
Other groundfish	UPOP	Pacific ocean perch group, unspec'd	NA
Other groundfish	URCK	Rockfish, unspecified	NA
Other groundfish	USHR	Nearshore rockfish, unspecified	NA
Other groundfish	USLF	Shelf rockfish, unspecified	NA
Other groundfish	USLP	Slope rockfish, unspecified	NA
Other groundfish	UTRB	Turbots, unspecified	NA
Other groundfish	VRM1	Nom. vermillion rockfish	NA
Other groundfish	WDW1	Nom. widow rockfish	NA
Other groundfish	YEY1	Nom. yelloweye rockfish	NA
Other groundfish	YTR1	Nom. yellowtail rockfish	NA
Halibut	CHL1	Nom. California halibut	NA
Halibut	CHLB	California halibut	*Paralichthys californicus*
Halibut	PHLB	Pacific halibut	*Hippoglossus stenolepis*
HMS	ALBC	Albacore tuna	*Thunnus alalunga*
HMS	BSRK	Blue shark	*Prionace glauca*
HMS	BTNA	Bluefin tuna	*Thunnus thynnus*
HMS	DRDO	Dorado	*Coryphaena hippurus*
HMS	ETNA	Bigeye tuna	*Thunnus obesus*
HMS	ISRK	Bigeye thresher shark	*Alopias superciliosus*
HMS	MAKO	Shortfin mako shark	*Isurus oxyrinchus*
HMS	PSRK	Pelagic thresher shark	*Alopias pelagicus*
HMS	STNA	Skipjack tuna	*Katsuwonus pelamis*
HMS	SWRD	Swordfish	*Xiphias gladius*
HMS	TSRK	Common thresher shark	*Alopias vulpinus*
HMS	UTNA	Tuna, unspecified	NA
HMS	YLTL	Yellowtail jack	*Seriola lalandi*
HMS	YTNA	Yellowfin tuna	*Thunnus albacares*
Other	ASRK	Pacific angel shark	*Squatina californica*
Other	BCLM	Washington butter clam	*Saxidomus giganteus*
Other	BMSL	Blue or bay mussel	*Mytilus edulus*
Other	BTRY	Bat ray	*Myliobatis californica*
Other	CKLE	Basket cockle	*Clinocardium nuttallil*
Other	CMSL	California mussel	*Mytilus californianus*
Other	CUDA	Pacific barracuda	*Sphyraena argentea*
Other	EELS	Eels, unspecified	NA
Other	ESTR	Eastern oyster	*Crassostrea virginica*
Other	EULC	Eulachon	*Thaleichthys pacificus*
Other	EURO	European oyster	*Ostrea edulis*
Other	GBAS	Giant sea bass	*Stereolepis gigas*
Other	GCLM	Gaper clam	*Tresus capax*
Other	GDUK	Geoduck	*Panopea abrupta*

Table 7 continued. IO-PAC commodity groupings. SPID = species identification, NA = not applicable.

IO-PAC	SPID	Common name	Scientific name
Other	GSTG	Green sturgeon	*Acipenser medirostris*
Other	HCLM	Horse clams	*Tresus* spp.
Other	KSTR	Kumamoto oyster	*Crassostrea gigas kumamoto*
Other	LCLM	Native littleneck	*Protothaca staminea*
Other	LOBS	California spiny lobster	*Panulirus interruptus*
Other	LSTR	Olympia oyster	*Ostrea conchaphila*
Other	MACL	Mud clams	*Macoma* spp.
Other	MCLM	Manila clam	*Ruditapes philippinarum*
Other	MEEL	Monkeyface prickleback	*Cebidichthys violaceus*
Other	MISC	Misc. fish/animals	NA
Other	MSC2	Misc. fish	NA
Other	MSHP	Plainfin midshipman	*Porichthys notatus*
Other	OABL	Other abalone	NA
Other	OBAS	Other bass	NA
Other	OCRK	Other croaker	NA
Other	OCTP	Octopus, unspecified	NA
Other	OMSK	Other mollusks	NA
Other	OSKT	Other skates	Other Rajidae
Other	OSRK	Other sharks	NA
Other	OURC	Other sea urchins	NA
Other	PHRG	Pacific herring	*Clupea harengus pallasii*
Other	PROW	Prowfish	*Zaprora silenus*
Other	PSTR	Pacific oyster	*Crassostrea gigas*
Other	RCLM	Razor clam	*Siliqua patula*
Other	RURC	Red sea urchin	*Strongylocentrotus franciscanus*
Other	SCLM	Soft-shelled clam	*Mya arenaria*
Other	SCLP	Sculpin, unspecified	*Cottidae* spp.
Other	SHAD	Shad, unspecified	NA
Other	SHP1	Nom. California sheephead	NA
Other	SMLT	Smelt, unspecified	NA
Other	SQID	Squid, unspecified	Decapoda
Other	SRFP	Surfperch spp.	Surfperch spp.
Other	UCLM	Clam, unspecified	NA
Other	UECH	Echinoderm, unspecified	NA
Other	UHAG	Hagfish, unspecified	*Eptatretus* spp.
Other	UMSK	Mollusks, unspecified	NA
Other	USCU	Sea cucumbers, unspecified	NA
Other	USKT	Skates, unspecified	Rajidae, unspecified
Other	USRK	Sharks, unspecified	NA
Other	WBAS	White seabass	*Atractoscion nobilis*
Other	WCRK	White croaker	*Genyonemus lineatus*
Other	WEEL	Wolf-eel	*Anarrichthys ocellatus*
Other	WSTG	White sturgeon	*Acipenser transmontanus*
Salmon	CHNK	Chinook salmon	*Oncorhynchus tshawytscha*
Salmon	CHUM	Chum salmon	*O. keta*
Salmon	COHO	Coho salmon	*O. kisutch*
Salmon	PINK	Pink salmon	*O. gorbuscha*
Salmon	SOCK	Sockeye salmon	*O. nerka*

Table 7 continued. IO-PAC commodity groupings. SPID = species identification, NA = not applicable.

IO-PAC	SPID	Common name	Scientific name
Salmon	STLH	Steelhead	*O. mykiss*
Salmon	USMN	Salmon, unspecified	NA
Sablefish	SABL	Sablefish	*Anoplopoma fimbria*
Shrimp	BSRM	Bait shrimp, unspecified	NA
Shrimp	GPRW	Yellowleg shrimp	*Penaeus californiensis*
Shrimp	GSRM	Bay ghost shrimp	*Callianassa californiensis*
Shrimp	MSRM	Blue mud shrimp	*Upogebia pugettensis*
Shrimp	OSRM	Other shrimp	NA
Shrimp	PSHP	Pink shrimp	*Pandaulus jordani*
Shrimp	RPRW	Ridgeback prawn	*Sicyonia ingentus*
Shrimp	SPRW	Spot shrimp	*Pandalus platyceros*
Shrimp	USRM	Ocean shrimp, unspecified	NA
Whiting	PWHT	Pacific whiting	*Merluccius productus*

(36%), other groundfish fixed gear (4%), other less than 15,000 (3%), and salmon trollers (2%). The remaining 4% of fixed gear sablefish landings was spread across the remaining vessel classifications. In this example, entering an exogenous reduction in the fixed gear sablefish harvest would result in a negative impact on all of these vessel classifications. The size of the impact in each vessel classification is determined by the specifics of its production function and its respective share of total sablefish fixed gear landings.

The overall impact would be different for a scenario in which the same exogenous reduction in harvest affects only vessels classified as sablefish fixed gear. The greater the differences between the production functions of all the other vessel classifications with fixed gear sablefish landings from those categorized as sablefish fixed gear, the greater the difference in the results. Assuming the production functions differ considerably, similar results using the vessel classification approach would require separate exogenous harvest estimates for each vessel classification. Prior to entering the downturn in fixed gear sablefish landings into model, the total downturn would require apportionment among the different vessel classifications and each expected change would be entered separately. For example, the total downturn in fixed gear sablefish landings would first require apportionment among sablefish fixed gear, crabbers, other groundfish fixed gear, etc. Then each of those expected changes would be entered in the model separately and the impacts estimated simultaneously.

4.3. Study Area

The IO-PAC model is a collection of region-specific models. There are models for Washington, Oregon, California, and the entire West Coast. Additionally, there are models for port areas, which consist of a collection of ports in a substate geographic area. Because each of the state, port, and port-area models are subregions of the West Coast region, they will all be referred to as subregions in the following discussion. This follows the terminology used by Steinback and Thunberg (2006) in the NERIOM.

Table 8. Landings by vessel type and commodity code, 2006 value ($).

IMPLAN code	Species and gear combinations	Vessel classification							
		510	511	512	513	514	515	516	517
529	Whiting, at sea	—	—	—	—	—	—	—	—
530	Whiting, trawl	—	—	16,049,437	1,135,712	126,452	—	—	—
531	Whiting, fixed gear	—	—	—	—	—	76	564	—
532	Sablefish, trawl	—	—	1,068,257	5,730,702	138,606	53,272	—	—
533	Sablefish, fixed gear	—	—	138,319	28,729	38,053	7,919,824	661,001	40,726
534	Dover/thornyhead, trawl	—	—	551,623	4,604,122	83,753	47,975	—	—
535	Dover/thornyhead, fixed gear	—	—	21	2,423	45	269,410	951,126	—
536	Other groundfish, trawl	—	—	665,810	9,788,725	352,668	72,835	—	—
537	Other groundfish, fixed gear	—	—	235	17,014	3,888	499,699	1,711,622	2,111
538	Other groundfish, net	—	—	—	3,284	45,670	—	—	24
539	Crab, trawl	—	—	35	1,850	77	—	—	—
540	Crab, fixed gear	—	—	3,349,458	6,782,547	36,395	2,822,517	787,886	608,683
541	Crab, net	—	—	—	6,090	1,894	—	—	—
542	Crab, other gear	—	—	—	—	—	—	—	—
543	Shrimp, trawl	—	—	21,632	1,300,335	1,182	40,758	—	—
544	Shrimp, fixed gear	—	—	—	—	—	5,175	—	—
545	Salmon, trawl	—	—	35,861	1,326	1,147	—	—	—
546	Salmon, fixed gear	—	—	—	87,169	82,705	913,815	119,999	11,461
547	Salmon, net	—	—	—	—	—	97,408	30,329	431,989
548	HMS, fixed gear	—	—	3,629	123,084	—	248,577	15,015	1,464
549	HMS, net	—	—	—	46	1,724	—	—	99,204
550	CPS, trawl	—	—	6,422	446	—	—	—	—
551	CPS, fixed gear	—	—	—	—	—	7	1,383	14,157
552	CPS, net	—	—	—	7	1,342	482	—	13,428,930
553	CPS, other gear	—	—	—	—	—	—	—	130
554	Halibut, trawl	—	—	4,257	1,112,077	597,291	2,167	191	—
555	Halibut, fixed gear	—	—	13,817	31,021	41,902	1,937,697	4,419,302	374
556	Halibut, net	—	—	—	77,175	198,605	—	—	4,532
557	Other species, trawl	—	—	66,680	355,360	39,601	580	—	—
558	Other species, fixed gear	—	—	865	487	41,364	103,281	35,273	14,958
559	Other species, net	—	—	—	36,319	169,934	294	23,352	26,808,914
560	Other species, other gear	—	—	—	—	—	2,176	22,474	—
	Total			**21,976,357**	**31,226,049**	**2,004,297**	**15,038,025**	**8,779,517**	**41,467,657**

Table 8 continued horizontally. Landings by vessel type and commodity code, 2006 value ($).

IMPLAN code	Species and gear combinations	Vessel classification 518	519	520	521	522	523	524
529	Whiting, at sea	—	—	—	—	—	—	—
530	Whiting, trawl	—	—	248	120,114	—	—	—
531	Whiting, fixed gear	—	—	—	75	—	—	—
532	Sablefish, trawl	—	—	—	404,879	—	—	—
533	Sablefish, fixed gear	23	164,342	22,474	5,692,071	325,330	11,554	—
534	Dover/thornyhead, trawl	—	—	—	265,548	—	—	—
535	Dover/thornyhead, fixed gear	—	85	—	6,655	1,133	—	—
536	Other groundfish, trawl	—	—	5,046	428,986	—	—	—
537	Other groundfish, fixed gear	7,336	5,537	20,897	382,240	94,442	160	5,379
538	Other groundfish, net	20,694	—	—	2,321	—	3,006	19,625
539	Crab, trawl	—	738	149	—	—	—	—
540	Crab, fixed gear	—	2,456,793	3,265,246	120,966,903	156,663	492,963	50,117
541	Crab, net	64	—	212	10,137	—	—	—
542	Crab, other gear	—	—	—	23,912	1,677	—	—
543	Shrimp, trawl	—	26,239	5,068,270	685,320	—	8,032	—
544	Shrimp, fixed gear	—	—	4,073,820	784,724	—	89,887	—
545	Salmon, trawl	—	—	—	4	—	—	—
546	Salmon, fixed gear	63,198	819,124	9,952	2,857,295	4,633,803	17,435	6,087
547	Salmon, net	—	—	85,904	3,952,646	21,664	18,003,891	18,040
548	HMS, fixed gear	326,417	17,765,249	123,245	4,887,944	204,346	28	—
549	HMS, net	28,216	2,424	—	2,803	146	—	13,205
550	CPS, trawl	—	—	40	11	—	—	—
551	CPS, fixed gear	10	2,884	36	894	357	—	—
552	CPS, net	2,525	38	—	262,979	11	7,316	459
553	CPS, other gear	—	—	—	2,152	—	—	—
554	Halibut, trawl	578	—	20,490	10,972	—	—	96
555	Halibut, fixed gear	57	140,159	49,680	2,536,750	279,460	14,731	827
556	Halibut, net	24,823	—	582	—	—	—	79,352
557	Other species, trawl	—	—	69,948	13,421	—	—	45
558	Other species, fixed gear	5,768	116,537	575,411	434,165	372	744	165,103
559	Other species, net	2,481,457	160,485	1,918	397,151	514	524,956	1,607,932
560	Other species, other gear	556,267	80,051	263	39,955	—	—	—
	Total	**3,517,434**	**21,740,683**	**13,393,830**	**145,173,028**	**5,719,919**	**19,174,704**	**1,966,268**

Table 8 continued horizontally. Landings by vessel type and commodity code, 2006 value ($).

IMPLAN code	Species and gear combinations	Vessel classification				
		525	526	527	528	Total all classifications
529	Whiting, at sea	—	—	—	—	—
530	Whiting, trawl	—	—	—	—	17,431,963
531	Whiting, fixed gear	—	—	—	12	727
532	Sablefish, trawl	—	—	323	2,810	7,398,850
533	Sablefish, fixed gear	17,637	—	122,157	424,009	15,606,247
534	Dover/thornyhead, trawl	—	—	467	1,973	5,555,461
535	Dover/thornyhead, fixed gear	33	—	1,193	36,329	1,268,452
536	Other groundfish, trawl	—	—	5,084	16,031	11,335,185
537	Other groundfish, fixed gear	65,764	51,480	10,211	804,012	3,682,029
538	Other groundfish, net	758	—	107	13,314	108,804
539	Crab, trawl	40	—	—	235	3,125
540	Crab, fixed gear	190,637	587	101,143	1,705,317	143,773,854
541	Crab, net	365	—	193	1,937	20,892
542	Crab, other gear	—	148	250	36,397	62,383
543	Shrimp, trawl	—	—	16,300	26,905	7,194,972
544	Shrimp, fixed gear	19,811	—	1,168	82,518	5,057,102
545	Salmon, trawl	—	—	—	—	38,338
546	Salmon, fixed gear	10,338	—	64,544	461,978	10,158,902
547	Salmon, net	—	—	628,156	1,470,652	24,740,680
548	HMS, fixed gear	5,946	58	5,452	390,513	24,100,967
549	HMS, net	—	—	—	4,008	151,777
550	CPS, trawl	—	—	2	—	6,920
551	CPS, fixed gear	5,894	—	1,859	11,647	39,129
552	CPS, net	18,440	—	—	285,975	14,008,503
553	CPS, other gear	—	—	—	—	2,282
554	Halibut, trawl	224	—	16,092	27,270	1,791,705
555	Halibut, fixed gear	225,269	46,328	185,968	312,887	10,236,229
556	Halibut, net	22,218	—	4,238	54,062	465,586
557	Other species, trawl	84	58	92,431	7,696	645,904
558	Other species, fixed gear	6,818,270	34,364	592,652	277,637	9,217,251
559	Other species, net	39,449	1,730	190,355	247,098	32,691,859
560	Other species, other gear	71,345	5,264,819	80,754,211	417,122	87,208,682
	Total	**7,512,522**	**5,399,571**	**82,794,555**	**7,120,343**	**434,004,758**

The collection of regional models is displayed in Figure 1. A detailed list of how the port areas were constructed using PacFIN data is in Table 9. The port areas were designed to correspond to the location and composition of port groups present in the 2005–2006 Pacific Coast groundfish environmental impact statement (Table 8-1 of Appendix A in PFMC 2004).

The IO-PAC approach of region-specific models is intended to be flexible enough to provide impact estimates for a wide variety of policy situations and analysis goals. It can provide coast-wide, statewide, and port-level impacts. The appropriate study area is dependent on the nature of the policy change, the goals of the analysis, and the resolution of the exogenous change in fish harvest that is expected.

If a policy change will only affect a few ports along the West Coast, then depending on the intent of the analysis, it may be preferable to use study areas for only those subregions. For example, assume that a given policy will reduce fish harvest in only Astoria and Westport, and estimating changes in income in these communities is the objective of the analysis. If exogenous estimates of the changes in harvest are known for Astoria and Westport, it will likely be preferable to estimate the impacts of the changes by using only Astoria and South Washington study areas. The multipliers from the Astoria and South Washington study areas will likely result in better estimates of income effects than using the entire West Coast as the study area. Additionally, performing an analysis on these smaller study areas will likely better depict the relative importance of the fishing industry.

However, estimated impacts are often desired that follow political or administrative boundaries. For example, estimated impacts may be needed for states or for the entire West Coast. In these cases, the state level and West Coast models will likely be more appropriate. In the example of a downturn in fish harvest in Astoria, the effects of the reduction will have a greater total income impact on the state of Oregon as a whole than in Astoria alone. The economy of Oregon is more diversified than the economy of Astoria, so the multiplier will be larger.

While the impact of using the Oregon study area will be greater, the relative importance of the fishing industry will be less. Obtaining results at the state level or for the entire West Coast will come at the expense of obtaining a clear picture of the effects at a particular port. An advantageous feature of the IO-PAC model is that it is flexible enough to estimate the effects of changes in fishing regulations at many different levels of geographic resolution.

An underlying assumption in the downturn of fish sales in the Astoria and Westport example is that the exogenous effects are known for a relatively small geographic area. For some policy or other effect on harvest, this may not be the case. However, the IO-PAC approach is also flexible enough to handle scenarios in which exogenous impacts are not known for individual ports. If a given policy is expected to result in a loss in fish sales across the entire West Coast, but no port level exogenous estimates are known, then the West Coast study area could be used to estimate the impacts of such a change. These West Coast impacts could then be apportioned to the state and port level of detail based on some metric of relative importance of the different regions to the whole. One such metric might be the proportion of landings of a particular species in the different geographic areas. Another approach used in NERIOM is to

Table 9. IO-PAC port groups and names (PCID = port-county ID, AGID = agency ID).

State	IO-PAC port group	PCID	Port name (PNAME)	AGID
CA	Bodega Bay	BDG	Bodega Bay	C
CA	Bodega Bay	RYS	Point Reyes	C
CA	Bodega Bay	SLT	Sausalito	C
CA	Bodega Bay	TML	Tomales Bay	C
CA	Bodega Bay	OSM	Other Sonoma, Marin County outer coast ports	C
CA	Crescent City	CRS	Crescent City	C
CA	Eureka	ERK	Eureka	C
CA	Eureka	FLN	Fields Landing	C
CA	Eureka	OHB	Other Humboldt County ports	C
CA	Eureka	TRN	Trinidad	C
CA	Fort Bragg	ALB	Albion	C
CA	Fort Bragg	ARE	Point Arena	C
CA	Fort Bragg	BRG	Fort Bragg	C
CA	Fort Bragg	OMD	Other Mendocino County ports	C
CA	Los Angeles	DNA	Dana Point	C
CA	Los Angeles	LGB	Long Beach	C
CA	Los Angeles	NWB	Newport Beach	C
CA	Los Angeles	OLA	Other Los Angeles, Orange County ports	C
CA	Los Angeles	SP	San Pedro	C
CA	Los Angeles	TRM	Terminal Island	C
CA	Los Angeles	WLM	Wilmington	C
CA	Monterey	CRZ	Santa Cruz	C
CA	Monterey	MNT	Monterey	C
CA	Monterey	MOS	Moss Landing	C
CA	Monterey	OCM	Other Santa Cruz, Monterey County ports	C
CA	Morro Bay	AVL	Avila	C
CA	Morro Bay	MRO	Morro Bay	C
CA	Morro Bay	OSL	Other San Luis Obispo County ports	C
CA	San Diego	OCN	Oceanside	C
CA	San Diego	OSD	Other San Diego County ports	C
CA	San Diego	SD	San Diego	C
CA	San Francisco	ALM	Alameda	C
CA	San Francisco	BKL	Berkeley	C
CA	San Francisco	OAK	Oakland	C
CA	San Francisco	OSF	Other San Francisco Bay, San Mateo County ports	C
CA	San Francisco	PRN	Princeton/Half Moon Bay	C
CA	San Francisco	RCH	Richmond	C
CA	San Francisco	SF	San Francisco	C
CA	Santa Barbara	HNM	Port Hueneme	C
CA	Santa Barbara	OBV	Other Santa Barbara, Ventura County ports	C
CA	Santa Barbara	OXN	Oxnard	C
CA	Santa Barbara	SB	Santa Barbara	C
CA	Santa Barbara	VEN	Ventura	C
OR	Astoria	AST	Astoria	O

Table 9 continued. IO-PAC port groups and names (PCID = port-county ID, AGID = agency ID).

State	IO-PAC port group	PCID	Port name (PNAME)	AGID
OR	Astoria	CNB	Cannon Beach	O
OR	Astoria	CRV	Pseudo port code for Columbia River	O
OR	Astoria	GSS	Gearhart/Seaside	O
OR	Tillamook	NHL	Nehalem Bay	O
OR	Tillamook	NTR	Netarts Bay	O
OR	Tillamook	PCC	Pacific City	O
OR	Tillamook	TLL	Tillamook/Garibaldi	O
OR	Brookings	BRK	Brookings	
OR	Brookings	GLD	Gold Beach	O
OR	Brookings	ORF	Port Orford	O
OR	Columbia River	CRV	Columbia River pseudo port code	O
OR	Coos Bay	BDN	Bandon	O
OR	Coos Bay	COS	Charleston (Coos Bay)	O
OR	Coos Bay	FLR	Florence	O
OR	Coos Bay	WIN	Winchester Bay	O
OR	Newport	DPO	Depoe Bay	O
OR	Newport	NEW	Newport	O
OR	Newport	WLD	Waldport	O
WA	North WA coast	LAP	La Push	W
WA	North WA coast	NEA	Neah Bay	W
WA	North WA coast	PAG	Port Angeles	W
WA	North WA coast	SEQ	Sequim	W
WA	North WA coast	TNS	Port Townsend	W
WA	Puget Sound	ANA	Anacortes	W
WA	Puget Sound	BLL	Bellingham Bay	W
WA	Puget Sound	BLN	Blaine	W
WA	Puget Sound	EVR	Everett	W
WA	Puget Sound	FRI	Friday Harbor	W
WA	Puget Sound	LAC	La Conner	W
WA	Puget Sound	OLY	Olympia	W
WA	Puget Sound	ONP	Other north Puget Sound ports	W
WA	Puget Sound	SEA	Seattle	W
WA	Puget Sound	SHL	Shelton	W
WA	Puget Sound	TAC	Tacoma	W
WA	South and central WA coast	CPL	Copalis Beach	W
WA	South and central WA coast	GRH	Grays Harbor	W
WA	South and central WA coast	LWC	Ilwaco/Chinook	W
WA	South and central WA coast	OCR	Other Columbia River ports	W
WA	South and central WA coast	WLB	Willapa Bay	W
WA	South and central WA coast	WPT	Westport	W

apportion the indirect effects based on the relative importance of subregional economies to the total regional economy.

The IO-PAC approach is intended to be flexible enough to handle numerous different types of analyses. For policies that only affect a few ports and the exogenous effects are known at that level, then models for port specific study areas can be used. For policies that will affect all ports along the West Coast, the model for the West Coast is available. Additionally, the state-level study areas are available to develop state-level impact estimates for cases in which exogenous impacts are state or port specific.

4.4. Product Flow

Product flow considerations are important for fishing industry impact and contribution models. Generally, as long as fish harvester sales are not to final consumers or exported from the study area, they continue to affect economic activity within the study area. Each firm that purchases the seafood may add value in the production of its own goods or services. Hence a fish processor may add value to raw fish by filleting, packaging, cooking, canning, or icing. Wholesalers may add value by freezing, warehousing, providing an auction market, or shipping services. Retailers may add value by storing, icing, and displaying the product for purchase by final consumers. Restaurants may add value by cooking and preparing the seafood for patrons. At any of these stages, there is the potential that a change in fishery regulations will have an economic impact.

The product flow of fishery resources is complex and there are few sources of data that can be used to accurately account for these transactions in an economic model. Like other fishery IO models (Kirkley et al. 2004, Steinback and Thunberg 2006), the IO-PAC model relies on simplifying assumptions. There are data available to help guide these assumptions, and while by no means extensive, the data are the best available at this time. The assumptions about the flow of fish in IO-PAC were derived by utilizing data from WDOR and the absorption of fish made by the IMPLAN default seafood product preparation and manufacturing sector (Sector 71).

The Washington form of a landing tax, the Enhanced Food Fish Tax, is administered by WDOR. Because the tax is levied on the individual or entity that first retains possession of the fish in Washington, the tax records are useful in understanding the flow of fish between different types of buyers. When a commercial vessel sells fish directly to the public, the vessel pays the tax. Every business entity in Washington must file a master business application with the WDOR Licensing Division. On this application, the business explains the type of commercial activity in which it will be involved. The business is then analyzed and classified by North American Industry Classification System (NAICS) code based on its principle source of revenue. Revisions to business classifications are made through time based on reported activity contained in tax returns.[11] The proportion of the tax paid by businesses thus classified provides insight into the flow of harvested fish.

Table 10 presents the proportion of Enhanced Food Fish Tax paid by type of business and six digit NAICS code in 2006. It indicates that the fish and seafood merchant wholesalers sector paid 30.2% of the tax. Based on this proportion, IO-PAC assumes that 30% of all fish landed in each study area along the West Coast will pass through fish and seafood merchant wholesalers. Fish purchased by wholesale seafood dealers will subsequently be purchased by final consumers, purchased by fish processors, or exported out of the region.

[11] B. Leech, WDOR, Olympia. Pers. commun., 10 July 2009.

Table 10. Washington Enhanced Food Fish Tax by NAICS, calendar year 2006.

NAICS code	Title	Tax share (%)
114111	Fin fishing	12.6
114112	Shellfish fishing	1.1
311711	Seafood canning	12.1
311712	Fresh and frozen seafood processing	30.1
423910	Sporting and recreational goods and supplies merchant wholesalers	0.1
424460	Fish and seafood merchant wholesalers	30.2
424490	Other grocery and related products merchant wholesalers	4.2
445220	Fish and seafood markets	4.6
451110	Sporting goods stores	0.1
454390	Other direct selling establishments	1.3
713930	Marinas	0.7
999999	Miscellaneous	2.9
	Total	**100.0**

The proportion of fish landings in each study area that will flow to fish processors is determined by constructing a default IMPLAN model for each study area, then viewing the commodity balance sheet for the commercial fishing sector. For the West Coast region as a whole, approximately 45% of all the default commercial fishing sector sales are made to the seafood product preparation and manufacturing sector. This is similar to the 42.3% that flows to the seafood canning and fresh and frozen seafood processing sectors according to Enhanced Food Fish Tax records in Washington.

The flow of fish in IO-PAC is displayed in Figure 2. Each solid line between the different entities in the harvesting and product distribution schematic is included as a calculated impact in IO-PAC. Those represented with a dashed line are not incorporated in IO-PAC. Similar to the approach by Steinback and Thunberg (2006), there are expected to be a number of seafood substitutes available beyond fish and seafood merchant wholesalers and seafood processors. Hence the impacts of most fishery management actions on final consumers and other intermediate demand industries are likely to be negligible.

4.5. Vessel Production Functions

The production functions in IO-PAC were developed by weighting the results of the three different NWFSC cost earnings surveys and incorporating information on landings taxes and moorage rates. Survey results provided the majority of the information used to construct the production functions. Results were weighted to produce a single production function that represents the vessels contained in each of the vessel classifications. Moorage and landings taxes were estimated using external sources and added to the production functions. There are some vessel classifications that have not yet been included in the cost earnings surveys. The assignment of production functions for these sectors is addressed in two ways. All of these sectors, with the exception of small groundfish trawlers, were assigned a weighted average production function. Small groundfish trawlers were assigned the production function of large groundfish trawlers.

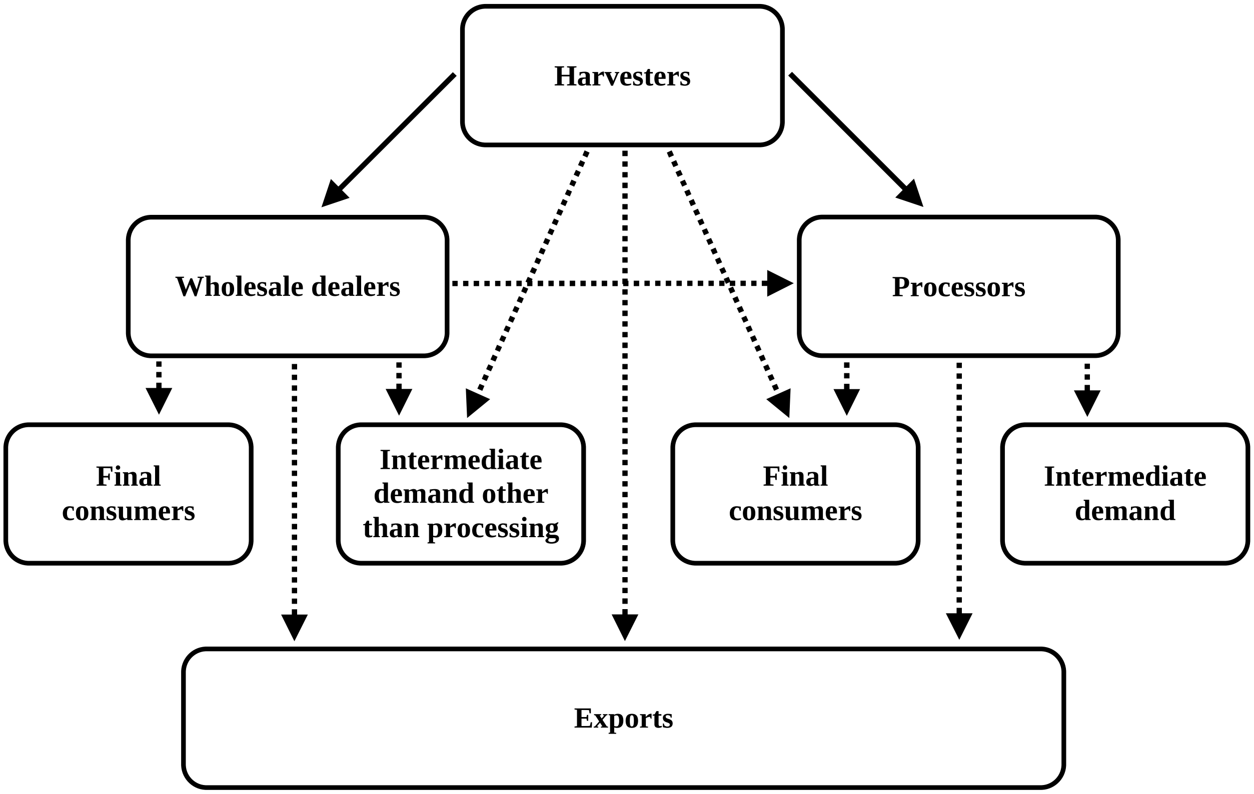

Figure 2. IO-PAC product flows. Product flows with solid lines are captured in IO-PAC; those with dashed lines are excluded.

Cost Earnings Surveys

The following steps describe how the results from the three cost earnings surveys were used to generate cost estimates for the production functions. First, the average expenditures by cost category from the three surveys were converted to a proportion of average revenue for each of the vessel classifications. If C_{ik} equals the average cost of each expenditure category (i) for vessel classification (k) and R_k is equal to the average revenue for vessel classification (k), then the proportion in each expenditure category from each survey (s) can be represented as

$$P_{iks} = \frac{C_{iks}}{R_{ks}} \tag{7}$$

Second, three of the vessel classifications shown in Table 1 (crabber, sablefish fixed gear, and other groundfish fixed gear), have survey results from more than one cost earnings survey. For these categories a weighting mechanism was used to combine the results from the surveys.

Total West Coast landings for each of the vessel classifications were converted to constant 2006 dollars using the Producer Price Index for unprocessed and packaged fish. West Coast landings by vessel classification (k) from each survey (s) is represented by WC_{ks}. The weights to combine the results of the three different surveys are given by

$$\frac{WC_{ks}}{\sum_{s}^{S} WC_{ks}} \tag{8}$$

Altogether, the survey portion of the production function for all vessel classifications (*k*) and all expenditure categories (*i*) is given by

$$P_{iks} \frac{WC_{ks}}{\sum_{s}^{S} WC_{ks}} \tag{9}$$

There are some vessel classifications that have no data from any of the NWFSC cost earnings surveys. These include mother ship catcher/processors, Alaska fishery vessels, small groundfish trawlers, pelagic netters, migratory netters, migratory liners, shrimpers, salmon netters, other netters, lobster vessels, and diver vessels. For all but small groundfish trawlers, these categories incorporate the survey data in the form of a weighted average production function. The production functions for all of the covered classifications were weighted based on their respective West Coast landings and included in this weighted average production function. Small groundfish trawlers are assumed to have the same production function as large groundfish trawlers. As additional data become available, specific production functions for these categories will be developed and incorporated into IO-PAC.

Moorage

Moorage was calculated by converting the moorage cost data presented in Table 2 to dollars per foot, multiplying dollars per foot by the average length of vessel by classification and survey population, and weighting the moorage expenditures of the different survey populations in the same manner described above. Annual dollars per foot from Table 2 for the West Coast range from $40.40 to $47.30, with an overall average of $44.90 in 2009 dollars. This per-foot amount was converted to 2006 dollars by using the consumer price index and equals $41.80.

Landings Taxes

Average federal taxes by vessel classification were estimated by multiplying the average value of landings by species and state within each vessel classification by the federal tax rates shown in Table 3. The federal tax rates are applied by species and state to all of the average landings made in each of the vessel classifications. The tax rate multiplied by the average landings by species is borne 100% by harvesters.

Average Washington taxes were estimated in two parts. First, Table 10 indicates that Washington commercial fishermen were responsible for 12.6% of landings taxes collections in 2006. Hence it is assumed that for all vessel classifications, 12.6% of average landings by species is sold directly to the public. On 12.6% of average landings by vessel classification by species, the full tax rate is assumed to be paid by harvesters. Second, because of the tax shifting arrangement in Washington, harvesters are estimated to pay half of the tax rate displayed in

Table 3 on the remaining 87.4% of average landings by species. Total average taxes by vessel classification are created by summing the direct to consumer and tax shifted components.

Average Oregon taxes were estimated by applying the tax rates by species in Table 3 to 12.6% of the vessel landings for each classification. Oregon is assumed to have the same proportion of fish sold directly to consumers as Washington. It is possible to segment sales by species for commercial fishing harvesters holding Limited Fish Seller Licenses in Oregon. These licenses permit harvesters to sell directly to the public off their vessels. Sales by harvesters with these licenses are a much smaller proportion of all landings than 12.6%. It is reported to be closer to 1%.[12] However, some harvesters have Wholesale Dealer Licenses, as they are required for harvesters who wish to sell landings directly to consumers and retail businesses from a location other than their vessel. The amount of landings sold in this manner is unknown, which necessitated an assumption that the flow of fish in Oregon is similar to Washington.

For each vessel classification, average California taxes were estimated by applying the tax rates by species in Table 3 to 2% of trawl gear landings and 21% of fixed gear landings. Approximately 2% of trawl caught groundfish and 21% of fixed gear groundfish bypassed wholesalers and processors and were purchased by final consumers in 2006.[13] These percentages are applied to all commodities in the model. The groundfish focus of the model at this time supports this assumption. As improved data for other species groups are added, these proportions will be adjusted.

The West Coast model includes an additional step that is not performed on any of the models for smaller study areas. For each vessel classification, it sums the federal and state taxes that were calculated separately, then divides the sum by total West Coast landings. This provides the percent of total revenue for each vessel classification that is used to pay landings taxes.

Table 11 presents the final production functions included in the West Coast model. The state and port-level models differ slightly in the moorage and tax component, but the production functions for the other categories are identical. The production function for other greater than $15,000 is not shown due to confidentiality restrictions. The expenditure categories shown in Table 11 must be mapped into IMPLAN commodity codes for inclusion in the model. The mapping of the expenditure categories in Table 11 into IMPLAN commodity codes is presented in detail in Appendix A.

4.6. Processor and Wholesale Seafood Dealer Production Functions

The processor production function is the default IMPLAN production function for seafood product preparation and packaging (Sector 71).

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[12] Based on data of landings by license type in 2006 supplied by M. Grooms, ODFW, Salem.

[13] D. Hansen, who worked with CDFG on development of the California Ocean Fish Harvester Economic (COFHE) model, provided information on the proportion of groundfish sales made directly to consumers. These numbers as direct sales to the public in 2006 were confirmed by T. Tillman, CDFG, Woodland. Pers. commun., 23 June 2009.

Table 11. Percentage distribution of commercial fishing production functions by expenditure categories.

Expenditure categories (table continued horizontally below)	**Mother ship catcher/ processor**	**Alaska**	**Pacific whiting trawler**	**Large groundfish trawler**	**Small groundfish trawler**	**Sablefish fixed gear**	**Other groundfish fixed gear**	**Migratory liner**	**Pelagic netter**	**Migratory netter**
Captain	—	—	14.3	18.9	18.9	18.2	30.1	20.1	20.1	20.1
Crew	—	—	18.4	20.9	20.9	33.6	18.1	20.2	20.2	20.2
Fuel, lubricants	—	—	12.0	12.4	12.4	4.5	12.0	9.3	9.3	9.3
Food, crew provisions	—	—	1.4	1.1	1.1	1.6	2.8	1.8	1.8	1.8
Ice	—	—	0.1	1.9	1.9	0.3	0.7	1.0	1.0	1.0
Bait	—	—	0.4	1.2	1.2	4.5	5.6	2.4	2.4	2.4
Repair and maintenance: vessel, gear, equipment	—	—	19.8	18.2	18.2	8.0	17.2	15.5	15.5	15.5
Insurance	—	—	*	5.7	5.7	2.2	1.0	3.8	3.8	3.8
Interest and financial services	—	—	*	1.7	1.7	0.9	1.0	1.1	1.1	1.1
Purchases of permits	—	—	1.0	1.8	1.8	0.6	0.5	1.1	1.1	1.1
Leasing of permits	—	—	0.0	1.2	1.2	5.8	0.1	1.0	1.0	1.0
Moorage	—	—	0.3	0.8	0.8	1.0	2.0	1.3	1.3	1.3
Landings taxes	—	—	3.7	4.1	1.1	0.9	0.6	2.0	2.0	2.0
Other miscellaneous	—	—	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Proprietary income	—	—	13.9	5.2	8.2	12.9	3.4	14.5	14.5	14.5
Total (%)			**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Expenditure categories (column list repeated from above)	**Shrimper**	**Crabber**	**Salmon troller**	**Salmon netter**	**Other netter**	**Lobster**	**Diver**	**Other >15,000**	**Other <15,000**
Captain	20.1	17.3	30.2	20.1	20.1	20.1	20.1	*	10.8
Crew	20.2	22.7	12.1	20.2	20.2	20.2	20.2	*	1.9
Fuel, lubricants	9.3	5.7	11.6	9.3	9.3	9.3	9.3	*	11.1
Food, crew provisions	1.8	1.1	4.0	1.8	1.8	1.8	1.8	*	2.1
Ice	1.0	0.5	1.8	1.0	1.0	1.0	1.0	*	0.7
Bait	2.4	3.1	1.4	2.4	2.4	2.4	2.4	*	0.3
Repair and maintenance: vessel, gear, and equipment	15.5	12.0	20.3	15.5	15.5	15.5	15.5	*	9.5
Insurance	3.8	3.1	2.7	3.8	3.8	3.8	3.8	*	1.2
Interest and financial services	1.1	0.5	1.4	1.1	1.1	1.1	1.1	*	0.5
Purchases of permits	1.1	0.7	1.5	1.1	1.1	1.1	1.1	*	0.8
Leasing of permits	1.0	0.4	0.0	1.0	1.0	1.0	1.0	*	0.0
Moorage	1.3	0.7	3.1	1.3	1.3	1.3	1.3	*	3.3
Landings taxes	2.0	1.0	1.3	2.0	2.0	2.0	2.0	*	0.7
Other miscellaneous	5.0	5.0	5.0	5.0	5.0	5.0	5.0	*	5.0
Proprietary income	14.5	26.2	3.6	14.5	14.5	14.5	14.5	*	52.1
Total (%)	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

*Percentages not shown due to confidentiality restrictions.

Wholesale seafood dealer production functions are assumed to equal those developed by Kirkley (2004), and subsequently used by Steinback and Thunberg (2006). This production function is presented in Table 12. The mapping of the expenditure categories included in the production function into IMPLAN commodity codes is presented in detail in Appendix A.

4.7. Sales

Baseline sales for all but two of the vessel classifications are derived from PacFIN fish ticket data. There are no landings data for Alaska fisheries vessels and mother ship catcher/processors contained in the model.

Baseline sales for the wholesale seafood dealer sector are estimated by margining the 30% of harvested fish that is estimated to flow to wholesale seafood dealers. IO-PAC utilizes a 16% markup margin, which is consistent with the margin from the 1997 Economic Census.[14]

Table 12. Seafood wholesale dealer production function.

Expenditure category	Seafood wholesale dealer (%)
Ice	2.80
Packaging, boxes	2.70
Shipping	4.10
Storage	14.70
Advertising	4.00
Rent	6.80
Repair and maintenance, building	6.90
Vehicle	4.10
Utilities, electric	1.37
Utilities, gas	1.37
Utilities, telephone	1.37
Insurance	4.10
Professional fees	0.70
Building principal payment	4.00
Interest payment, building	1.40
Bank service charge	0.08
Taxes	2.12
Employee compensation	33.35
Proprietary income	4.05
Total	**100.00**

[14] The most recently published markup margin for fish and seafood wholesalers (NAICS code 4226) is from the 1997 Economic Census. It is contained in Table 7, Gross margin and its components for merchant wholesalers for the United States: 1997. This table is available for the 2002 Economic Census, however, the markup margin is not published for fish and seafood wholesalers due to disclosure considerations. Evidence of the approximate range of the markup margin in 2002 can be calculated with the census's preliminary tables, and the margin published in 1997 is within this range. For additional information, contact J. Leonard, NWFSC, 2725 Montlake Blvd. E., Seattle, WA 98112.

Total sales are entered as the margin only, which excludes the costs of raw fish. This practice is analogous to the default IMPLAN treatment of the wholesale trade sector.

Baseline sales for the seafood processing sector are those contained in the default IMPLAN model for seafood product preparation and packaging (Sector 71).

4.8. Employment

In Oregon and California, employment estimates for the vessel classifications are made by multiplying the weighted average number of crew plus captain by the number of unique vessel IDs. In Washington, the ZZZ IDs necessitated an adjustment to the employment estimates. First, employment estimates for the vessel classifications are made by multiplying the weighted average number of crew plus captain by the number of unique non-ZZZ vessel IDs. The non-ZZZ employment estimates are then inflated to adjust for the ZZZ landings. It is assumed employees on vessels with ZZZ IDs are of equal productivity as those on vessels without a ZZZ ID. Thus the number of ZZZ employees will be the same share of total employees as the value of ZZZ landings is of total landings.

The cost earnings surveys capture the average number of crew members on each vessel not including the captain while performing five different activities: trawling, longlining, shrimping, crabbing, and trolling. IO-PAC uses the average number of crew for each vessel classification that best corresponds to the primary activity of the classification. For example, the applicable average number of crew for large groundfish trawlers is assumed to be the average number of crew while the vessel is engaged in trawling.

For the three vessel classifications that are covered by more than one cost earnings survey, a weighted average is used. The weighting scheme follows the approach used to weight the different elements of the production function. Essentially, for each vessel classification, the weights are comprised of the share of total inflation-adjusted West Coast landings attributable to vessels covered by the respective surveys.

Employment for wholesale seafood dealers is calculated by dividing the portion of total value-added paid to employees by the average wage paid to fish and seafood merchant wholesalers (NAICS Code 42446) from County Business Pattern data for 2006.[15] Average earnings per employee in Washington and California were $42,300 and $36,051, respectively. Average earnings per employee were not disclosed for Oregon, so the average for the West Coast was created by using the weighted mean for Washington and California, where the weights are the proportion of total employment in Washington and California that exists in each respective state. The number of paid employees was 1,015 in Washington and 4,429 in California, so the weighted average earnings per employee is $36,057.[16]

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[15] See Census Bureau county business patterns, online at http://www.census.gov/econ/cbp/index.html.

[16] Because earnings per employee was not reported for Oregon, the Oregon models utilize the $36,057 weighted average earnings.

5. Model Construction

The following discussion details the steps used to construct the model in the IMPLAN system. Much of this discussion is drawn from Steinback and Thunberg (2006). IMPLAN contains more than 60 Microsoft Access tables. Table 13 lists the underlying data tables in the IMPLAN system and a short descriptor of the type of data contained therein. The construction of IO-PAC entailed modifying 14 of these tables, as noted in Table 13.

The modification procedure consists of the following steps. First, Microsoft Excel worksheets that mirror the layout of the Access tables that needed to be modified were created. Second, all of the new data necessary to modify the Access tables were entered into the Excel worksheets. Third, the data were copied from the Excel worksheets and pasted at the bottom of the relevant Access table. Lastly, the Access tables were sorted based on the necessary variables to maintain the records format.

5.1. Model Construction Steps

These nine steps describe the creation of the IO-PAC model. The steps are repeated for each geographic area displayed in Figure 1.

1. A default West Coast region model was created with IMPLAN software.
2. The default model was opened using Access 2003.
3. Three of the U.S. tables and the Observed RPCs table were then deleted. This step was necessary because all IMPLAN Pro models share the following five tables: U.S. Absorption Table, U.S. Absorption Totals, U.S. Byproducts Table, Observed RPCs, and Margin Codes. Deletion of these tables breaks the link so that any subsequent changes made in Access will not affect other IMPLAN models. No changes were made to the Margin Codes table so it was not necessary to remove the link to that table.
4. The deleted tables (the three U.S. tables and the Observed RPCs table) were then replaced with the same tables contained in the 2005 IMPLAN structural matrix file 06NAT509.IMS through the import feature in Access.
5. For each of the 14 tables that needed to be modified, Excel worksheets were created that mirror the layout of the tables in Access.
6. Data in these 14 tables were modified to better reflect the sector linkages among fisheries-related industries.
7. After the new data for 14 tables were created in Excel, the data were copied from the Excel worksheets and pasted at the bottom of the relevant Access table.
8. The Access tables were resorted to follow the original format.

Table 13. IMPLAN tables (adapted from Steinback and Thunberg 2006).

Table name	Description
*Industry/Commodity Codes *Type Codes	Codes (modified)
Margins Codes	Codes
*U.S. Absorption *U.S. Absorption Totals *U.S. Byproducts *SACommodity Sales *SAEmployment *SAFinal Demands *SAForeign Exports *SAOutput *SAValue Added	Raw input data (modified)
SA Transfers	Raw input study area data
*Observed RPCs *RPC Methods	Raw input data (modified)
Margins *Deflators	Raw input data
General Information Model Specs. Multiplier Specs.	Model-building information
SARatios	Ratios for impact and multiplier calculations
IMCommodity Transactions IMEvents IMFactor Transactions IMGroups IMIndustry Transactions IMInstitutions Transactions IMMargins IMProjects	Impact report data (empty before impact analysis)
Regional Absorption Regional Byproducts Regional Commodity Balances Regional Direct Institutional Requirements Regional Factor Balances Regional Industry Balances Regional Institution Balances Regional Institution Demand Regional IxI Regional Market Shares Regional Multipliers Induced Regional Multipliers Type I Regional SAM Balances Regional SAM Balances Aggregated Regional SAM Balances Industry Detail Regional SAM Balances IxI Regional SAM Balances IxI Industry Detail Regional SAM Distribution Regional Value Added Coefficients	Output/report data for regional I-O model (empty before impact analysis)
rptEC Multipliers rptEmployment Multipliers rptIBT Multipliers rptOPTI Multipliers rptOutput Multipliers rptPersonal Income Multipliers rptPropInc Multipliers rptTotal VA Multipliers	Output reports
rptSAFinal Demands	Data from SAFinal Demands and SAForeign Exports (modified)
rptSAIndustry Data	Data from SAOutput, SAEmployment & SAValue Added (modified)
SAM Rollup	SAM report data
Tax Impacts	Tax report data
Type Code Rollup	Type code report data
CGE Account	Output data for computable general equilibrium models

*The construction of IO-PAC entailed modifying the table.

9. The modified model was then opened in IMPLAN; the model was reconstructed and multipliers were reestimated. IMPLAN will not recognize changes made to the underlying data tables unless the model is reconstructed using the updated data.

5.2. IMPLAN Table Adjustments

The following provides a more detailed discussion of modifications to certain Access tables.

Industry and Commodity Codes

This table contains unique code numbers for industries and commodities, which share the same name and number in an IMPLAN model. Modifications included adding 21 different industry classifications: 19 different vessel categories, a bait ship category, and a wholesale seafood dealer category. Additionally, 33 different commodity sectors were added: 32 different gear/species commodity sectors and a single sector for bait. These industry sectors identify the 19 different vessel classification categories developed by Radtke and Davis (2000). The industry and commodity sectors that are added along with their IMPLAN code numbers are displayed in Table 4 and Table 5.

Type Codes

This table contains coding information on all transaction types in the data sets. For it we added the 54 industry and commodity code designations discussed above and the associated 54 SAM commodity codes. Transaction codes associated with factors, households, institutions, transfers, employment, output, and trade remained the same.

U.S. Absorption

This table contains the U.S. absorption matrix which, in IO terminology, is the coefficient form of the Use Table, that contains the dollar value of goods and services purchased by each industry for use in its production process. Essentially, the U.S. absorption matrix contains each industry's production function. We added 1,720 rows of data that contained the production functions of each of the 19 fisheries-related vessel categories, the bait ship category, and the wholesale seafood dealer category that were added to the model.

U.S. Absorption Totals

This table contains the sum of the absorption coefficients for each industry sector. We added the appropriate absorption coefficients for the 21 new industry sectors in the model. The sum of the coefficients from each sector in the U.S. Absorption table must match the coefficients in the U.S. Absorption Totals table.

U.S. Byproducts

This table contains estimates of the proportions of each commodity that an industry produces. In IO terminology, it is the coefficient form of the Make Table derived by dividing each element by the table row totals. This table contains the value of each good or service produced by each industry. A single industry can produce more than one category of goods and services and this information is contained in the Make Table. For the U.S. Byproducts table, we added the commodity proportions for the 21 industries added to the model. The commodities produced by these industries include the 32 gear and species commodities and the bait commodity.

SACommodity Sales

This table shows sales of commodities by households and institutions in the study area. We assumed that no households or institutions sold any of the 33 commodities that were added. We also assumed that there was no institutional (federal and state governments) production in any of the industries or commodities added to the model and that there would be no inventory additions. The table was modified by adding rows of zeros for the institutions and inventory additions for each of the industries and commodities added.

SAEmployment

This table delineates average annual jobs for each industry in the study area. Jobs are measured in terms of both full-time and part-time workers combined. Employment estimates for all industry categories added to the model were included here.

SAFinal Demands

This table consists of purchases of commodities for final consumption by households and institutions. The objective of modifying this table is to assign final demands for each of the commodities added to the model. This was accomplished by using information about final demand for the default fishing sector contained in IMPLAN. Final demand for the default fishing sector is apportioned among households of different incomes, government entities, and inventory. These are referred to as data type codes in IMPLAN. We assume that the demand for the new species and gear commodities entered into the model will follow the same final demand distribution as the default fishing sector (sector 16). Demand totals for each of the type codes (households earning less than $10,000, $15,000–$25,000, federal nondefense, etc.) are generated by multiplying the proportion of default fishing sector demand (sector 16) attributable to the different types by the total production of the new commodities entered into the model. Since the RPCs for the newly added sectors are set to zero, effectively there is no distribution of fish harvested to the final demand categories in the study area. IMPLAN will fulfill demand with imports to the study area.

SAForeign Exports

This table shows demand made for goods and services by consumers and industries outside the United States. For it we estimated exports of the 32 commodities added to the model by assuming the same proportion of each would be exported as appears for the default fishing sector in IMPLAN.

SAOutput

This table is a vector of output values in millions of dollars that represents an industry's total production. There is a single value for each of the 21 industrial sectors entered into the model.

SAValue Added

This table details payments made and received by each industry to employee compensation (wage and salary payments, insurance, retirement, etc.), proprietary income (all income received), other property type income (payments from interest, rents, royalties, dividends, corporate profits, etc.), and indirect business taxes (primarily excise and sales taxes). The value-added transactions associated with the 21 industrial sectors were added to the table.

Observed RPCs

This table contains forced RPC values for all states in the model. We added the 21 industrial sectors to the table and included a RPC value of 0 for all sectors except the bait sector, which was assigned an RPC of 1. We also added a RPC of 0 for the default IMPLAN fishing sector 16 and default seafood processing sector 71.

RPC Methods

This table contains information for creation of the RPCs. We added each of the newly created industry and commodities to the table, and set the method variable of each added sector to "observed." Additionally, we changed the default seafood processing sector and default fish harvesting sector method from "regress" to "observed."

Deflator1

This table contains deflators that account for relative price changes over time. The IMPLAN deflators are derived from the U.S. Bureau of Labor Statistics Growth Model. The 2006 IMPLAN database contains deflators from 1977 to 2020 for each commodity in the model. We replicated the deflators IMPLAN contains for the default fish harvesting sector for all of the newly created sectors except wholesale seafood dealers, for which we used the deflator for the default wholesale trade sector in IMPLAN.

6. Impact Estimation

6.1. Estimation Procedure

IO-PAC can be used to assess the impact of a given fishery management action when an externally derived, exogenous assessment of how the action will affect the gross output of industries or commodities that are included in the model is available. With an exogenous estimate of the effect of a management action on fish harvest, IO-PAC will estimate the backward-linked impacts of the action on the economy.

Entering an exogenous impact on sales by fish harvesters is the first step in calculating an impact. However, doing so will have no impact on the businesses that rely on the supply of fish as input in production, such as seafood processors. Since the RPC for all fishing related sectors has been set to zero, all supply of fish to these establishments will be sourced from outside the study area in the model. If the backward-linked impact of the fishery management action on seafood processors and wholesale seafood dealers is included, estimated changes in sales for these sectors must also be entered into the model.

With an exogenous estimate of a change in dollar value of sales by harvesters, the estimated change in sales of wholesale seafood dealers in the study area is made by utilizing the product flow and wholesale dealer markup margin assumptions discussed in subsections 4.6 and 4.7 above. It is assumed that 30% of harvested fish in the study area flow to wholesale seafood dealers and that their markup margin is 16%. Because the wholesale seafood dealers are treated as margin sectors, the cost of fish purchased by wholesalers is excluded from estimated sales impacts. If ΔL_k represents the change in total fish landings among vessel classification *(k)* within the study area, then the change in sales for wholesale seafood dealers in the study area (ΔWS) is given by

$$\Delta WS = \left[\frac{\left(\sum_{k}^{K} \Delta L_k \right)(0.3)}{0.84} \right] - \left(\sum_{k}^{K} \Delta L_k \right)(0.3) \qquad (10)$$

Estimated sales changes for seafood processors are made by using product flow and markup margin information contained in IMPLAN for the default seafood processing sector (71). IO-PAC assumes that landings from the fish harvesting sectors that are added to the model flow to seafood processors in the same proportion as the default IMPLAN flow of sales from the default fish harvesting sector (16) to the default processing sector (71). This value can be determined by constructing a default IMPLAN model for the study area of interest, then examining the commodity balance sheet for the default commercial fishing sector. In 2006 the commodity balance sheet indicated that seafood processors purchased approximately 32% of the sales produced by the commercial fishing sector on the West Coast. In IO-PAC it is assumed that seafood processors will purchase the same share of fish landings directly from the harvesting sectors that were created.

Fish landings that are purchased by the processing sector in each study area are converted into revenue changes by applying the margins derived from the production function for processors in the area. For the West Coast, the margin for processors in 2006 was 70%. This value can be determined by constructing a default IMPLAN model for the study area, then examining the industry balance sheet for the default seafood processing sector. These producer values are then entered as the change in direct sales for the seafood processing sector. For each study area, if (*p*) represents the proportion of landings purchased by the default seafood processing sector and (*m*) represents the margin among seafood processors, then the change in sales for seafood processors (Δ*PS*) is given by

$$\Delta PS = \left[\frac{\left(\sum_{k}^{K} \Delta L_k \right)(p)}{(1-m)} \right] \tag{11}$$

The total effect on economic activity in the study area is derived by simultaneously multiplying the estimated exogenous gross output changes for the harvesting sectors, wholesale seafood dealers, and seafood processing sectors by their corresponding model-generated multipliers. This will capture the backward-linked effects associated with a change in commercial fishing harvest within the study area. This is accomplished by entering all three values in the IMPLAN impact analysis window.

6.2. Hypothetical Examples

Two hypothetical reductions in harvest are used to illustrate the outputs produced by IO-PAC. Scenario one will illustrate the impact of a reduction in sales of a particular vessel classification. Scenario two will illustrate the impact of a reduction in sales for a particular commodity (species/gear type).

For scenario one, assume that the fishery management action will result in a $500,000 decline in total ex-vessel West Coast landings for sablefish fixed gear vessels. If $500,000 is the change in total ex-vessel revenue on the West Coast, then the decline in sales of wholesale seafood dealers is $28,571 and the decline in sales for seafood processors is $756,412. All three of these effects are entered on the main impact analysis window in IMPLAN, then the impact results are analyzed. Table 14 displays the resulting effects on total output, income, and employment. The results are aggregated at the two digit NAICS code level for all sectors that were not added to the default IMPLAN model. The added sectors appear individually.

For scenario two, assume that the fishery management action will result in a $500,000 decline in total ex-vessel West Coast landings for sablefish caught using fixed gear. This is the commodity classification, not the vessel classification. Vessels of numerous classifications have sablefish landings while using fixed gear. If $500,000 is the reduction in total ex-vessel revenue of the sablefish fixed gear commodity on the West Coast, then the decline in sales of wholesale

Table 14. Impact of reduced harvest among sablefish fixed gear vessels.

NAICS code and industry	Aggregated output impact report (2009 dollars)			
	Direct	**Indirect**	**Induced**	**Total**
11 Ag, forestry, fish, and hunting	0	–9,189	–4,005	–13,194
21 Mining	0	–2,229	–2,112	–4,341
22 Utilities	0	–8,096	–9,876	–17,972
23 Construction	0	–7,388	–10,325	–17,713
31–33 Manufacturing	–530,932	–38,810	–72,538	–642,279
42 Wholesale trade	0	–93,158	–33,725	–126,883
48–49 Transportation and warehousing	0	–23,552	–15,870	–39,421
44–45 Retail trade	0	–18,719	–65,957	–84,676
51 Information	0	–9,329	–21,692	–31,021
52 Finance and insurance	0	–28,451	–51,503	–79,954
53 Real estate and rental	0	–15,959	–30,963	–46,922
54 Professional-scientific and tech services	0	–30,340	–29,408	–59,748
55 Management of companies	0	–33,378	–7,393	–40,771
56 Administrative and waste services	0	–10,766	–13,325	–24,091
61 Educational services	0	–167	–8,892	–9,059
62 Health and social services	0	–7	–79,517	–79,524
71 Arts-entertainment and recreation	0	–7,256	–8,416	–15,672
72 Accommodation and food services	0	–4,139	-30,893	–35,032
81 Other services	0	–7,053	–23,247	–30,300
92 Government and non-NAICS	0	–5,298	–110,492	–115,790
Sablefish fixed gear	–500,000	0	0	–500,000
Bait ship	0	–22,309	0	–22,309
Wholesale seafood	–28,571	0	0	–28,571
Total	**–1,059,503**	**–375,592**	**–630,148**	**–2,065,243**

seafood dealers and processors is the same as scenario one. All three of these effects are entered on the main impact analysis window in IMPLAN, then the impact results are analyzed. Table 15 displays the resulting effects on total output, income, and employment. The major difference in the two scenarios is that numerous vessel classifications are affected in the commodity run. The effects are still the greatest for vessels classified as sablefish fixed gear because they have the largest landings of this commodity, but sizable effects are also seen for vessels classified as crabbers in the model. Which approach one should use depends on the specifics of the issue being analyzed.

Table 14 continued horizontally. Impact of reduced harvest among sablefish fixed gear vessels.

NAICS code and industry	**Aggregated income impact report (2009 dollars)**			
(column list repeated from previous page)	**Direct**	**Indirect**	**Induced**	**Total**
11 Ag, forestry, fish, and hunting	0	–1,503	–1,417	–2,919
21 Mining	0	–1,160	–1,098	–2,258
22 Utilities	0	–3,613	–5,195	–8,808
23 Construction	0	–3,431	–5,526	–8,957
31–33 Manufacturing	–105,975	–7,276	–16,613	–129,864
42 Wholesale trade	0	–49,052	–17,758	–66,810
48–49 Transportation and warehousing	0	–13,888	–8,489	–22,378
44–45 Retail trade	0	–10,078	–34,885	–44,961
51 Information	0	–4,282	–9,862	–14,144
52 Finance and insurance	0	–16,076	–27,855	–43,930
53 Real estate and rental	0	–8,674	–17,159	–25,833
54 Professional-scientific and tech services	0	–15,844	–16,241	–32,084
55 Management of companies	0	–19,737	–4,371	–24,108
56 Administrative and waste services	0	–6,528	–8,181	–14,710
61 Educational services	0	–95	–5,315	–5,410
62 Health and social services	0	–4	–50,076	–50,080
71 Arts-entertainment and recreation	0	–3,852	–4,693	–8,545
72 Accommodation and food services	0	–2,141	–14,488	–16,628
81 Other services	0	–3,416	–11,813	–15,229
92 Government and non-NAICS	0	–2,797	–89,935	–92,732
Sablefish fixed gear	–356,014	0	0	–356,014
Bait ship	0	-8,709	0	–8,709
Wholesale seafood	–11,828	0	0	–11,828
Total	**–473,817**	**–182,152**	**–350,970**	**–1,006,939**

Table 14 continued horizontally. Impact of reduced harvest among sablefish fixed gear vessels.

NAICS code and industry (column list repeated from previous page)	**Aggregated employment impact report (full and part-time)**			
	Direct	**Indirect**	**Induced**	**Total**
11 Ag, forestry, fish, and hunting	0	–0.2	0	–0.2
21 Mining	0	0	0	0
22 Utilities	0	0	0	0
23 Construction	0	–0.1	–0.1	–0.1
31–33 Manufacturing	–1.7	–0.1	–0.2	–1.9
42 Wholesale trade	0	–0.5	–0.2	–0.6
48–49 Transportation and warehousing	0	–0.2	–0.1	–0.3
44–45 Retail trade	0	–0.2	–0.8	–1.0
51 Information	0	0	–0.1	–0.1
52 Finance and insurance	0	–0.1	–0.2	–0.3
53 Real estate and rental	0	–0.1	–0.2	–0.2
54 Professional-scientific and tech services	0	–0.2	–0.2	–0.4
55 Management of companies	0	–0.1	0	–0.2
56 Administrative and waste services	0	–0.2	–0.2	–0.4
61 Educational services	0	0	–0.2	–0.2
62 Health and social services	0	0	–0.8	–0.8
71 Arts-entertainment and recreation	0	–0.1	–0.1	–0.2
72 Accommodation and food services	0	–0.1	–0.5	–0.5
81 Other services	0	–0.1	–0.4	–0.4
92 Government and non-NAICS	0	0	–0.6	–0.6
Sablefish fixed gear	–14.2	0	0	–14.2
Bait ship	0	0	0	0
Wholesale seafood	–0.2	0	0	–0.2
Total	**–16.1**	**–2.1**	**–4.7**	**–23.0**

Table 15. Impact of reduced sablefish harvest using fixed gear (commodity scenario).

	Aggregated output impact report (2009 dollars)			
NAICS code and industry	**Direct**	**Indirect**	**Induced**	**Total**
11 Ag, forestry, fish, and hunting	0	–9,185	–3,904	–13,089
21 Mining	0	–2,438	–2,061	–4,499
22 Utilities	0	–8,137	–9,634	–17,771
23 Construction	0	–6,999	–10,205	–17,203
31–33 Manufacturing	–530,932	–41,488	–70,745	–643,166
42 Wholesale trade	0	–95,544	–32,872	–128,416
48–49 Transportation and warehousing	0	–23,531	–15,477	–39,008
44–45 Retail trade	0	–20,302	–64,249	–84,551
51 Information	0	–9,437	–21,147	–30,584
52 Finance and insurance	0	–29,431	–50,193	–79,625
53 Real estate and rental	0	–16,116	–30,182	–46,299
54 Professional-scientific and tech services	0	–30,542	–28,696	–59,239
55 Management of companies	0	–33,529	–7,205	–40,734
56 Administrative and waste services	0	–10,877	–13,004	–23,882
61 Educational services	0	–170	–8,663	–8,833
62 Health and social services	0	–7	–77,454	–77,461
71 Arts-entertainment and recreation	0	–7,310	–8,199	–15,508
72 Accommodation and food services	0	–4,170	–30,104	–34,274
81 Other services	0	–7,081	–22,659	–29,739
92 Government and non-NAICS	0	–5,317	–108,418	–113,735
Pacific whiting trawler	–4,428	0	0	–4,428
Large groundfish trawler	–920	0	0	–920
Small groundfish trawler	–1,219	0	0	–1,219
Sablefish fixed gear	–253,732	0	0	–253,732
Other groundfish fixed gear	–21,177	0	0	–21,177
Pelagic netter	–1,302	0	0	–1,302
Migratory liner	–5,266	0	0	–5,266
Shrimper	–721	0	0	–721
Crabber	–182,366	0	0	–182,366
Salmon troller	–10,423	0	0	–10,423
Salmon netter	–369	0	0	–369
Lobster vessel	–565	0	0	–565
Other, more than $15,000	–3,926	0	0	–3,926
Other, less than $15,000	–13,584	0	0	–13,584
Bait ship	0	–18,839	0	–18,839
Wholesale seafood	–28,571	0	0	–28,571
Total	**–1,059,503**	**–380,451**	**–615,073**	**–2,055,027**

Table 15 continued horizontally. Impact of reduced sablefish harvest using fixed gear (commodity scenario).

NAICS code and industry (column list repeated from previous page)	**Aggregated income impact report (2009 dollars)** Direct	Indirect	Induced	Total
11 Ag, forestry, fish and hunting	0	–1,502	–1,381	–2,882
21 Mining	0	–1,269	–1,072	–2,340
22 Utilities	0	–3,632	–5,068	–8,701
23 Construction	0	–3,252	–5,465	–8,718
31–33 Manufacturing	–105,975	–7,629	–16,200	–129,804
42 Wholesale trade	0	–50,309	–17,308	–67,617
48–49 Transportation and warehousing	0	–13,859	–8,280	–22,140
44–45 Retail trade	0	–10,929	–33,981	–44,911
51 Information	0	–4,331	–9,615	–13,946
52 Finance and insurance	0	–16,439	–27,147	–43,586
53 Real estate and rental	0	–8,763	–16,725	–25,488
54 Professional-scientific and tech services	0	–15,954	–15,850	–31,804
55 Management of companies	0	–19,825	–4,260	–24,086
56 Administrative and waste services	0	–6,597	–7,985	–14,583
61 Educational services	0	–97	–5,178	–5,275
62 Health and social services	0	–4	–48,777	–48,781
71 Arts-entertainment and recreation	0	–3,881	–4,572	–8,453
72 Accommodation and food services	0	–2,157	–14,118	–16,274
81 Other services	0	–3,430	–11,514	–14,943
92 Government and non-NAICS	0	–2,809	–88,384	–91,194
Pacific whiting trawler	–2,101	0	0	–2,101
Large groundfish trawler	–442	0	0	–442
Small groundfish trawler	–620	0	0	–620
Sablefish fixed gear	–180,664	0	0	–180,664
Other groundfish fixed gear	–11,028	0	0	–11,028
Pelagic netter	–741	0	0	–741
Migratory liner	–2,997	0	0	–2,997
Shrimper	–411	0	0	–411
Crabber	–122,782	0	0	–122,782
Salmon troller	–4,947	0	0	–4,947
Salmon netter	–210	0	0	–210
Lobster vessel	–322	0	0	–322
Other, more than $15,000	–1,433	0	0	–1,433
Other, less than $15,000	–8,909	0	0	–8,909
Bait ship	0	–7,354	0	–7,354
Wholesale seafood	–11,828	0	0	–11,828
Total	**–455,411**	**–184,024**	**–342,881**	**–982,317**

Table 15 continued horizontally. Impact of reduced sablefish harvest using fixed gear (commodity scenario).

NAICS code and industry (column list repeated from previous page)	**Aggregated employment impact report (full and part-time)**			
	Direct	**Indirect**	**Induced**	**Total**
11 Ag, forestry, fish and hunting	0	–0.2	0	–0.2
21 Mining	0	0	0	0
22 Utilities	0	0	0	0
23 Construction	0	0	–0.1	–0.1
31–33 Manufacturing	–1.7	–0.1	–0.1	–1.9
42 Wholesale trade	0	–0.5	–0.2	–0.6
48–49 Transportation and warehousing	0	–0.2	–0.1	–0.3
44–45 Retail trade	0	–0.2	–0.7	–1.0
51 Information	0	0	–0.1	–0.1
52 Finance and insurance	0	–0.1	–0.2	–0.3
53 Real estate and rental	0	–0.1	–0.1	–0.2
54 Professional-scientific and tech services	0	–0.2	–0.2	–0.4
55 Management of companies	0	–0.1	0	–0.2
56 Administrative and waste services	0	–0.2	–0.2	–0.4
61 Educational services	0	0	–0.1	–0.1
62 Health and social services	0	0	–0.8	–0.8
71 Arts-entertainment and recreation	0	–0.1	–0.1	–0.2
72 Accommodation and food services	0	–0.1	–0.5	–0.5
81 Other services	0	–0.1	–0.4	–0.4
92 Government and non-NAICS	0	0	–0.6	–0.6
Pacific whiting trawler	0	0	0	0
Large groundfish trawler	0	0	0	0
Small groundfish trawler	–0.1	0	0	–0.1
Sablefish fixed gear	–7.2	0	0	–7.2
Other groundfish fixed gear	–0.7	0	0	–0.7
Pelagic netter	0	0	0	0
Migratory liner	–0.2	0	0	–0.2
Shrimper	0	0	0	0
Crabber	–3.8	0	0	–3.8
Salmon troller	–0.8	0	0	–0.8
Salmon netter	0	0	0	0
Lobster vessel	0	0	0	0
Other, more than $15,000	0	0	0	0
Other, less than $15,000	–7.1	0	0	–7.1
Bait ship	0	0	0	0
Wholesale seafood	–0.2	0	0	–0.2
Total	**–21.9**	**–2.2**	**–4.6**	**–28.7**

7. Discussion

IO-PAC is designed to estimate the backward-linked multiplier effects of policy changes that affect gross revenues of commercial fish harvesters, wholesale seafood dealers, and seafood processors. The IO-PAC model is a fisheries-specific IO model in which 19 unique harvesting sectors, one wholesale seafood dealer sector, and one bait sector are incorporated into a customized IMPLAN regional IO model.

IO-PAC is similar in many respects to the NERIOM model developed by Steinback and Thunberg (2006). IO-PAC is incorporated into the ready-made IO IMPLAN system. Building the model directly in IMPLAN permits an analyst to trace the effects with a high level of industry detail and generate disaggregated estimates of indirect and induced multiplier effects. As Steinback and Thunberg (2006) pointed out, this approach differs from the mixed exogenous/endogenous variables models and spreadsheet-type models based on limited IO multipliers. These approaches derive backward linked multiplier effects by aggregating or condensing the same ready-made models. The approach of building the model in IMPLAN will also aid in the construction of a CGE model in the future. Information contained in the underlying SAM in IMPLAN can be used as the starting point for building a CGE model.

The study areas used in IO-PAC are intended to be flexible enough to provide impact estimates for a wide variety of policy situations and analysis goals. It can provide coast-wide, statewide, and port-level impacts. The appropriate study area is dependent on the nature of the policy change, the goals of the analysis, and the resolution of the exogenous changes in fish harvest that are anticipated.

The multiplier effects generated by IO-PAC are static and should be viewed as the immediate/short-term impacts of an analyzed policy change. There are several assumptions built into the model that diminish its accuracy in modeling change over an extended period of time. Underlying assumptions such as fixity of prices and zero-substitution elasticities in consumption and production are more applicable to shorter than longer periods of time. In reality, harvesters, seafood dealers, and seafood processors will all likely shift production practices to mitigate losses from changes in policy that result in reduced harvest, and maximize opportunities from changes in policy that will increase harvest. These longer term behavioral adjustments are not captured in IO-PAC.

IO-PAC does not include impacts beyond seafood wholesalers and processors. It is possible that West Coast restaurants and food service establishments could experience a reduction in local supply because of a restrictive fishery management action. This is likely to be particularly true in isolated port communities that source a high proportion of seafood demand from local producers. Following the approach of Steinback and Thunberg (2006), we assumed that consumers would choose from among the many other close substitutes (e.g., other fish species, poultry, beef, etc.). As a result, retail level gross revenues would remain unchanged.

IO-PAC can accept input data for the years 2006 through 2020. Data contained in IMPLAN are based on economic relationships in 2006; the impacts of management actions in succeeding years are determined by converting the estimated changes in gross revenues to year 2006 dollars before the impacts are estimated. IO-PAC then converts the impact estimates back to the year of the input data (through 2020). This process accounts for the effects of inflation on the impact estimates.

IO-PAC is likely more accurate for estimating impacts resulting from changes in groundfish harvest than other species. Vessels pursuing groundfish are captured in all three NWFSC cost earning surveys, so the production functions for these vessels are likely to be more accurate. However, the cost earnings surveys capture a sizable number of crab vessels and salmon trollers, so IO-PAC is likely to be reasonably accurate for these sectors as well.

There are a few areas where IO-PAC can potentially be improved. First, some simplifying assumptions were made regarding product flow. Because of the assumptions regarding product flow in IO-PAC, it is not set up to capture impacts of sales of seafood by harvesters to wholesalers and processors operating in different port study areas. The effect of excluding these interarea effects is unknown. The greater the cross-hauling of fish landed in one area to other port areas for processing, the greater the error of using the assumption included in IO-PAC. The inclusion of these interarea effects would ideally be accomplished with input from seafood processors and wholesalers about where fish are processed when they are landed in different ports. However, there are other approaches that may be used to include at least some interarea effects. These approaches are being examined and will be included in IO-PAC if they prove worthwhile.

Second, IO-PAC relies on the default IMPLAN production function for seafood processors, which is based on data from the entire United States. The more production practices differ on the West Coast than in the United States as a whole, the more error will result from using this assumption. Future research efforts will attempt to obtain better information about production practices of seafood processors on the West Coast.

Third, IO-PAC relies on economic relationships that existed in 2006; however, technology and prices change at relatively slow rates, so the model can likely be used for subsequent years with minimal error. Fourth, IO-PAC relies on a generic production function for all commercial vessels on the West Coast that are currently not covered by NWFSC cost earnings surveys. As a result, the model is likely to be more accurate for those sectors that have direct survey coverage.

There are several planned improvements to IO-PAC to address these issues, including updating the production functions, adding recreational fisheries, adjusting the product flow assumptions, potentially changing the processor production function, and moving to the newest version of IMPLAN. The production functions included in IO-PAC will be adjusted as data from updated and expanded cost earnings surveys are collected and analyzed. NWFSC recently completed another survey of the limited entry trawl fleet. An expanded open access survey is currently underway. A new limited entry fixed gear survey will be completed in fall 2011. A for-hire recreational fishing sector (charter vessels) will be added to the Oregon and Washington models using data from a survey of for-hire vessels that was completed in 2007. The product flow assumptions and processor production functions will be updated as better data become available. Better data may arise as a result of the mandatory Economic Data Collection, which is part of the Groundfish Trawl Rationalization Catch Share Program. Lastly, a new version of IMPLAN was recently released and IO-PAC will be updated to use the new IMPLAN.

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Appendix A: Bridge between Expenditures and IMPLAN Sectors

Factor expenditures by harvesters and seafood wholesalers were allocated to IMPLAN sectors. The following lists represent the bridge between harvester and seafood wholesaler expenditures and IMPLAN sectors. These allocations often follow the scheme developed by Steinback and Thunberg (2006).

Harvester Expenditures

Fuel and lubricant expenses were allocated based on the IMPLAN default margin table for sector 142 (petroleum refineries).

Sector	Title	Proportion
142	Petroleum refineries	0.393794
390	Wholesale trade	0.361077
392	Rail transportation	0.006754
393	Water transportation	0.005192
394	Truck transportation	0.008658
396	Pipeline transportation	0.004953
407	Gasoline stations	0.219571
	Total	1.000000

Food and beverage expenses were allocated based on the IMPLAN personal consumption expenditure vector 1111. This vector represents the national average expenditure pattern for groceries. However, following the approach of Steinback and Thunberg (2006), purchases associated with the two default seafood sectors (i.e., commercial fishing and seafood product preparation and packaging) were reallocated to sector 60 (frozen food manufacturing), believed to better reflect likely consumption habits aboard commercial fishing vessels.

Sector	Title	Proportion
1	Oilseed farming	6.36E-05
2	Grain farming	0.000379
3	Vegetable and melon farming	0.022642
4	Tree nut farming	0.000749
5	Fruit farming	0.014302
6	Greenhouse and nursery production	0.000652
10	All other crop farming	0.000203
12	Poultry and egg production	0.006205
15	Forest nurseries, forest products, and timber	0.000137
26	Other nonmetallic mineral mining	1E-05
46	Dog and cat food manufacturing	0.016556
47	Other animal food manufacturing	0.002251
48	Flour milling	0.002340

Groceries list continued

Sector	Title	Proportion
49	Rice milling	0.001427
51	Wet corn milling	0.002738
52	Soybean processing	7.65E-05
54	Fats and oils refining and blending	0.004478
55	Breakfast cereal manufacturing	0.016116
56	Sugar manufacturing	0.005154
57	Confectionery manufacturing from cacao beans	0.003429
58	Confectionery manufacturing from purchased chocolate	0.015461
59	Nonchocolate confectionery manufacturing	0.013150
60	Frozen food manufacturing	0.035386
61	Fruit and vegetable canning and drying	0.051314
62	Fluid milk manufacturing	0.040036
63	Creamery butter manufacturing	0.002148
64	Cheese manufacturing	0.014711
65	Dry, condensed, and evaporated dairy products	0.008433
66	Ice cream and frozen dessert manufacturing	0.005012
67	Animal, except poultry, slaughtering	0.057514
68	Meat processed from carcasses	0.054934
70	Poultry processing	0.027721
72	Frozen cakes and other pastries manufacturing	0.005509
73	Bread and bakery product, except frozen, manufacturing	0.046437
74	Cookie and cracker manufacturing	0.016265
75	Mixes and dough made from purchased flour	0.009065
76	Dry pasta manufacturing	0.003576
77	Tortilla manufacturing	0.002269
78	Roasted nuts and peanut butter manufacturing	0.004765
79	Other snack food manufacturing	0.017670
80	Coffee and tea manufacturing	0.012974
81	Flavoring syrup and concentrate manufacturing	0.005455
82	Mayonnaise, dressing, and sauce manufacturing	0.008480
83	Spice and extract manufacturing	0.007112
84	All other food manufacturing	0.018899
85	Soft drink and ice manufacturing	0.060190
171	Other miscellaneous chemical product manufacturing	0.000167
390	Wholesale trade	0.098877
391	Air transportation	0.000487
392	Rail transportation	0.002832
393	Water transportation	0.001729
394	Truck transportation	0.013268
399	Couriers and messengers	0.001554
400	Warehousing and storage	0.000889
402	Furniture and home furnishings stores	9.66E-05
404	Building material and garden supply stores	0.001584
405	Food and beverage stores	0.196583
407	Gasoline stations	0.016591
410	General merchandise stores	0.006296
411	Miscellaneous store retailers	0.008340
500	Noncomparable imports	0.006314
	Total	**1.000000**

Ice expenses were allocated based on the IMPLAN default margin table for sector 85 (soft drink and ice manufacturing).

Sector	Title	Proportion
85	Soft drink and ice manufacturing	0.628331
390	Wholesale trade	0.102750
392	Rail transportation	0.000222
393	Water transportation	3.14E-05
394	Truck transportation	0.006453
405	Food and beverage stores	0.193154
407	Gasoline stations	0.069058
	Total	**1.000000**

Bait expenses were allocated to a fishing bait sector that was created and added to the model. The production function for the bait sector that was created mirrors the production function in the default fishing sector.

Sector	Title	Proportion
16	Fishing	0.001894
43	Maintenance and repair of nonresidential buildings	0.102952
68	Meat processed from carcasses	0.000061
85	Soft drink and ice manufacturing	0.010734
103	Other miscellaneous textile production	0.007470
125	Paper and paperboard mills	0.000970
126	Paperboard container manufacturing	0.000022
129	Coated and laminated paper	0.000017
130	Coated and uncoated paper bag manufacturing	0.000212
131	Die-cut paper office supplies manufacturing	0.000028
132	Envelope manufacturing	0.000016
133	Stationery and related products	0.000067
136	Manifold business forms printing	0.000038
138	Blank-book and loose-leaf binders	0.000006
142	Petroleum refineries	0.022730
145	Petroleum lubricating oil and gas manufacturing	0.047874
163	Soap and other detergent manufacturing	0.000744
164	Polish and other sanitation goods manufacturing	0.000303
170	Photographic film and chemicals	0.000008
172	Plastics, packaging materials	0.001415
177	Plastics, plumbing fixtures	0.000044
179	Tire manufacturing	0.000120
278	AC, refrigeration and forced air	0.000171
325	Electric lamp bulb and part manufacturing	0.000097
333	Electric power and specialty transmission	0.000407
338	Primary battery manufacturing	0.000214
350	Motor vehicle parts manufacturing	0.000715
383	Office supplies except paper manufacturing	0.000027
390	Wholesale trade	0.051741
391	Air transportation	0.000780
392	Rail transportation	0.006179
393	Water transportation	0.008966
394	Truck transportation	0.006553

Default fishing list continued

Sector	Title	Proportion
396	Pipeline transportation	0.000325
397	Scenic and sightseeing transport	0.055514
398	Postal service	0.000641
401	Motor vehicle and parts dealers	0.000350
402	Furniture and home furnishings	0.000083
403	Electronics and appliance stores	0.000100
404	Building material and garden supplies	0.000153
405	Food and beverage stores	0.000257
406	Health and personal care stores	0.000149
407	Gasoline stations	0.000083
408	Clothing and clothing accessory	0.000116
409	Sporting goods, hobby, book stores	0.000042
410	General merchandise stores	0.000265
411	Miscellaneous store retailers	0.000146
412	Nonstore retailers	0.000107
425	Nondepository credit intermediaries	0.000254
426	Securities, commodity contracts	0.002401
427	Insurance carriers	0.009664
430	Monetary authorities and depository institutions	0.005333
431	Real estate	0.000403
432	Automotive equipment rental	0.000259
434	Machinery and equipment rental	0.012181
435	General and consumer goods rental	0.000055
437	Legal services	0.000292
439	Architectural and engineering services	0.000577
445	Environmental and other technical services	0.001204
447	Advertising and related services	0.000650
450	All other miscellaneous professions	0.000424
457	Investigation and security services	0.001708
459	Other support services	0.000468
478	Other amusement, gambling, and recreation industries	0.010884
479	Hotels and motels, including casinos	0.000023
500	Noncomparable imports	0.001524
	Total	**1.000000**

Repair and maintenance expenses for vessel gear and equipment were allocated to sector 357, which includes ship building and repairing.

Sector	Title	Proportion
357	Ship building and repairing	1.00
	Total	**1.00**

Moorage expenses were allocated to sector 478, which includes the activities of marinas. Marinas usually offer mooring, dockage, and haul out services for a fee.

Sector	Title	Proportion
478	Other amusement, gambling, and recreation industries	1.00
	Total	**1.00**

Insurance expenses for vessels were allocated to sector 427, which includes establishments primarily engaged in underwriting and assuming the risk of insurance policies.

Sector	Title	Proportion
427	Insurance carriers	1.00
	Total	**1.00**

Interest and financial services were allocated to sector 430, which includes establishments primarily engaged in financial services.

Sector	Title	Proportion
430	Monetary authorities and depository credit institutions	1.00
	Total	**1.00**

Permit and license fees were allocated to IMPLAN's value-added sector, indirect business taxes. These fees are paid during the normal operation of a business.

Sector	Title	Proportion
Value-added	Indirect business taxes	1.00
	Total	**1.00**

Payments received by vessel owners as income were classified as value-added sector, proprietary income.

Sector	Title	Proportion
Value-added	Proprietary income	1.00
	Total	**1.00**

All other vessel expenditures were allocated according to proportions contained in the production function of the default commercial fishing sector in IMPLAN. This allocation scheme is identical to that developed by Steinback and Thunberg (2006) for the miscellaneous trip supplies cost category in the Northeast Region Commercial Fishing Input-Output Model. They summed the absorption coefficients associated with the manufacturing sectors that produce the commodities used in the commercial fishing production function and allocated the commodity expenditures to the appropriate manufacturing industries. Additionally, their estimates include average wholesale, transportation, and retail margins across all the manufacturing sectors since the majority of these purchases occur at the retail level.

Sector	Title	Proportion
100	Curtain and linen mills	0.008560
103	Other miscellaneous textiles	0.007716
125	Paper and paperboard mills	0.040025
126	Paperboard container manufacturing	0.180838
130	Coated and uncoated paper bag manufacturing	0.023750
163	Soap and other detergent manufacturing	0.047259
164	Polish and other sanitation goods manufacturing	0.040146
172	Plastics packaging materials	0.054372
177	Plastic plumbing fixtures and all other plastics	0.008319
179	Tire manufacturing	0.006631
278	Air conditioning, refrigeration	0.007234
286	Other engine equipment manufacturing	0.074987

Other vessel expenditures list continued

Sector	Title	Proportion
289	Air and gas compressor manufacturing	0.004581
321	Watch, clock, and other measuring and controlling devices	0.007475
325	Electric lamp bulb and part manufacturing	0.012176
333	Electric power and specialty transformer manufacturing	0.005184
338	Primary battery manufacturing	0.010247
350	Motor vehicle parts manufacturing	0.047500
392	Rail transportation	0.001000
390	Wholesale trade	0.161000
404	Building material and gardening supplies	0.001000
405	Food and beverage stores	0.185000
407	Gasoline stations	0.013000
410	General merchandise stores	0.014000
411	Miscellaneous store retailers	0.038000
	Total	**1.000000**

Tax expenditures were allocated to IMPLAN's value-added sector, indirect business taxes. This sector consists of excise taxes, property taxes, and sales taxes, but excludes income taxes paid by businesses.

Sector	Title	Proportion
Value-added	Indirect business taxes	1.00
	Total	**1.00**

Wages and salaries of employees (captain and crew) were allocated to the value-added sector, employee compensation.

Sector	Title	Proportion
Value-added	Employee compensation	1.00
	Total	**1.00**

Vessel residuals were allocated to the value-added sector, proprietary income.

Sector	Title	Proportion
Value-added	Proprietary income	1.00
	Total	**1.00**

Seafood Wholesale Dealer and Processor Expenditures

Wholesale seafood dealers purchase many of the same commodities and services as commercial harvesters. To avoid duplication, detailed descriptions of wholesale dealer expenditures are only provided for products and services not purchased by commercial harvesters.

Advertising fees were allocated to IMPLAN sector 447.

Sector	Title	Proportion
447	Advertising and related services	1.00
	Total	**1.00**

Packaging (boxes) expenses were allocated using the default IMPLAN margin table for sector 126 (paperboard container manufacturing).

Sector	Title	Proportion
126	Paperboard container manufacturing	0.581083
390	Wholesale trade	0.016356
391	Air transportation	0.000463
392	Rail transportation	0.026539
394	Truck transportation	0.130381
411	Miscellaneous store retailers	0.245178
	Total	**1.000000**

Rental payments were allocated to the sector 431, which includes establishments that are primarily engaged in the renting or leasing real estate to others, including the leasing of miniwarehouses and storage buildings.

Sector	Title	Proportion
431	Real estate	1.00
	Total	**1.00**

Building repair and maintenance payments were allocated to sector 458, which includes establishments primarily engaged in cleaning and maintaining building interiors and providing landscape care and maintenance.

Sector	Title	Proportion
458	Services to buildings and dwellings	1.00
	Total	**1.00**

Shipping expenses were allocated to sector 394, comprised of establishments primarily engaged in providing general freight trucking.

Sector	Title	Proportion
394	Truck transportation	1.00
	Total	**1.00**

Storage expenses were allocated to sector 400, comprised of establishments primarily engaged in operating warehousing and storage facilities for general merchandise.

Sector	Title	Proportion
400	Warehousing and storage	1.00
	Total	**1.00**

Electrical utility expenses were allocated to sector 30, comprised of establishments primarily engaged in generating, transmitting, or distributing electric power.

Sector	Title	Proportion
30	Power generation and supply	1.00
	Total	**1.00**

Natural gas utility expenses were allocated to sector 31, comprised of establishments primarily engaged in transmitting and distributing gas to final consumers.

Sector	Title	Proportion
31	Natural gas distribution	1.00
	Total	**1.00**

Telephone utility expenses were allocated to the sector 422, comprised of establishments that are primarily engaged in operating, maintaining, or providing access to facilities for the transmission of voice, data, text, sound, and video.

Sector	Title	Proportion
422	Telecommunications	1.00
	Total	**1.00**

For seafood processor expenditures, the default production function for Sector 71 (seafood product preparation and packaging) was used to allocate purchases by seafood processors. This production function includes more than 140 industry sectors that sell commodities and services to processors.

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