IV. THE CALIFORNIA OCEAN FISH HARVESTER ECONOMIC (COFHE) MODEL

For the second part of this project the economic data collected in part one was used by King and Associates, Incorporated to develop customized input-output models of the California economy, and for coastal regions and counties within California. These models show how each commercial fishing OC is linked with other industries and with households. The models were then used to develop economic "multipliers" that show the "ripple" effects of changes in fisheries and fisheries management decisions on the California economy.

Cost and earnings data from the survey and CDFG landings and revenue data generated during part one of the study were used to develop input-output models with 20 detailed fishery sectors for the state of California, four coastal regions within California, and 22 individual counties that make up those coastal regions. These 27 models, collectively called the California Ocean Fish Harvester Economic (COFHE) Model, were developed by King and Associates, Inc. from a widely used and respected regional economic modeling tool called the IMPLAN (IMpact Analysis for PLANning) system (IMPLAN Group, 2008).

Sections IV.1 to IV.4 below describe how the COFHE model was developed and how it works, provide some representative statistical results, and present several illustrations that demonstrate how model results can be used to assess the direct, indirect, and induced economic impacts of changes in fisheries and fisheries management.

Section **IV.1** includes a brief overview of economic input-output models in general and fishery-related input-output models in particular. This overview will be useful to COFHE Model users who are interested primarily in results (e.g., using multiplier effects or estimating economic impacts of policy options), and need only a general understanding of the type of economic analysis that generated them. This section also provides references to some widely used text books and websites related to input-output models and recent articles that summarize how they have been used in fisheries.

Section **IV.2** describes the development of the COFHE model, defines some terms that are used to present model results (e.g., indirect vs. induced impacts, value added multipliers, etc.), explains what assumptions are imbedded in the model, and provides some guidance regarding the interpretation and use of COFHE model results.

Section **IV.3** presents "look-up" tables of statewide economic multipliers that were generated for each OC using the COFHE model, and describes what various types of multipliers mean and how they should be interpreted. Multiplier tables similar to those presented here for the state are available for each coastal region and each county within these regions. Regional results can be interpreted in the same way as the state results presented in this section. Users of the COFHE model can use the multipliers presented in these tables to assess the economic impacts of many types of fishery management decisions at the state, regional or county scale without the need to work directly with the COFHE model itself.

Section **IV.4** provides illustrations of how to use the economic multipliers generated by the COFHE model to assess the economic impacts of alternative fishery management strategies. However, as fishery management objectives have shifted from conserving fish stocks to restoring depleted fish stocks, it is more likely that users may sometimes want to examine the potential economic impacts of structural changes in a fishery that will change input-output relationships and economic multipliers associated with some OCs. Increasing near-term restrictions on fishing, for example, may result in a predictable short-term decline in earnings in the fishery, and related multiplier impacts associated with some OCs that can be assessed using the "look-up" multiplier tables. However, if such efforts to rebuild fish abundance are successful they will eventually increase fish abundance and, therefore, catch per unit effort, and change associated input-output relationships for some OCs in ways that will eventually increase earnings and result in favorable multiplier impacts.

For this reason, this section provides guidance and illustrations for two distinct types of COFHE model applications, including:

- Typical application where users can use “look-up” tables of economic multipliers to assess and compare relatively short-term economic impacts of changes in fish markets and fishery management without referring directly to underlying COFHE model itself, and
- More complex applications where the sources of the economic impacts under investigation involve long-term structural changes in input-output relationships, for example changes in fish abundance and catch-effort and associated input-output relationships.

The above distinction is important for two reasons. First, multipliers generated by the COFHE model, like the multipliers from all input-output models, are reliable primarily when input-output relationships are relatively stable. In fisheries this means when fish stock abundance, as reflected by catch/effort relationships, is relatively stable so that changes in input purchases (effort) are roughly proportional to changes in output (catch). However, the purpose of fishery management is often to rebuild rather than merely conserve fish stocks. In this case, users of the COFHE model may be interested in the potential long-term economic payoff of expected increases in catch per unit effort (i.e., output per unit input), and how they are expected to result in "non-linear" increases in fishermen’s income and related economic impacts. In these situations, it will be necessary for users to employ the COFHE model directly rather than refer only to "look-up” tables. Users will need to adjust the input-output relationships specified in the COFHE model to reflect expected changes (fewer direct input purchases and more direct household income per unit output) and use the adjusted model to generate new multipliers. In other words, they will need to look at the dynamic aspects of fishery economic impacts by comparing the results of static runs of the COFHE model with current and expected future input/output relationships.

IV.1 The Basics of Input - Output (I/O) Analysis

General Overview of I/O Analysis

Firms in every industry are linked through their purchases and sales with firms in other industries and with households. Inter-industry linkages and the impact of activities in one industry on overall household income, employment, business sales, tax revenues, and other economic conditions are important but not always apparent by examining direct industry statistics. The purpose of an input-output model is to display direct, indirect, and induced economic linkages, and to measure impacts of changes or proposed changes in industrial activity or in government policies that are expected to change industrial activity. **Direct impacts** are associated with the direct purchases of inputs (e.g., labor and intermediate inputs) by an industry to support an increase in industry output. **Indirect impacts** are associated with additional “rounds” of inter-industry purchases and sales that are generated as a result of direct impacts. **Induced**

impacts are from increases in household expenditures that result from increases in household income associated with direct and indirect impacts. The COFHE model is designed to show the economic linkages and impacts of California's commercial fish harvesting industries and how they are affected by changes in fishing regulations.

The theoretical foundation for input-output analysis rests with eighteenth century French economists, but the technique was developed and refined during the 1950's by a Harvard University economist, Wassily Leontief, who won the 1962 Nobel Prize for his work on I/O analysis (summarized in Leontief, 1986). Since then, I/O models that describe economic linkages in national economic systems have been developed routinely by industrialized and developing countries, and are used regularly by government agencies and affected industries to assess the impacts of economic policies and to identify "bottlenecks" in industrial development plans. Special-purpose state and regional I/O models, like the one described here for California fisheries, are also common. These versions are usually designed to show the economic impact of specific industries on specific regional economies, and are used by policy analysts to evaluate economic trade-offs, and to prepare for economic change.

All I/O models are fundamentally the same, but the intended use of the model determines which industrial activities and economic linkages are emphasized. The basic approach is to collect as much purchase and sales information as possible from each industry, describe where each industry buys inputs and sells outputs, and evaluate how changes in one industry or changes in the final demand for the output of one industry will work their way through the economic system. The best way to understand I/O analysis is to consider the inter-industry linkages in a very simple economy.

Illustration of I/O Analysis

Consider a simple regional economy with only three industrial activities which are called Sector A, Sector B, and Sector C. Table 27 describes such an economy by showing the dollar value of transactions among the three industries, and between each of them and households in the region.

Table 27. Illustrative Input-Output Transactions Table (in Millions of Dollars)

	Producing Sector			Consuming Sector		Total Sales
	Industry A	Industry B	Industry C	Exports	Households	
Producing Sector						
Industry A	10	5	3	1	12	**31**
Industry B	3	9	8	1	4	**25**
Industry C	8	4	6	3	3	**24**
Primary Inputs						
Households	4	5	6	0	4	**19**
Imports	6	2	1	0	4	**13**
Total Inputs	**31**	**25**	**24**	**5**	**27**	**112**

Reading down the column for each sector shows the value of goods and services purchased by the sector listed above the columns from each of the sectors listed along the rows. Reading across the row for each sector shows the value of goods and services sold by the sector listed along the row to each of the sectors listed above the columns. Imports, exports, and transactions with households are also shown in the I/O model.

The shaded row shows that during the period under consideration, Sector B sold $3 million to firms in Sector A, $9 million to other firms in Sector B, and $8 million to Sector C. It also shows that Sector B sold $4 million to households and exported $1 million; total sales by Sector B were $25 million.

The shaded column for Sector B shows firms in that sector purchased $5 million from firms in Sector A, $9 million from other firms in Sector B, and $4 million from firms in Sector C. Sector B also purchased $2 million from outside the region (imports) and $5 million from households. In this model some of the $5 million paid to households is in the form of profits (payments to the households that own businesses in the sector) as well as in the form of wages, rents, etc. As a result, the total purchases for Sector B, including purchases from households, are shown here to equal total sales.

Table 27 is referred to as a **Transactions Table** and is the foundation of I/O analysis. It is also a useful starting point for many types of production and marketing studies since it identifies where industries buy and sell and where economic activities are "leaking" outside the region because of imports.

Starting with the Transactions Table, it is simple to develop what is called a **Technical Coefficients Table** which shows the direct dollar purchases which are required from each row sector to support each dollar sales by each column sector.[1] Table 28 shows the technical coefficients derived from Table 27. The numbers in Table 28 show that for each $1 of sales, Sector B purchases $0.20 from Sector A, $0.36 from Sector B, and $0.16 from Sector C. Based on the assumption that an X% increase in the output by a given sector requires an X% increase in the purchase of inputs by that sector, the technical coefficients allows the determination of direct input-output requirements.

Table 28. Illustrative Inter-industry Technical Coefficients Table*

	Industry A	**Industry B**	**Industry C**
Industry A	0.32	0.20	0.13
Industry B	0.10	0.36	0.33
Industry C	0.26	0.16	0.25

* Dollars of direct input purchases from each producing sector listed in the rows by the producing sector listed in the column per dollar of output by the sector listed in the column.

The third table shown, Table 29, is called an **Interdependency Coefficients Table**. It shows the amount of sales generated directly and indirectly in each row sector by each dollar of sales by the column sector. Note from the above illustration that the purchase of $0.16 by Sector B would also call for additional production of $0.04 (.16 x .25) by Sector C as well as $0.05 (.16 x .33) by Sector B, and so on. There are many additional rounds of indirect economic impacts and these are what are reflected in the numbers

[1] In the Technical Coefficients table, the column for each sector represents a linear cost function for that sector, but the columns are often referred to as production functions.

shown in Table 29. The end result of a $1 increase in sales by Sector B is not just a $0.16 increase in sales by Sector C, as shown in Table 28, but a $0.69 increase. Given the input-output relationships in the illustrative economy, Table 29 shows that each $1 of sales by Sector A, B, and C respectively increases total regional economic production by $3.29, $3.45, and $3.42.

Table 29. Illustrative Total Inter-industry Requirements Table*

	Industry A	Industry B	Industry C
Industry A	1.82	0.73	0.64
Industry B	0.69	2.03	1.01
Industry C	0.78	0.69	1.77
Total	**3.29**	**3.45**	**3.42**

* Total local production required by each producing sector listed in the rows to satisfy each dollar of new demand from each producing sector listed in the columns. For purposes of this study, however, we developed interindustry requirement estimates per dollar of direct industry output, not per dollar of new final demand. (See Footnote 2 below)

It is not always necessary to refer directly to the I/O analysis to assess or compare economic impacts because the direct, indirect, and induced economic impacts of changes in industrial activity can be expressed most simply using **Multipliers**. Output Multipliers and Income Multipliers can be developed directly from the Interdependency Coefficients presented in Table 29, and additional employment statistics can be used to estimate Employment Multipliers. In each case, two types of multipliers can be developed: Type I Multipliers show the impact of inter-industry transactions only; Type II Multipliers include those impacts and the effects of transactions on household income and related changes in household spending. Because Type II Multipliers include additional "rounds" of spending by households, they are larger than Type I output, income and employment multipliers. Both types of multipliers are normally presented with the results of an I/O analysis. Because they are simpler to understand and facilitate most useful types of impact assessments, economic multiplier impacts, whether they involve jobs, household income, value added, taxes, or other measures, are often expressed per dollar (or per million dollars) of new final demand, or per dollar (or per million dollars) of direct output.[2] The multipliers developed through the COFHE model are presented per million dollars of direct sector output.

A description of how input-output multipliers can be used and abused is beyond the scope of this paper. However, details are provided in most introductory economic texts and at many university websites (e.g., Raa, 2006). A website at www.math.louisville.edu contains a step-by-step tutorial about input-output analysis and the development and use of regional multipliers.

[2] Because of certain income and production linkages, a $1 increase in the final demand for a sector's output can result in more than a $1 increase in that sector's output. This can affect the estimation of multipliers. In California commercial fisheries, however, this is not the case; changes in output (landings) are usually a result of changes in fishing conditions or fishery policies, and do not influence and are not influenced by changes in consumer demand. The models developed here will also be used most often to examine changes in fishing conditions and policies that constrain fishing sector output. For these reasons, the multipliers estimated in this study are based on changes in sector output, not changes in final demand.

Description of IMPLAN

The particular regional input-output modeling system used to develop the COFHE model is called the IMPLAN system (Minnesota IMPLAN Group, 2008). This system includes state and county I/O models that separate economic activity into 509 industrial sectors, and a set of primary or non-industrial sectors to reflect payments to households, taxes, and so on. IMPLAN was developed during the 1970s by the U.S. Forest Service, but was privatized in 1993 and is now maintained and updated routinely by the Minnesota IMPLAN Group. Customized IMPLAN models are used extensively by federal and state government agencies and industry and trade groups to evaluate all sorts of economic impacts. The Minnesota IMPLAN Group maintains a website and online IMPLAN users forum with an enormous amount of information about I/O models in general, and about IMPLAN in particular (www.IMPLAN.com).

Fishery-related I/O Analysis

I/O models of fisheries can be divided into three categories: those that address commercial fishing, those that address recreational fishing, and those that address both. The COFHE model addresses only commercial fishing.

An extensive review of all fishery-oriented I/O models was prepared in 1986 (Andrews and Rossi, 1986) and a review of all fishery-oriented economic impact models, which included mostly I/O models and some lesser used types of economic impact models, was prepared in 2006 (Seung and Waters, 2006). The following section describes the options for developing regional fishery-oriented I/O models and how King and Associates decided to develop the COFHE model. In general, the approach was to develop the COFHE model in the simplest way possible so that users who have only a basic understanding of I/O analysis will know how economic impacts were generated, and how to modify impact estimates to take account of changes in I/O relationships.

IV.2 Development of the COFHE Model

General Approach

Standard IMPLAN models that include 509 industrial sectors based on the North American Industrial Classification System (NAICS), including one fish harvesting sector (IMPLAN Sector 16), are available for each U.S. state and county.[3] The input-output relationships specified for Sector 16 within the IMPLAN model are based on national average revenues and costs for all vessel and gear types across all types of U.S. fisheries. This is too highly aggregated to reflect input-output relationships associated with the varied and relatively unique types of commercial fishing that takes place in California.

There are two ways to customize IMPLAN applications to estimate economic impacts related to specific regional fisheries. The first and most direct method is to replace Sector 16 with a number of more specific regional fishing sectors (i.e. the 20 OCs). The second method is more complex, less transparent, and involves leaving the IMPLAN model intact, developing sets of final demand changes that reflect the allocation of input purchases by an individual OC, and using the economic impacts generated by those assumed changes in final demand to reflect the economic impact of changes in intermediate input

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[3] NAICS replaced the Standard Industrial Classification (SIC) system in 1997. NAICS is the standard system used by federal agencies in classifying business establishments for the purposes of collecting data related to the US economy. This system was developed in cooperation with Canada and Mexico to allow business statistics to be comparable between countries (http://www.census.gov/eos/www/naics/).

purchases by that particular OC. If the production functions used to reflect the allocation of input purchases per dollar of output using the first method are the same as the entries used to reflect the allocation of "final demand" purchases using the second method, then both approaches, with one simple adjustment to prevent double counting direct industry output, should yield more or less the same results.

Considering the wide range of potential users and uses of the COFHE model, King and Associates decided to keep the specification of the model simple and chose the first approach. The COFHE model was developed, therefore, by replacing Sector 16 of IMPLAN with 20 new sectors that correspond to the 20 OCs described in Part 1.

Once the decision was made to include OCs directly in the inter-industry matrix, there was an additional important choice to be made. One could eliminate Sector 16 and add 20 new fishing sectors to the remaining set of 508 IMPLAN sectors, or one could eliminate Sector 16 and replace it and 19 other existing IMPLAN sectors that are either unimportant in California and/or have no direct, indirect, or induced economic relationship with California fisheries.

For a variety of reasons, including previous experience and advice from IMPLAN staff and other IMPLAN users, the decision was made to replace rather than add IMPLAN sectors. King and Associates simulated a $1 million increase in output in the existing fishing sector (Sector 16) in the state of California IMPLAN model, and selected existing IMPLAN sectors to replace that showed no resulting direct, indirect, or inducted economic impacts (e.g., IMPLAN Sector 7, Tobacco Farming); there were 16 sectors in this category. Three other IMPLAN sectors that had very low (≤ $6) total output impacts resulting from a $1 million simulated increase in fishing output (Sector 16) were also replaced; and the final sector replaced was the existing commercial fishing sector itself (IMPLAN Sector 16). Replacing these twenty IMPLAN sectors which have no link with California fisheries with the 20 new OCs representing fishing sectors will not result in any significant loss of direct, indirect, or induced "rounds" of economic impacts associated with fishing activity. A list of OCs and the IMPLAN sectors they replace is included as Table 30.

Table 30. IMPLAN Sectors Replaced with California Operational Configurations (OCs).

IMPLAN Sector	Sector Description	OC Code	Operational Configuration Name
1	Oilseed farming	1	Trawl - Northern California
7	Tobacco Farming	2	Trawl - Southern California
15	Forest nurseries, forest products, and timber tracts	3	CPS Seine
16	Fishing	4	Herring Gillnet
20	Coal mining	5	Other Gillnet
21	Iron ore mining	6	Salmon
22	Copper, nickel, lead, and zinc mining	7	Salmon & Albacore
24	Stone mining and quarrying	8	Salmon & Dungeness Crab – Small Vessels
29	Support activities for other mining	9	Salmon & Dungeness Crab – Medium and Large Vessels
33	New residential 1-unit structures, non-farm	10	Dungeness Crab - Small Vessels
34	New multifamily housing structures, non-farm	11	Dungeness Crab– Medium and Large Vessels
35	New residential additions and alterations, non-farm	12	Longline
36	New farm housing units, additions, and alterations	13	Harpoon/Spear
37	Manufacturing and industrial buildings	14	Hook & Line
38	Commercial and institutional buildings	15	Hook & Line Live
39	Highway, street, bridge, and tunnel construction	16	Lobster & Crab
40	Water, sewer, and pipeline construction	17	Nearshore & Groundfish Trap
41	Other new construction	18	Prawn Trap
44	Maintenance and repair of highways, streets, and bridges	19	Sea Urchin
52	Soybean processing	20	Tuna/Other Seine

Replacing IMPLAN sectors

The procedure for replacing a sector in IMPLAN is described in the IMPLAN manual and on the IMPLAN website, but essentially involves accessing the IMPLAN model, changing the sector name, editing the study area data to reflect the characteristics of the new sector, and then replacing the production function for the original sector with a new production function based on the new sector.[4]

Calculating production functions for the new OC sectors involved two steps. First, convert the OC expenditure data generated by the survey research described in Part 1 of this report ($ spending by expense category) into input purchase data ($ purchases from specific IMPLAN industrial and value added sectors). Second, for each OC, divide the estimated dollar purchases from each IMPLAN sector by the total value of output (landings value) for that OC.

One adjustment to survey results was necessary to develop the production functions for the OC sectors. Initially, the survey data related to output (landings), costs, and earnings for each fisherman in each OC were combined in the following basic equation:

> Net earnings (profits) = total value of landings (output) - input purchases from all industrial sectors within CA - all purchases outside CA - wages, salaries and other payments to labor - taxes.

However, some fishing operations had such negative profits that the total net earnings for some OCs were negative during 2006. Because I/O models are linear models, leaving negative net earnings for an OC would result in impact estimates showing that an increase in landings by that OC would result in a decrease in net earnings and in related economic impacts. Eliminating those fishermen with negative net revenues on the assumption that they are not representative of long-term operators would have solved the problem, but would have prevented the utilization of a great deal of otherwise useful cost data provided by those fishermen. After considering and testing that option and others, and consulting with other researchers who have experienced similar survey results that reflect temporary economic losses in fisheries, the decision was made to substitute $1 in net earnings for each survey respondent with negative net earnings in a given OC.[5] This resulted in positive net earnings for all OCs and preserved useful cost data obtained from fishermen with negative net revenues without significantly biasing analytical results. However, it did result in fleet-wide output for some OCs in the models being somewhat higher than reported output for those OCs based on CDFG data.

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[4] Within the context of input-output models a set of gross absorption coefficients that show the input purchases from various row sectors per dollar of output by a column sector represents a cost function. Because COFHE models are regional, however, "regional absorption coefficients" are used which show purchases within the region from various row sectors per dollar of output by a column sector; and purchases from outside the region from any sector are lumped together in a separate row sector called "imports." The technical coefficients in these regional models, therefore, reflect only regional purchases of inputs per $1 of sector output and do not represent "cost functions."

[5] The other option considered here involved discarding survey results from fishermen reporting negative income. NOAA economists constructing similar models encountered similar problems. The authors agreed with their conclusion that the survey data regarding the distribution of input costs from these fishermen are valid and important and should not be discarded. The approach used, which makes use of these cost data, was preferable to ignoring these survey results. Trial model runs comparing multiplier and impact estimates using survey results that include and exclude responses from fishermen reporting negative earnings showed minimal differences in estimated economic impacts.

Replacing negative earnings with $1 in positive earnings resulted in somewhat higher overall earnings for some OCs, and required that the control totals (landings values) for those OCs be increased by a comparable amount so that the technical coefficients used to describe the allocation of input purchases summed to one. However, in order to keep the total output statistics in the COFHE model consistent with the CDFG statistics, King and Associates used the production functions developed using the adjusted survey results with the CDFG control totals for each OC to develop a revised transactions table.[6]

Generating Study Area Data

Study area data consist of output, value added and employment.[7] The output and employment data for each OC in each study area were derived directly from CDFG landings data. Statewide value added was calculated by multiplying the coefficient of each value added component by the statewide landings value (output) for each OC.[8]

Output for each OC in each region and county had already been derived during Part 1 (Table 6) from CDFG landings data. Value added information for each county was calculated by multiplying the statewide value added coefficients by county-specific OC output. Jobs/output was calculated on a statewide basis for each OC and then multiplied by the county-specific OC output to estimate the number of jobs per OC in each county. To generate study area data for the regional versions of the COFHE model, output, employment, and value added information were summed for each county within the region.

COFHE Model Construction

Once the background study area data calculations were complete, King and Associates created new IMPLAN models for the state and each county and region that included the 20 new sectors representing the 20 OCs. The assumption was made that each OC in each county and region in the state has the same production and cost functions (input-output relationships) but may have very different regional spending patterns. Prior to any model construction, the production functions for all OCs were saved to the "production function library" within IMPLAN. Then, models for each of the 27 study areas (22 California counties, four California regions, and the state) were constructed using the following steps:

1. A new model was created for each study area.
2. The Access version of the model was opened, and the “Industry/Commodity Codes” and “Type Codes” tables were replaced with tables that contained the names of the new sectors substituted for the original IMPLAN sectors.
3. The study area data (value added, employment and output) for each new sector/OC was manually entered, overwriting existing data for the sector being replaced. When an OC did not exist in a given study area, existing values in the sector being replaced were zeroed out.
4. Social accounts were created.

[6] The coefficients and multiplier impacts per dollar change in OC output are the same regardless of the OC control total. This adjustment was made only to make the numbers in various tables match and avoid confusion.
[7] In IMPLAN, employment refers to the total number of jobs (full and part-time), not full-time equivalents. Many California fishermen work part-time in multiple fisheries. Therefore, the sum of employment (full and part time jobs) across fisheries in California is greater than the number of fishermen participating in California fisheries.
[8] The four components of value added are employee compensation, proprietor’s income, other property income, and indirect business tax.

5. Using the “edit production function” tool, the production functions were retrieved for each OC from the library, and the “Balance Value Added” option was selected.
6. Social accounts were then rerun.
7. Using the “edit byproducts” tool, byproducts were edited because a number of the sectors that were replaced produce multiple commodities.[9] Byproducts were manually edited so that each of the new fishing sectors only produced one commodity (i.e., the target of the OC).
8. Social accounts were rerun a final time, and the final model was constructed with Type II multipliers.

IV.3 Results from the COFHE Model

Statewide COFHE Multipliers
This section contains tables of economic impact coefficients and multipliers generated for the state of California using the COFHE model. Table 31 through Table 37 show the statewide direct, indirect, induced and total economic impacts of a $1 change in output (landings) in each OC on the following: Output (Table 31), Value Added (Table 32), Labor Income (Table 33), Employee Compensation (Table 34), Proprietor’s Income (Table 35), Other Property Income (Table 36), and Indirect Business Taxes (Table 37). Table 38 shows Employment impacts of a $1 million dollar change in output for each OC. Table 39 defines the terms that are used to describe various types of economic impacts in these tables. As discussed elsewhere, these multiplier impacts are estimated per dollar of direct output for each OC, and not per dollar of new final demand for the output of each OC. Further explanations are provided in the following sections.

Regional and County COFHE Multipliers
Sets of multipliers with the same definitions and characteristics as the statewide multipliers shown in Tables 31 through 38 are available for each of the four regions and 22 counties that are included in the COFHE model. These are available electronically at the CDFG website (http://www.dfg.ca.gov/marine/) and can be used as described above to determine the impacts of federal, state, regional, and county fishery management policies on regional or county economies. Economic impacts estimated at various scales are "nested" in the sense that statewide impacts are distributed among regions, and regional impacts are distributed among counties within each region. Differences between impacts in the state and in any particular region accrue to other regions as reflected in the tables for those regions. Those impacts that do not accrue to any of the four coastal regions, but are shown to accrue in the state, impact "the rest of the state".

Use of COFHE Multipliers
In general, using these multipliers to estimate statewide economic impacts of changes in fishery management policies involves three steps. First, estimate how the policy change is expected to affect the landings of each OC. Second, multiply those direct changes in the value of OC landings by the appropriate multipliers from these tables to estimate the economic impacts of policy changes related to each OC. Third, add the economic impacts associated with all OCs in the study area of interest (e.g., the

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[9] For example, the industry Soybean Processing (sector 52) was replaced with Tuna Seiners (OC 20). Soybean Processing produces commodities in soybean processing (88.5%), flour milling (1.2%), and fats and oils refining and blending (10.3%). Editing the byproducts meant deleting the latter two byproducts described above so that everything produced by the “new” industry is in sector 52.

state or San Diego County) to determine the overall economic impacts of the policy changes in that study area.

Background Data and Documentation

The Transactions, Technical Coefficients (production functions), and Inter-industry Interdependence Tables that form the basis of the 27 I/O models that make up the COFHE model include well over 500 rows and 500 columns each. Since these will be of little interest to the general user of the COFHE model and would take up many pages, they are not included here. Interested readers can contact CDFG to obtain electronic copies of these underlying Input-Output tables.

Special Case Applications

The look-up tables described and illustrated below (Tables 31 through 38) are used in the most typical situation where economic impacts are being assessed under conditions where fish stock abundance is relatively stable, and a change in landed value is associated with a proportional change in fishing effort and associated input purchases. This "typical" situation is described more fully in the following section as part of Illustration 1.

In some situations, however, landing values for an OC may change as a result of changes in fish abundance, for example as a result of a successful fish stock rebuilding program, with no corresponding change in fishing effort or associated fishing costs. Economic impacts in this case are associated with changes in fishermen income (proprietor's income), not changes in fishing input purchases. Because changes in fish abundance do not necessarily change the level of fishing effort or associated input purchases, in other words, their impacts, somewhat surprisingly, can be estimated without ever referring to the economic multipliers developed for any particular OC. Assessing economic impacts of changes in fish abundance when there is no associated change in fishing effort requires information only about how the change in fish abundance affects fishermen's income and the indirect and induced economic impacts of changes in fishermen's income.

Table 31. Direct, Indirect, and Induced Output Multipliers for the State of California

California State Model
Output Effects (per $1 of Sector Output)

		Output			
Sector #	**Industry**	**Direct Effects**	**Indirect Effects**	**Induced Effects**	**Total Effects**
1	Trawl - Northern California	1.000000	0.157398	0.761073	1.918471
7	Trawl - Southern California	1.000000	0.478548	0.621735	2.100284
15	CPS Seine	1.000000	0.104635	0.839207	1.943841
16	Herring Gillnet	1.000000	0.501883	0.272540	1.774423
20	Other Gillnet	1.000000	0.560064	0.516185	2.076249
21	Salmon	1.000000	0.647435	0.346116	1.993551
22	Salmon & Albacore	1.000000	0.595575	0.360100	1.955675
24	Salmon & Dungeness Crab – Small Vessels	1.000000	0.557012	0.481445	2.038457
29	Salmon & Dungeness Crab – Medium and Large Vessels	1.000000	0.344622	0.650989	1.995611
33	Dungeness Crab - Small Vessels	1.000000	0.413674	0.564044	1.977718
34	Dungeness Crab– Medium and Large Vessels	1.000000	0.187314	0.746530	1.933843
35	Longline	1.000000	0.308046	0.665408	1.973454
36	Harpoon/Spear	1.000000	0.460222	0.526523	1.986745
37	Hook & Line	1.000000	0.669752	0.357249	2.027002
38	Hook & Line Live	1.000000	0.605724	0.409830	2.015554
39	Lobster & Crab	1.000000	0.446213	0.566867	2.013080
40	Nearshore & Groundfish Trap	1.000000	0.548300	0.414999	1.963299
41	Prawn Trap	1.000000	0.261228	0.682268	1.943496
44	Sea Urchin	1.000000	0.504400	0.478604	1.983003
52	Tuna/Other Seine	1.000000	0.070415	0.914868	1.985283

Table 32. Direct, Indirect, and Induced Value Added Multipliers for the State of California

California State Model
Total Value Added Effects (per $1 of Sector Output)

		Total Value Added			
Sector #	**Industry**	**Direct Effects**	**Indirect Effects**	**Induced Effects**	**Total Effects**
1	Trawl - Northern California	0.764204	0.084599	0.451283	1.300086
7	Trawl - Southern California	0.510777	0.267401	0.368662	1.146840
15	CPS Seine	0.860317	0.056494	0.497613	1.414424
16	Herring Gillnet	0.249737	0.269352	0.161605	0.680694
20	Other Gillnet	0.402773	0.312742	0.306075	1.021591
21	Salmon	0.251005	0.342667	0.205232	0.798904
22	Salmon & Albacore	0.299564	0.317323	0.213523	0.830411
24	Salmon & Dungeness Crab – Small Vessels	0.383775	0.282440	0.285476	0.951690
29	Salmon & Dungeness Crab – Medium and Large Vessels	0.611761	0.182054	0.386008	1.179823
33	Dungeness Crab - Small Vessels	0.509415	0.218209	0.334454	1.062077
34	Dungeness Crab– Medium and Large Vessels	0.748767	0.098030	0.442660	1.289456
35	Longline	0.631739	0.160222	0.394558	1.186519
36	Harpoon/Spear	0.466397	0.244188	0.312205	1.022790
37	Hook & Line	0.250079	0.351421	0.211833	0.813333
38	Hook & Line Live	0.311459	0.311089	0.243011	0.865559
39	Lobster & Crab	0.489494	0.235907	0.336127	1.061528
40	Nearshore & Groundfish Trap	0.348464	0.281544	0.246076	0.876085
41	Prawn Trap	0.689703	0.131223	0.404555	1.225481
44	Sea Urchin	0.422830	0.264557	0.283791	0.971178
52	Tuna/Other Seine	0.904620	0.038471	0.542477	1.485567

Table 33. Direct, Indirect, and Induced Labor Income Multipliers for the State of California

California State Model
Labor Income Effects (per $1 of Sector Output)

		Labor Income			
Sector #	**Industry**	**Direct Effects**	**Indirect Effects**	**Induced Effects**	**Total Effects**
1	Trawl - Northern California	0.685245	0.051253	0.248637	0.985135
7	Trawl - Southern California	0.440568	0.161092	0.203116	0.804776
15	CPS Seine	0.777720	0.034389	0.274162	1.086271
16	Herring Gillnet	0.099689	0.164051	0.089037	0.352777
20	Other Gillnet	0.310947	0.188571	0.168634	0.668152
21	Salmon	0.125703	0.209237	0.113073	0.448014
22	Salmon & Albacore	0.155229	0.193243	0.117642	0.466114
24	Salmon & Dungeness Crab – Small Vessels	0.296861	0.169038	0.157284	0.623183
29	Salmon & Dungeness Crab – Medium and Large Vessels	0.518544	0.111424	0.212673	0.842641
33	Dungeness Crab - Small Vessels	0.413527	0.132304	0.184269	0.730100
34	Dungeness Crab– Medium and Large Vessels	0.662628	0.059797	0.243885	0.966310
35	Longline	0.546699	0.097223	0.217384	0.861306
36	Harpoon/Spear	0.361229	0.148292	0.172011	0.681532
37	Hook & Line	0.131537	0.214177	0.116711	0.462424
38	Hook & Line Live	0.206153	0.190443	0.133888	0.530484
39	Lobster & Crab	0.404686	0.143877	0.185191	0.733754
40	Nearshore & Groundfish Trap	0.228287	0.173312	0.135577	0.537176
41	Prawn Trap	0.579095	0.081142	0.222892	0.883129
44	Sea Urchin	0.303328	0.159822	0.156356	0.619506
52	Tuna/Other Seine	0.862077	0.023249	0.298880	1.184207

Table 34. Direct, Indirect, and Induced Employee Compensation Multipliers for the State of California

California State Model
Employee Compensation Effects (per $1 of Sector Output)

		Employee Compensation			
Sector #	**Industry**	**Direct Effects**	**Indirect Effects**	**Induced Effects**	**Total Effects**
1	Trawl - Northern California	0.175501	0.043792	0.213403	0.432695
7	Trawl - Southern California	0.144826	0.141886	0.174333	0.461045
15	CPS Seine	0.081214	0.029457	0.235311	0.345982
16	Herring Gillnet	0.072453	0.140931	0.076420	0.289804
20	Other Gillnet	0.072527	0.165243	0.144737	0.382507
21	Salmon	0.068214	0.180553	0.097050	0.345817
22	Salmon & Albacore	0.073728	0.165847	0.100971	0.340546
24	Salmon & Dungeness Crab – Small Vessels	0.161357	0.143923	0.134996	0.440275
29	Salmon & Dungeness Crab – Medium and Large Vessels	0.094073	0.095666	0.182536	0.372275
33	Dungeness Crab - Small Vessels	0.141552	0.114774	0.158157	0.414483
34	Dungeness Crab– Medium and Large Vessels	0.125116	0.051320	0.209325	0.385761
35	Longline	0.232770	0.083050	0.186579	0.502399
36	Harpoon/Spear	0.053918	0.126580	0.147636	0.328133
37	Hook & Line	0.097877	0.185017	0.100172	0.383066
38	Hook & Line Live	0.079168	0.164052	0.114915	0.358135
39	Lobster & Crab	0.062198	0.125286	0.158948	0.346432
40	Nearshore & Groundfish Trap	0.089179	0.149368	0.116365	0.354912
41	Prawn Trap	0.070849	0.069940	0.191306	0.332095
44	Sea Urchin	0.082279	0.137109	0.134199	0.353587
52	Tuna/Other Seine	0.060606	0.019900	0.256527	0.337033

Table 35. Direct, Indirect, and Induced Proprietor's Income Multipliers for the State of California

California State Model
Proprietor's Income Effects (per $1 of Sector Output)

		Proprietor's Income			
Sector #	**Industry**	**Direct Effects**	**Indirect Effects**	**Induced Effects**	**Total Effects**
1	Trawl - Northern California	0.509744	0.007461	0.035234	0.552439
7	Trawl - Southern California	0.295741	0.019206	0.028783	0.343730
15	CPS Seine	0.696506	0.004932	0.038851	0.740289
16	Herring Gillnet	0.027237	0.023119	0.012617	0.062973
20	Other Gillnet	0.238421	0.023328	0.023897	0.285645
21	Salmon	0.057489	0.028684	0.016023	0.102197
22	Salmon & Albacore	0.081501	0.027396	0.016671	0.125568
24	Salmon & Dungeness Crab – Small Vessels	0.135504	0.025115	0.022288	0.182908
29	Salmon & Dungeness Crab – Medium and Large Vessels	0.424472	0.015758	0.030137	0.470367
33	Dungeness Crab - Small Vessels	0.271975	0.017530	0.026112	0.315617
34	Dungeness Crab– Medium and Large Vessels	0.537512	0.008477	0.034560	0.580549
35	Longline	0.313929	0.014173	0.030805	0.358907
36	Harpoon/Spear	0.307311	0.021712	0.024375	0.353399
37	Hook & Line	0.033660	0.029160	0.016539	0.079359
38	Hook & Line Live	0.126985	0.026391	0.018973	0.172349
39	Lobster & Crab	0.342487	0.018591	0.026243	0.387322
40	Nearshore & Groundfish Trap	0.139108	0.023944	0.019212	0.182264
41	Prawn Trap	0.508246	0.011202	0.031585	0.551034
44	Sea Urchin	0.221049	0.022713	0.022157	0.265919
52	Tuna/Other Seine	0.801471	0.003349	0.042354	0.847174

Table 36. Direct, Indirect, and Induced Other Property Income Multipliers for the State of California

California State Model
Other Property Type Income Effects (per $1 of Sector Output)

		Other Property Type Income			
Sector #	**Industry**	**Direct Effects**	**Indirect Effects**	**Induced Effects**	**Total Effects**
1	Trawl - Northern California	0.022077	0.021635	0.157882	0.201594
7	Trawl - Southern California	0.019136	0.073057	0.128977	0.221170
15	CPS Seine	0.014140	0.014571	0.174091	0.202802
16	Herring Gillnet	0.054317	0.069800	0.056538	0.180655
20	Other Gillnet	0.036513	0.085147	0.107081	0.228741
21	Salmon	0.051219	0.088314	0.071801	0.211334
22	Salmon & Albacore	0.067683	0.081709	0.074702	0.224093
24	Salmon & Dungeness Crab – Small Vessels	0.006076	0.075644	0.099874	0.181594
29	Salmon & Dungeness Crab – Medium and Large Vessels	0.029530	0.046292	0.135046	0.210868
33	Dungeness Crab - Small Vessels	0.012119	0.058215	0.117009	0.187344
34	Dungeness Crab– Medium and Large Vessels	0.018486	0.025351	0.154866	0.198703
35	Longline	0.025421	0.041411	0.138037	0.204869
36	Harpoon/Spear	0.052609	0.062383	0.109226	0.224218
37	Hook & Line	0.030699	0.092297	0.074110	0.197107
38	Hook & Line Live	0.029802	0.079893	0.085018	0.194713
39	Lobster & Crab	0.017751	0.061836	0.117595	0.197182
40	Nearshore & Groundfish Trap	0.039265	0.070962	0.086090	0.196318
41	Prawn Trap	0.019636	0.032755	0.141534	0.193925
44	Sea Urchin	0.029189	0.069926	0.099285	0.198399
52	Tuna/Other Seine	0.012059	0.009901	0.189787	0.211747

Table 37. Direct, Indirect, and Induced Indirect Business Taxes Multipliers for the State of California

California State Model
Indirect Business Taxes Effects (per $1 of Sector Output)

		Indirect Business Taxes			
Sector #	**Industry**	**Direct Effects**	**Indirect Effects**	**Induced Effects**	**Total Effects**
1	Trawl - Northern California	0.056882	0.011711	0.044764	0.113357
7	Trawl - Southern California	0.051073	0.033252	0.036569	0.120894
15	CPS Seine	0.068457	0.007534	0.049360	0.125351
16	Herring Gillnet	0.095731	0.035501	0.016030	0.147262
20	Other Gillnet	0.055313	0.039025	0.030360	0.124699
21	Salmon	0.074083	0.045116	0.020358	0.139557
22	Salmon & Albacore	0.076653	0.042372	0.021180	0.140204
24	Salmon & Dungeness Crab – Small Vessels	0.080838	0.037758	0.028317	0.146913
29	Salmon & Dungeness Crab – Medium and Large Vessels	0.063687	0.024338	0.038289	0.126314
33	Dungeness Crab - Small Vessels	0.083768	0.027689	0.033175	0.144633
34	Dungeness Crab– Medium and Large Vessels	0.067654	0.012881	0.043909	0.124443
35	Longline	0.059619	0.021587	0.039137	0.120344
36	Harpoon/Spear	0.052559	0.033512	0.030968	0.117040
37	Hook & Line	0.087843	0.044947	0.021012	0.153802
38	Hook & Line Live	0.075504	0.040754	0.024105	0.140362
39	Lobster & Crab	0.067057	0.030193	0.033341	0.130592
40	Nearshore & Groundfish Trap	0.080912	0.037270	0.024409	0.142591
41	Prawn Trap	0.090972	0.017326	0.040129	0.148427
44	Sea Urchin	0.090314	0.034809	0.028150	0.153273
52	Tuna/Other Seine	0.030483	0.005320	0.053810	0.089614

Table 38. Direct, Indirect, and Induced Employment Multipliers for the State of California

California State Model
Employment Effects (per $million of Sector Output)

		Employment			
Sector #	**Industry**	**Direct Effects**	**Indirect Effects**	**Induced Effects**	**Total Effects**
1	Trawl - Northern California	8.736587	0.996073	5.598445	15.331105
7	Trawl - Southern California	29.969845	4.020573	4.573479	38.563897
15	CPS Seine	4.215650	0.681394	6.173195	11.070240
16	Herring Gillnet	213.002518	3.315430	2.004805	218.322752
20	Other Gillnet	23.663147	4.527082	3.797056	31.987285
21	Salmon	120.899811	4.272575	2.546027	127.718413
22	Salmon & Albacore	110.634270	3.787865	2.648888	117.071023
24	Salmon & Dungeness Crab – Small Vessels	43.211334	3.387939	3.541502	50.140776
29	Salmon & Dungeness Crab – Medium and Large Vessels	13.202336	2.210238	4.788669	20.201242
33	Dungeness Crab - Small Vessels	43.290043	2.724747	4.149105	50.163895
34	Dungeness Crab– Medium and Large Vessels	8.422259	1.159816	5.491467	15.073542
35	Longline	38.488274	1.914074	4.894737	45.297085
36	Harpoon/Spear	40.368099	2.938477	3.873095	47.179671
37	Hook & Line	432.529633	4.592621	2.627923	439.750176
38	Hook & Line Live	151.975250	3.903198	3.014702	158.893151
39	Lobster & Crab	21.578495	3.105995	4.169867	28.854357
40	Nearshore & Groundfish Trap	81.911232	3.455154	3.052729	88.419115
41	Prawn Trap	9.256892	1.550592	5.018754	15.826239
44	Sea Urchin	38.070057	3.253822	3.520605	44.844484
52	Tuna/Other Seine	8.540385	0.445111	6.729758	15.715254

Table 39. Definitions of Terms Included in Tables 31 through 38*

IMPLAN Term	Definition
Direct Effects	The impacts associated with the direct purchases of inputs (e.g., labor and intermediate inputs) by an industry to support a $ 1 increase in industry output.
Indirect Effects	The impacts associated with additional "rounds" of inter-industry purchases and sales that are generated as a result of direct impacts. Indirect impacts include the direct impacts of purchases of inputs (e.g., labor and intermediate inputs) by industries that sell to the industry responsible for the direct impacts, and by the industries that sell to those industries, and so on.
Induced Effects	The impacts associated with increases in household expenditures that result from increases in household income associated with direct and indirect impacts. The inclusion of induced impacts based on "income effects" is what distinguishes Type II multiplier Effects from Type I multiplier effects.
Total Effects	The total of all direct, indirect, induced impacts.
Industry Output	Total industry production, equal to shipments plus net additions to inventory.
Employment	Annual average number of full and part-time jobs, including self-employed individuals.
Employee Compensation	Total payroll costs, including wages and salaries plus benefits.
Indirect Business Tax	Sales, excise fees, licenses and other taxes paid during normal operation. This includes all payments to the government except for taxes based on income.
Labor Income	Sum of Employee Compensation and Proprietor's Income
Other Property Income	Includes corporate income, rental income, interest and corporate transfer payments.
Proprietor Income	Income from self-employment.
Total Value Added	The value added during production to all purchased intermediate goods and services. This is equal to employee compensation plus proprietor's income plus other property income plus indirect business taxes.

*Source: Adapted from IMPLAN User Guide, Version 2.0

IV.4 Illustrations of the Use of Economic Multipliers

Background

The COFHE model will be used most often to assess and compare state, regional, or county-level economic impacts of changes in fishing regulations. In most cases this can be accomplished using the multiplier tables developed from the COFHE model without using the COFHE model directly, as described in section IV.3. However, there are occasions where new fishing restrictions are expected to result in negative short term economic impacts; but to result, eventually, in long term improvements in fishing conditions, higher fishermen earnings, and positive long term economic impacts. There may be occasions, in other words, when it will be useful to compare the negative short-term economic impacts that must be endured to achieve fish stock rebuilding targets with the potential positive economic impacts of achieving them.

This section provides three illustrations of how the COFHE model can be used to examine the costs and benefits of fishery management strategies. In each case, the illustrations are limited to showing expected changes in annual economic impacts associated with a hypothetical OC with no accounting for time (e.g., how many years a restriction might be in place or how many years it might take for stocks to rebuild) or risk (e.g., the likelihood that fishing restrictions may adversely affect markets or that stock rebuilding will not succeed.)

The use of the COFHE model becomes increasingly complicated as the types of changes in the fishery that are being addressed become sophisticated. The following three illustrations show progressively more complex applications. Illustration 1 is the most simple and most typical application where the model is used to show the near-term costs and adverse economic impacts of new fishing regulations that restrict the allowable harvest or limit fishing effort.

Illustration 2 is more complicated and shows how the model might be used to measure future benefits and positive economic impacts of fishing restrictions if they succeed at increasing stock abundance resulting in more revenues and fishermen earnings per unit fishing effort. Illustration 3 is the most complicated and shows how the model might be used to estimate future benefits and positive economic impacts of current fishing restrictions if they both increase stock abundance and result in a greater allowable harvest. Attempting the types of analysis shown in Illustrations 2 and 3 will require more advanced understanding of both input-output modeling and fishery economics than the simple application shown in Illustration 1. Illustrations 2 and 3 are therefore written for analysts with more advanced training in IMPLAN modeling.

Illustration 1: Near-term economic impacts of changes in fishery regulations

Based on legal mandates and the advice of scientists to restore fish stocks, suppose that fishery managers decide they need to reduce the allowable annual commercial harvest of a particular OC by 500,000 pounds. Fishery managers reduce days-at-sea limits for the OC to levels they expect will reduce OC landing by 500,000 pounds. The planner for San Diego County is interested in determining what impact this is likely to have on the county’s economy to determine if the county should take any action to mitigate local economic hardships or apply for federal assistance.

Using the COFHE Model (for illustration purposes only)

Using the results of the COFHE model to assess near-term economic impacts of changes in a fishing restriction, which reduces an OC's output by limiting days at sea or the allowable harvest, involves a three step process:

1. Determine how the change is expected to increase or decrease the expected value of landings by one or more of the 20 OCs.
2. Identify the study area of interest. Within the COFHE model, this can be specified as the state of California, one or more of four regions within the state, one or more counties within those regions, or any combination.
3. Find the multipliers of interest for each OC identified in Step 1 in the COFHE multiplier tables that correspond with the study area of interest identified in Step 2, and multiply the expected direct change in landed value by each OC identified in Step 1 by the appropriate impact effect coefficients from the appropriate look-up tables.

The San Diego County planner in this illustration would thus take the following steps:

Step 1

Assuming 2006 ex-vessel fish prices of $1.50/pound, the 500,000 pound reduction in landings will reduce the statewide landed value (output) of the OC by $750,000.

Step 2

San Diego County includes home ports for roughly 50% of vessels in the OC, and landings in the county usually account for 50% of statewide landings by the OC. Based on the results of Step 1 the county planner estimates that output (landings) by this OC in the county will go down by $375,000 (50% of $750,000).

Step 3

The planner refers to the multiplier tables from the San Diego County version of the COFHE model (Table 40) and multiplies the "effects coefficients" that represent the direct, indirect, induced, and total effects per $1 in landed value for the OC in that county by the expected $375,000 decline in OC landings in the county.

The results of Step 3 show the total (direct, indirect, and induced) economic impacts of this change in fishing regulations on the San Diego County economy, as illustrated in Table 41.

Table 40. Direct, Indirect, Induced, and Total effects per $1 output (For Illustration # 1)

Impact Type	Direct	Indirect	Induced	Total
Output (per $1 direct output)	1.000000	0.308046	0.665408	1.973454
Value Added (per $1 direct output)	0.631739	0.160222	0.394558	1.186519

Table 41. Economic Impacts of Proposed Reductions in Allowable Days at Sea Limits for an OC (For Illustration # 1)

Impact Type	Direct	Indirect	Induced	Total
Output	-$375,000	-$115,517	-$249,528	-$740,045
Value Added	-$236,902	-$60,083	-$147,959	-$444,945

Illustration 2: Potential Year 5 Economic Benefits of current Catch or Effort Restrictions

Proposed gear restrictions that are expected to reduce the harvest of a particular OC are being challenged by some state political leaders because of the negative short term economic impacts they will have on fishing industries. Fishery managers argue that accepting these fishing restrictions now will result in a 10% increase in fish stock abundance within five years, and increase fishermen incomes enough to justify the near-term sacrifice. To support their position they are interested in an analysis that provides numerical estimates of the economic impacts of increasing stock abundance by 10%.

Fishing effort is a commonly used index of the amount of input used in fishing, and catch per unit effort (CPUE) is a commonly used index of fish abundance. For purposes of this analysis, therefore, 10% higher stock abundance corresponds with a 10% increase in CPUE. If fishing effort and costs are assumed to be constant the only direct effect of a 10% increase in CPUE is a 10% increase in the value of landings by this OC which will all contribute directly to fishermen earnings (proprietor's income).

Using the COFHE Model (for illustration purposes only)

For the sake of illustration, assume a constant fish price of $1.50 per pound, and that the OC operates exclusively in the fishery being regulated and lands fish worth $500,000 per year in the year when the fishing restrictions will take place. Within the COFHE model a 10% increase in fish abundance and CPUE can be reflected as a $50,000 increase (10% increase) in landed value with no increase in fishing effort. This means the full $50,000 increase in revenue associated with the increase in fish abundance generates new fishermen's income. The economic impact of fishing activity does not change because fishing effort and related purchases of fishing inputs do not change.

If the change in CPUE is expected to be permanent it might be worth putting in the effort to adjust input coefficients in the COFHE model to reflect the fact that fewer inputs are purchased and more proprietor's income is generated per dollar of landing by this OC (as shown in Illustration 3 below). However, if fishing effort is expected to remain constant, it is easier to simply estimate the impact of a $50,000 increase in proprietor's income in the appropriate study area by multiplying the impact multipliers per $10,000 of proprietor's income in Table 42 by 5. As long as effort is expected to remain constant, in other words, the direct effect of a change in catch per unit effort is associated only with a change in proprietor's income, and the impacts of such a change can be estimated without using COFHE multipliers for any particular OC. Impacts of changes in proprietor's income are the same for all OCs.

Table 42. Economic Impact of $10,000 Change in Proprietor's Income (For Illustration # 2)

Type of Impact	Direct Effects	Indirect Effects	Induced Effects	Total Effects
Output	$10,000	$1,892	$2,438	$14,330
Total Value Added	$3,281	$1,019	$1,446	$5,746
Labor Income	$1,713	$647	$797	$3,156
Employee Compensation	$1,484	$543	$684	$2,710
Proprietor's Income	$229	$104	$113	$446
Other Property Type Income	$1,220	$294	$506	$2,020
Indirect Business Taxes	$348	$79	$143	$570
Employment	0.0	0.0	0.0	0.1

* These effects on proprietor's income do not include the initial $10,000 change in proprietor's income that caused the effects.

Illustration 3: Potential Year 10 Economic Benefits of an Increase in CPUE and an Increase in the Allowable Annual Harvest

The same fishing restrictions described in Illustration #2 are being proposed here, and are expected to temporarily reduce the allowable annual harvest by a particular OC by 100,000 pounds, from 500,000 to 400,000 pounds. Here again, fishery managers argue that accepting these fishing restrictions will result in future economic benefits. In this case, however, they believe that they will result in a 10% increase in fish stock abundance in ten years and allow the annual harvest limit to increase at that time from 400,000 pounds to 600,000 pounds. The short-term adverse economic impacts of these fishing restrictions have been assessed using the approach described in Illustration 1 above. Fishery managers are interested in examining their potential beneficial economic impacts starting in year 10.

In this illustration there are two sources of expected economic benefits from stock rebuilding in year 10. First, the 10% increase in fish abundance will reduce effort and costs per unit output and increase fishermen earnings per dollar of output (landed value) as described in Illustration 2. Second, the stock rebuilding is expected to increase allowable annual harvest from the current level of 500,000 pounds to 600,000 pounds.

Here again, assume a constant fish price of $1.50 per pound and that the OC operates exclusively in the fishery being regulated. The value of annual landings by the OC, therefore, is $750,000 now (@ 500,000 pounds allowable harvest), will be $600,000 in the short term with the proposed restriction (@400,000 pounds allowable harvest), and is predicted to be $900,000 in year 10 (@ 600,000 pounds allowable harvest). One direct economic impact during year 10, therefore, will be a $150,000 increase in landed value of the harvest. However, a second direct impact is associated with the 10% increase in abundance and associated CPUE which means that the $900,000 in allowable harvest in year 10 would be taken with less fishing effort resulting in an increase in fishermen income per dollar of output.

Using the COFHE Model (for illustration purposes only)

Assume that in the current version of the COFHE model, the technical coefficients in the production function for the affected OC show that each $1 in output (landed value) is associated with $0.80 in direct input purchases from various IMPLAN sectors, $0.15 in direct labor payments (employee compensation) and $0.05 in proprietor's income (fishermen earnings). After a 10% increase in CPUE, the same purchases of inputs and labor payments associated with the same level of fishing effort would generate $1.10 in revenues. Since the increase of $0.10 in revenues is generated using the same level of effort and input costs it would all contribute to proprietor's income (fishermen earnings) which would increase from $0.05 to $0.15. If fisheries managers were only interested in this direct effect one could use the approach used in Illustration 2. In this illustration, however, fisheries managers are interested in the economic impacts of: a) the reduction in inputs purchased per dollar of output for this OC, b) the corresponding increase in fishermen income per dollar of output for this OC, and c) the 100,000 pound increase in the output (allowable harvest) by this OC.

Since technical coefficients in the COFHE model, like all I/O models, are expressed per $1 in output, accounting for this change would require re-estimating technical coefficients for this OC before estimating economic impacts by dividing the new lower input purchases and labor payments, and higher proprietor's income by $1.10 to get the new technical coefficients showing the allocation of input and primary sector payments per $1.00 of output. This results in: 1) all technical coefficients associated with input use and labor purchases being reduced by 9.1% (from $0.80 to $0.727 in direct input purchases per dollar of output and from $0.15 to $0.136 in direct labor payments per dollar of output), and 2) a 272% increase in the technical coefficient associated with proprietor's income, from $0.05 to $0.136. (Note: the $0.10 increase in proprietor's income from $0.05 to $0.15 is associated with a landed value of $1.10, so the new technical coefficient representing proprietor's income as a portion of $1 in landed value is $0.15/$1.10 or $0.136.)

In summary, then, the economic impacts of stock rebuilding in year 10 include:

- A 20% increase in annual landed value of the OC, from $750,000 to $900,000.
- A 9.1% decrease in input purchases and payments to labor per dollar output for the OC (overall, from 0.80 to 0.727).
- A 326% increase in proprietor's income in the OC from $37,500 ($750,000 X $0.05) to $122,400 ($900,000 X $0.136).

Using the COFHE model to assess the indirect and induced statewide economic impacts in year 10 of a fish stock rebuilding program that is expected to increase the allowable harvest by this OC by $150,000, and increase fish abundance and corresponding CPUE for the OC by 10% involves the following five steps:

1. Estimate current economic impacts of the OC using the current California state version of the COFHE model and current annual output (landed value) of $750,000 using the method shown in Illustration 1.
2. Modify the state COFHE model by reducing all value added and input use coefficients by 9.1% (to reflect a decline from 0.95 to 0.864 in fishermen costs per dollar of output), and increase proprietor's income per dollar of OC output by 272% (to reflect an increase from 0.05 to 0.136 in earnings per dollar of output). To obtain the COFHE IMPLAN models for modification purposes, please contact CDFG.
3. Generate revised COFHE multipliers for the OC based on the new COFHE model.

4. Compute the economic impacts generated by the new annual harvest ($900,000) using the new COFHE multipliers.
5. Subtract the results of Step 4 from the results of Step 1 to estimate the combined economic impacts in year 10 of a 10% increase in fish abundance and a 100,000 pound increase in the allowable annual harvest.

Note: A complete economic analysis to compare the economic impacts of short-term costs (Illustration 1) with long-term gains (Illustrations 2 and 3) may require economic analysis that cannot be performed using the COFHE model by itself. Although not discussed here, such an analysis may need to account for time (e.g., present value analysis), risks of fishery and market changes, and economic costs to fishermen during stock rebuilding, as well as potential effects of changes in near-term supply of fish on markets, consumer preferences, import substitution, etc.