PACIFIC HALIBUT MULTIREGIONAL ECONOMIC IMPACT ASSESSMENT (PHMEIA) – PROJECT REPORT

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PURPOSE

Under the Convention, the IPHC's mandate is *optimum* management of the Pacific halibut resource, which necessarily includes an economic dimension. Pacific Halibut Multiregional Economic Impact Assessment (PHMEIA) is a core product of the IPHC socioeconomic study that directly responds to the Commission's "desire for more comprehensive economic information to support the overall management of the Pacific halibut resource in fulfilment of its mandate" (economic study terms of reference adopted at FAC095 (IPHC-2019-FAC095) and endorsed at AM095 in 2019).

ABSTRACT

The economic effects of changes to harvest levels can be far-reaching. Fisheries management policies that alter catch limits have a direct impact on commercial harvesters, but at the same time, there is a ripple effect through the economy. Fisheries operations create demand for inputs from other sectors, while at the same time support industries further along the value chain that rely on the supply of fish, such as seafood processors. Recreational fishing is key to a broad set of local businesses' prosperity and creates employment opportunities supporting local households. Policies or any other exogenous changes may also have an economic impact not only on the region where they are observed but also on the regions with strong economic ties with the region subjected to the change.

Pacific halibut multiregional economic impact assessment (PHMEIA) model is a multiregional social accounting matrix-based model describing economic interdependencies between sectors and regions developed to bring a better understanding of the role and importance of Pacific halibut resource in a regions' economies. The model describes the within-region production structure of the Pacific halibut sectors (fishing, processing, charter) and accounts for economic activity generated through sectors that supply fishing vessels, processing plants, and charter businesses with inputs to production, by embedding Pacific halibut sectors into the model of the entire economy of Canada and the United States. In addition, the PHMEIA model traces the flow of earnings from the harvest stage to the beneficial owners of the resource, accounting for cross-regional income spillovers, which represent economic stimulus in the regions other than the one in which the harvest occurs.

The results suggest that the revenue generated by Pacific halibut at the harvest stage accounts for only a fraction of economic activity that would be forgone if the resource was not available to fishers in the Pacific Northwest. On average, in 2019, one USD/CAD of Pacific halibut commercial landings was linked to over four USD/CAD-worth economic activity in Canada and the United States and contributed USD/CAD 1.3 to households. This adds up to USD 551 mil. (CAD 731 mil) of economic impact in terms of output and USD 179 mil (CAD 238 mil) impact on households. The charter sector contribution to economic activity is estimated at USD/CAD 3.4 per one USD/CAD spent on party/charter fishing services, adding up to USD 133 mil (CAD 177 mil) economic impact in terms of output. However, when the economic impact of marine angler expenditures on fishing trips and durable goods is added, the Pacific halibut recreational fishing total contribution stands at USD 463 mil. (CAD 615 mil.)

and contribution to households at USD 147 mil. (CAD 195 mil.). The total economic activity linked to Pacific halibut sectors in 2019 is estimated at USD 1,014 mil. (CAD 1,346 mil), and contribution to households at USD 326 mil. (CAD 432 mil.). These estimates represent what is considered a more typical year in the economy. Pacific halibut commercial sector contribution to households' income in 2020 dropped by a quarter, highlighting the devastating impact of the covid-19 pandemic.

INTRODUCTION

While previous studies examined aspects of socioeconomic impacts of the Pacific halibut fisheries and there is a regular reporting of fisheries-related economic data by agencies of both Canada and the United States of America, the total picture of the economic impact of the Pacific halibut fisheries is incomplete. Pacific halibut-dependent sectors have not been examined in a comprehensive way and most of the economic data is limited to ex-vessel or wholesale value. In addition, the value of the community, social, and cultural impacts of the fishery have generally not been assessed. As a result, the resource managers and policy makers are unable to meaningfully compare the economic and social impact of the different sectors of the Pacific halibut fishery to each other, to other fisheries, to other communities, or to other industries. Additionally, achievement of optimum yield (understood as yield balancing biological and socioeconomic objectives) has not been quantified or assessed.

The goal of the IPHC socioeconomic study is to provide stakeholders with an accurate and all-sectors-encompassing assessment of the socioeconomic impact of the Pacific halibut resource that includes the full scope of Pacific halibut's contribution to regional economies of Canada and the United States of America. To that end, the IPHC developed the Pacific Halibut Multiregional Economic Impact Assessment (PHMEIA)[1] model that informs stakeholders on the importance of the Pacific halibut resource and fisheries to their respective communities, but also broader regions and nations, and contributes to a wholesome approach to Pacific halibut management that is optimal from both biological and socioeconomic perspective, as mandated by the Convention.

The economic effects of changes to harvest levels can be far-reaching. Fisheries management policies that alter catch limits have a direct impact on commercial harvesters, but at the same time, there is a ripple effect through the economy. Industries that supply commercial fishing vessels with inputs, generally referred to as *backward-linked* sectors, rely on this demand when making decisions related to their production levels and expenditure patterns. For example, vessels making more fishing trips purchase more fuel and leave more money in a local grocery store that supplies crew members' provisions. More vessel activity means more business to vessel repair and maintenance sector or gear suppliers. An increase in landings also brings more employment opportunities, and, as a result, more income from wages is in circulation. When spending their incomes, local households support local economic activity that is indispensable to coastal communities' prosperity.

[1] While this type of assessment is typically termed "economic impact assessment," calculated alongside the impact in terms of output also the impact on employment and wages, and households' prosperity, introduce a broader socioeconomic context.

Changes in the domestic fisheries output, unless fully substituted by imports, are also associated with production adjustments by industries relying on the supply of fish, such as seafood processors. These changes also affect suppliers to the *forward-linked sectors*, creating an additional ripple effect.

Economic impacts are also attributed to recreational fishing activities. By running their businesses, charter operators create demand for fuel, bait fish, boat equipment, and fishing trip provisions. They also create employment opportunities and generate incomes that, when spent locally, support various local businesses. Pacific halibut supports various angling-dependent services, for example, hospitality services in the case of fly-in lodges that specialize in serving customers interested in Pacific halibut fishing.

What is more, anglers themselves contribute to the economy by creating demand for goods and services related to their fishing trips. This includes expenses related to the travel that would otherwise not be incurred (e.g., auto rental, fuel cost, lodging, food, site access fees), as well as money spent on durable goods that are associated with recreational fishing activity, e.g., rods, tackle, outdoor gear, boat purchase, and applies to both guided and unguided recreational fishing.

These types of economic impacts are typically estimated with the use of an input-output (IO) model. The traditional IO model is used to investigate how changes in final demand affect economic variables such as output, income and employment or contribution to the region's gross domestic product (GDP). This is known as impact analysis. With an adjustment for the shock type, the model can also demonstrate the magnitude of changes in supply-constrained industries such as total allowable catch (TAC) constrained fisheries. Adopting a multiregional approach, the model accommodates the cross-regional trade. The IO model can also be extended to the so-called social accounting matrix (SAM). Adopting SAM, the calculated effects account for labor commuting patterns and residency of beneficial owners of production factors, and as a result, the flow of earnings between regions.

The PHMEIA is a multiregional SAM-based model describing economic interdependencies between sectors and regions developed to assess three **economic impact (EI)** components pertaining to Pacific halibut. The **direct EIs** reflect the changes realized by the direct Pacific halibut resource stock users (fishers, charter business owners), as well as the forward-linked Pacific halibut processing sector (i.e., EI related to downstream economic activities). The **indirect EIs** are the result of business-to-business transactions indirectly caused by the direct EIs. The indirect EIs provide an estimate of the changes related to expenditures on goods and services used in the production process of the directly impacted industries. In the context of the PHMEIA, this includes an impact on upstream economic activities associated with supplying intermediate inputs to the direct users of the Pacific halibut resource stock, for example, impact on the vessel repair and maintenance sector or gear suppliers. Finally, the **induced EIs** result from increased personal income caused by the direct and indirect effects. In the context of the PHMEIA, this includes economic activity generated by households spending earnings that rely on the Pacific halibut resource, both directly and indirectly.

To accommodate an increasing economic interdependence of regions and nations, the model accounts for cross-regional spillovers. These represent economic stimulus in regions other than the one in which the exogenous change, for example, management intervention, is considered. Economic benefits from the primary area of the resource extraction are leaked when inputs are imported, when wages earned by nonresidents are spent outside the place of employment, or when earnings from quota holdings flow to nonresident beneficial owners. At the same time, there is an inflow of economic benefits to the local economies from when products are exported, or services are offered to non-residents. PHMEIA offers the first consistent estimation of both backward-linked (related to inputs) and forward-linked (input-dependent) effects of changes to the fisheries sectors in a multiregional setup tracing the transmission of economic impacts internationally. By linking multiple spatial components, the model offers a better understanding of the impacts of shared stock supply changes (see **Figure 1** for the map of the IPHC Convention area).

Besides providing economic impact estimates for broadly-defined regions,[2] the PHMEIA model details the geography of impacts in Alaska and highlights areas particularly dependent on Pacific halibut fishing-related economic activities, addressing the Commission's interest in community impacts. A good understanding of localized effects is pivotal to policymakers who are often concerned about community impacts, particularly in terms of impact on employment opportunities and households' welfare. Fisheries policies have a long history of disproportionally hurting smaller coastal communities, often because potential adverse effects were not sufficiently assessed.

What is more, the economic impact assessment is supplemented by an analysis of the formation of the price paid for Pacific halibut products by final consumers (end-users) that is intended to provide a better picture of Pacific halibut contribution to the GDP along the entire value chain, ***from the hook-to-plate***. This supplemental material is available in IPHC-2021-ECON06. Moreover, the IPHC is working with the National Oceanic and Atmospheric Administration (NOAA) Alaska Fisheries Science Center on the Pacific halibut portion of the update of the report *Wholesale Market Profiles for Alaska Groundfish and Crab Fisheries* (AFSC, 2019).

[2] Full economic impact assessment based on the SAM methodology is conducted for six regions: (1) Alaska, (2) British Columbia, (3) the US West Coast (CA, OR, WA), (4) the rest of the USA, (5) the rest of Canada, and (6) the rest of the world. The results, however, treat transactions with the rest of the world as exogenous.

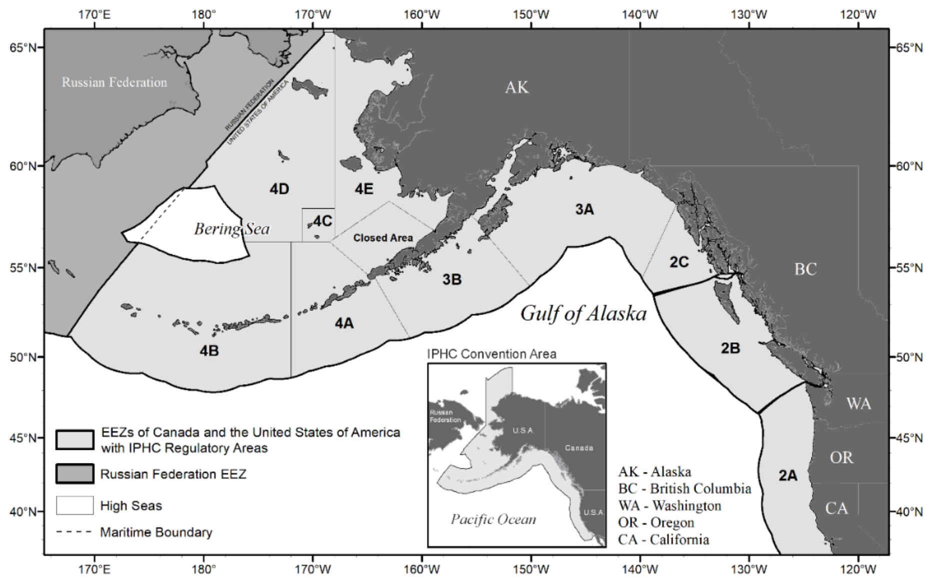


Figure 1: Map of the IPHC Convention area.

MOTIVATION

Under the Convention, the IPHC's mandate is optimum management of the Pacific halibut resource, which necessarily includes a socioeconomic dimension. The study brings the human dimension to the IPHC's research framework and portfolio of tools for assessing policy-oriented issues, providing for an essential input to optimum management of Pacific halibut that is aligned with socioeconomic objectives prevalent in the legislation of Canada and the USA.

Federal laws governing US marine fisheries require assessing any proposed fishery management action in terms of its regional or community economic impacts. These laws include, among others, the Magnuson-Stevens Fishery Conservation and Management Act (MSA, amended on January 12, 2007), National Environmental Policy Act (NEPA), and Executive Order 12866. For example, the National Standard 8, one of the principles mandated by the MSA, requires that while the conservation and management measures must be consistent with the conservation requirements, they must also account for "*the importance of fishery resources to fishing communities*" and "*to the extent practicable, minimize adverse economic impacts on such communities*" (Section 301[a]8). It implies that fishery managers, when considering any action, must take into account the economic impact on various stakeholder groups, including fishers, but also processors and fishing-dependent communities. The MSA also establishes Regional Fishery Management Councils, which role is to develop fisheries management plans that "*take into account the social and economic needs of the States*" while working on the stewardship of fishery resources. Lately, NOAA recommended routine consideration of socioeconomic drivers in the fisheries stock assessment process (Next Generation Stock Assessment framework, NOAA 2018).

The document establishing national fisheries policy in Canada for the modern era is the 1976 Policy for Canada's Commercial Fisheries. It states that "*the guiding principle in fishery management no longer would be maximization of the crop sustainable over time but the best use of society's resources.*" The "*best use"* is defined as "*the sum of net social benefits (personal income, occupational opportunity, consumer satisfaction and so on) derived from the fisheries and the industries linked to them*" (Fisheries Act, R.S.C. 1985, c. F-14). These objectives have been affirmed in legislation (Oceans Act, S.C. 1996, c.31), according to which fisheries are expected to be managed to meet a full spectrum of social and economic objectives. More recently, the commitment to the sustainability of fisheries – "*as a vital part of our* [Canada's] *food supply, as well as an important source of jobs and economic activity for coastal communities*" – has been reaffirmed in the Government Response to the report *West Coast Fisheries: Sharing Risks and Benefits* by the Standing Committee on Fisheries and Oceans (House of Commons Canada, 2019).

LITERATURE

There is a few decades' worth of experience in developing economic impact assessment models with applications to fisheries. Seung and Waters (2006) provide an excellent overview of IO studies available up to 2006, starting with papers published as early as 1967 (Rorholm *et al.*, 1967). The majority of these studies consider a single region with one exception. Butcher et al. (1981) offer an early example of multiregional analysis applied to the Alaska shellfish fishery. An early example of a supply-driven model for fisheries is available in Leung and Pooley (2002), who use the IO modeling technique to assess the impact of the reduction in fishing areas adopted in order to protect certain turtle populations. The majority of earlier models are using the demand-driven approach.

More recent models offer ever more complex mathematical depictions of the economy comprised of hundreds of interlinked sectors that are built with the purpose of assessing the economic effects of fishery management policies that alter seafood sectors. The majority of these models, developed for various regions of the United States, rely on adaptations to the widely distributed commercial regional input-output modeling system known as IMPLAN (IMPLAN Group LLC. IMPLAN 2020. Huntersville, NC. IMPLAN.com.). Currently, IMPLAN data contains 546 sectors representing all private industries in the United States classified based on the U.S. Census Bureau's North American Industry Classification System (NAICS). It includes three sectors that are directly related to the seafood supply chain: commercial fishing (sector 17), seafood product preparation and packaging (sector 92), and wholesale - grocery and related product wholesalers (sector 398). IMPLAN is a widely-used tool for academic and professional economists for the estimation of economic impact in a variety of sectors.

One of the earlier examples of IMPLAN adaptations to fisheries is the Northeast Region Commercial Fishing Input-Output Model (Steinback and Thunberg, 2006). The model covers 24 regions in the Northeast and focuses on refining fishing-related sectors by disaggregating them into more detailed subsectors. The modifications include splitting the commercial fishing sector based on gear type and vessel size class, detaching seafood wholesalers from a more general wholesale category, and adding seafood dealer sectors for each coastal region. Given the high spatial granularity, the model makes a number of simplifying assumptions on the industries' structure. Harvesters are assumed to sell all of their output to wholesale dealers via direct sales or through fish exchanges/auctions. Wholesale dealers are assumed to sell their output to final consumers, intermediate demand industries (including seafood processors), and businesses located outside of the Northeast region (export). Seafood dealer sectors and fish exchanges/auctions are treated as margin sectors. This means the value of their sales excludes the cost of the sold goods, i.e., the sales include only the value added to the sold product, and impacts that may accrue beyond the processor level are not incorporated. The model is only partially multiregional as it accounts for the interconnections only between the fishing-related businesses (commercial harvesters, wholesale seafood dealers, bait suppliers, and seafood processors). The non-fishing effects are estimated jointly and appropriated to regions according to their relative importance to the total Northeast economy. Due to its extensive data requirements, this model was difficult to keep up-to-date and is not maintained anymore (Steinback, personal communication).

The US-wide application of the IO modeling technique to commercial fishing and seafood industry is a model developed for the National Marine Fisheries Service (NMFS) by Kirkley (2009). Economic impacts are expressed in terms of employment (full-time and part-time jobs), personal income, and output (sales by US businesses), separately for 18 categories of species of fish defined by the model, as well as for seafood processors, wholesalers/distributors, grocers, and restaurants. Geographically, the model estimates impacts for the US as a whole and for 23 coastal states. At the state level, estimates for each sector are based on fishery products harvested in that state or imported to that state from a foreign source. The model serves as a base for producing annual fisheries impacts estimates for the Fisheries Economics in the United States report, published since 2006 and available here. The latest report is available for 2018 (NOAA, 2021b).

IMPLAN customization for the US Pacific Coast has been developed by Leonard and Watson (2011), largely following the approach by Steinback and Thunberg (2006). The model distinguishes 19 vessel categories that produce 32 unique species and gear commodity outputs. These include three groundfish sectors (large groundfish trawlers, small groundfish trawlers, other groundfish fixed gear) that harvest Pacific halibut. Data used to build the custom fishing sectors were obtained from Pacific Fisheries Information Network (PacFIN) fish ticket data maintained by the Pacific States Marine Fisheries Commission (PSMFC), the Northwest Fisheries Science Center's (NWFSC) cost earnings surveys, moorage rates from ports along the West Coast, and collection statistics for the Washington Enhanced Food Fish Tax used to estimate the flow of fish landings to wholesalers. Default IMPLAN 2006 data were used for the regional non-fishing economy, as well as the various institutions in the region such as households and the government.

Periodically, NOAA also provides an assessment of the economic contribution of marine angler expenditures in the United States (Steinback and Gentner, 2008; Lovell, Steinback and Hilger, 2013; Lovell *et al.*, 2016). The latest estimates (based on data from 2014), limited to the contribution of expenditures on durable goods (excluding trip cost, covered in the report from 2013), suggest that at the national level, marine anglers spent USD 28 billion on fishing equipment and durable goods (e.g., fishing rods, tackle, boats). These expenditures are assessed to generate an estimated USD 49.6 billion in total output, added USD 29 billion in contribution to GDP, contributed USD 18 billion to personal income, and supported more than 358,000 jobs across the United States. No estimates specific to subsectors defined based on target species are available.

BC Stats (Sun and Hallin, 2018) provide estimates of direct, indirect, and induced effects arising from the economic activities of industries within the fisheries sector in British Columbia, including capture fisheries, seafood processing, and sport fishing. The assessment is based on the British Columbia input-output model built using information from the 2014 IO tables for the province available from Statistics Canada (Statistics Canada, 2019). The results suggest that for every dollar of output in capture fishery, aquaculture, and fish and seafood processing combined, an additional CAD 0.386 is generated in the province by industries supplying goods and services used by commercial fishing, aquaculture, fish processing, and sport fishing industries. This model, however, does not provide Pacific-halibut specific estimates and analyses economic impact only within the region of the resource extraction, omitting impacts outside British Columbia.

The fisheries sector is often fixed on the supply side as fisheries policies usually target output by setting TAC limits. Supply-driven approach applications have been applied in a variety of settings, for example, to study backward and forward linkage effects of Alaska fisheries (Seung and Waters, 2009) or to assess the economic impacts of restricting catch of Pacific cod and Atka mackerel in the Aleutian Islands in order to protect Steller sea lions (Seung and Waters, 2013), Chinook salmon fishery failures (Seung, 2017) and catch limits on Alaska pollock fishery (Seung, 2014).

The most advanced multiregional economic analysis focused on fisheries, applied at borough level to the seafood industry in Alaska, is a social accounting matrix developed at the NOAA Alaska Fisheries Science Center (AFSC) by Seung, Waters, and Taylor (2019). The model allows for analysis of the impacts on individual fishing-dependent communities (at the borough level) rather than broad administrative areas (e.g., the entire state), serving as a useful tool to fishery managers interested in more localized impacts of exogenous shocks, either natural or policy-induced. The model uses the results of a detailed survey of fish harvesting vessel owners and interviews with key seafood business stakeholders from six boroughs and census areas in the Southwest Alaska region. The survey, designed specifically to account for cross-regional effects, collected information on the geographic distribution of expenditures. A detailed survey description is available in Waters, Baker, and Taylor (2016). An earlier, three-region version of this model (Alaska, West Coast, and rest of USA) has been used for several economic impact assessments in the pacific northwest, including Alaska head and gut (H&G) fishing fleet (Waters *et al.*, 2014). The full description of this model, accompanied by a manual to a web-based application for custom estimates, is available in Seung and Miller (2018).

No models focused on fisheries connecting the economies of the United States and Canada were identified. Although (Gislason *et al.*, 2017) analyze the impact of Pacific Salmon fisheries on the economy of both countries using the IO approach, their models are disconnected and do not offer the consistency of an integrated multiregional model.

The IO approach can also be used to assess the impact of the reduced number of recreational fishing trips. A multiregional computable general equilibrium (CGE) model developed by Seung and Lew (2017) assesses the economic impact of restrictions imposed on saltwater sport fishing in Alaska, considering a variety of limit changes to Pacific halibut, chinook salmon, and coho salmon. The findings suggest that although adverse economic impacts of reduced bag limits on Alaska can be to some degree compensated for by increases in economic activities in the other regions or other sectors, the cost of one fewer Pacific halibut allowance can still decrease the economic activity in Alaska by USD 4.7-9.0 mil. The model uses fishing participation changes arising due to changes in the limits predicted from a stated-preference model.

METHODS

Input-output framework

Traditional Leontief (Leontief, 1966) single-region IO model, a Nobel prize (1973) worth advance in understanding economic impact in a system consisting of multiple interlinked industries, can be described by:

$$\mathbf{X} = (\mathbf{I} - \mathbf{A})^{-\mathbf{1}}\mathbf{f}, \qquad [\ 1\ ]$$

where $\mathbf{X}$ is the total industry output (production) vector, $\mathbf{A}$ is the matrix of technical coefficients, and $\mathbf{f}$ is the vector of total industry final demands. $(\mathbf{I} - \mathbf{A})^{-1}$ is collectively known as Leontief inverse or total requirements matrix. This model requires data input in the form of $n \times n$ transaction matrix $\mathbf{Z} = |z_{ij}|$, as $\mathbf{A} = \mathbf{Z}\hat{\mathbf{x}}^{-1}$. Here, z_{ij} represent sector j's demand for input from sector i. For each industry, the sum of its intermediate inputs ($\mathbf{Z}$ column) and value added components should equal the sum of intermediate outputs ($\mathbf{Z}$ row) and final demand components. The value added components typically include labor income (employee compensation, including salaries and wages, and social contributions) and proprietors' income (income from self-employment), taxes and subsidies on production and imports, and other property income (return on capital). Taxes and subsidies on products are not considered value added components. Final demand categories typically include final consumption by households and government, and net export.

The IO models are used to investigate how changes in final demand affect economic variables such as output, income[3] and employment or value added that provides an assessment of the sector's contribution to the GDP in a region (Lovell *et al.*, 2016). This is known as impact analysis.

In order to account for the fact that industry may produce more than one commodity (i.e., secondary products), economic impact assessment models typically adopt a commodity-by-industry approach. In this case, $\mathbf{Z}$ is replaced by *Use matrix*, $\mathbf{U} = |u_{ij}|$, where u_{ij} is the value of the purchase of commodity i by industry j, that is presented in conjunction with the transpose of supply matrix, *Make matrix*, $\mathbf{V} = |v_{ij}|$, where v_{ij} is the value of the output of commodity j that is produced by industry j. These two matrices allow to build an analogous industry-based technology single region IO model:

$$\mathbf{q} = (\mathbf{I} - \mathbf{BD})^{-\mathbf{1}}\mathbf{e}. \qquad [\ 2\ ]$$

Here, $\mathbf{q}$ is the vector of total commodity output, $\mathbf{e}$ is the vector of total commodity demand, and $\mathbf{BD}$ is equivalent to $\mathbf{A}$ in the original Leontief model, with $\mathbf{B}$ defined as $\mathbf{B} = \mathbf{U}\hat{\mathbf{x}}^{-1}$, where column j represents the value of inputs of each commodity per dollar's worth of industry j's output, and $\mathbf{D}$ defined as $\mathbf{D} = \mathbf{V}\hat{\mathbf{q}}^{-1}$, where each element d_{ij} in $\mathbf{D}$ denote the fraction of total commodity j output produced by industry i. Derived from *Make* and *Use matrices* $(\mathbf{I} - \mathbf{BD})^{-1}$ is the commodity-by-commodity total requirements matrix. The total requirement matrix can be used to assess the effects of exogenous changes on the final demand for each commodity specified by the model.

[3] This can include both personal income (wages and salaries) and proprietors' income (income from self-employment).

Alternatively, one may want to build a commodity-based single-region IO model (Miller and Blair, 2009). Research on which method is more economically-sound remains ongoing. Choosing the industry-based model is dictated by proven consistency with Leontief demand-driven model (De Mesnard, 2004; Jackson and Schwarm, 2007).

Linking multiple regions

Policies or any other exogenous changes may have an economic impact not only on the region where they are observed but also on the regions with strong economic ties with the region subjected to the change. A multiregional IO model accounts for that.

Linking multiple spatial components is done by the mean of trade coefficients matrix $\mathbf{C}$. In the multiregional version of the model, the vector of gross outputs by sector and region is given by:

$$\mathbf{q} = (\mathbf{I} - \mathbf{CBD})^{-\mathbf{1}}\mathbf{Ce}. \qquad [\ 3\ ]$$

Here, the matrix of technical coefficients ($\mathbf{BD}$) is combining technical coefficients for each region considered in the model. In a two-region (r, s) example, this matrix takes the form:

$$\mathbf{BD} = \begin{bmatrix} \mathbf{BD}^r & 0 \\ 0 & \mathbf{BD}^s \end{bmatrix}, \qquad [\ 4\ ]$$

where $\mathbf{BD}^r$ is the matrix of technical coefficients for region r and $\mathbf{BD}^s$ is the matrix of technical coefficients for region s. The two-region $\mathbf{C}$ matrix takes then the form:

$$\mathbf{C} = \begin{bmatrix} \hat{\mathbf{c}}^{rr} & \hat{\mathbf{c}}^{rs} \\ \hat{\mathbf{c}}^{sr} & \hat{\mathbf{c}}^{ss} \end{bmatrix}, \qquad [\ 5\ ]$$

where $\hat{\mathbf{c}}^{rr}$ and $\hat{\mathbf{c}}^{ss}$ are intraregional trade coefficients matrices of region r and s, and $\hat{\mathbf{c}}^{rs}$ and $\hat{\mathbf{c}}^{sr}$ are interregional trade coefficients matrices derived from transaction matrices. $\hat{\mathbf{c}}^{rs}$ ($\hat{\mathbf{c}}^{rs}$) describe the flow of commodities from region r (s) to region s (r), or how much of good or services used in s (r) comes from region r (s). The trade coefficients indicate the shares of domestic vs. imported input to the domestic production process. This widely used specification (e.g., Bachmann, Roorda, and Kennedy 2015) implies the same pattern of inputs use between domestically produced and imported commodities. This simplification implies that the possibility of different use patterns for domestic vs. imported commodities is not considered.

Economic impact multipliers

Output multiplier for sector j is defined as the total value of production in all sectors of the economy necessary to satisfy a dollar's worth of final demand for sector j's output (Miller and Blair 2009, pp. 245). Simple multipliers are obtained by summing the columns of the $(\mathbf{I} - \mathbf{CBD})^{-1}$ matrix. Formally, defining elements of this matrix as l_{ij}, the output multiplier is given by:

$$m(o)_j = \sum_{i=1}^{n} l_{ij}. \qquad [\ 6\ ]$$

This sum reflects direct and indirect effects. Direct effects for sector j are captured by l_{jj}.[4]

The same matrices can be used to explore the impact of changes in final demand on jobs created or wages earned. Labor input coefficients (γ_i) - either monetary, in the form of wages per unit of output or physical, in the form of, for example, number of jobs per unit of output - are multiplied by l_{ij} coefficients that relate final demand in sector j to output in sector i:

$$m(l)_j = \sum_{i=1}^{n} \gamma_i l_{ij}. \qquad [\ 7\ ]$$

Employment can be specified on the basis of full-time and part-time jobs, or full-time equivalents. There is significant part-time and seasonal employment in commercial and recreational fishing and many other industries. Employment is an important metric when considering community impacts. The impact on value added that reflects changes in sectors' contribution to the GDP is calculated the same way. The same approach can also be applied to various other variables, for example, CO_2 emissions.

It is also worth noting that multipliers based on single-region models may overstate the effects when the industry is operating at or near its capacity, and some of the additional inputs may need to be imported or shifted from exports. This, however, is addressed by using multiregional analysis, where such effects are accounted for (Miller and Blair 2009, pp. 246).

Worth noting is also that standard economic multipliers do not capture intangible benefits of the fish as a resource, for example, ecosystem services or cultural value. However, the non-market values can be consistently incorporated into the IO model (Carbone and Smith, 2013). Such an avenue can be explored, but it is not considered at this stage.

Supply-driven approach

The standard input-output approach uses output multipliers to describe the economy-wide backward linked output effects associated with exogenously specified changes in final demand for commodities ($\mathbf{e}$). Demand-side shocks include changes in consumer demand, investment patterns, exports, government spending, or exogenous changes to taxes that affect demand. However, in the case of fisheries that are rather fixed on the supply side as it is the output that is usually targeted by fisheries policies, a supply-driven approach is more appropriate for assessing the economic impact (Leung and Pooley 2002; Steinback and Thunberg 2006; Seung and Miller 2018).

The modified IO approach based on the method developed by Tanjuakio, Hastings, and Tytus (1996) is used to demonstrate the magnitude of changes in supply-constrained industries. Accordingly, the impact assessment is conducted using a modified total requirements matrix. The process of "*extracting*" the sector is done by setting regional purchase coefficients (elements of $\mathbf{CBD}$, denoted here by α_{ij}) for exogenized sectors to zero, which implies the elimination of these sectors as suppliers of inter-industrial inputs. Then, the changes in output are modeled as if they originated from the final demand.

[4] Calculation of induced effects requires adopting a matrix that is closed with respect to households or a fully articulated SAM matrix. See Social accounting matrix subsection below for details on the calculation of induced effects using PHMEIA.

Forward linkages

In the input-output framework, changes to the production by a particular sector have two kinds of effects on other industries. Backward linkages refer to the changes to the goods and services that serve as inputs to the affected sector, defining relations with so-called *upstream* sectors. For the fisheries sector, these include, for example, impacts on the vessel building sector or supply stores equipping vessels for their fishing trips. These effects are captured by the equation [3].

Changes in the domestic fisheries output, unless fully substituted by imports, are also associated with production adjustments by industries relying on the supply of fish, such as seafood processors. Forward linkages describe the effects on the industries for which the affected sector is a supplier, defining its relations with the *downstream* industries. While these forward linkages are not typically included in the calculation of economic impacts, mainly because early attempts (e.g., Cai et al. 2005) using Ghosh approach have been criticized for the lack of economic foundation (Oosterhaven, 1988, 1989), application of the method described in Seung (2014, 2017) allows for such extension. The proposed method implies exogenous specification of changes in the forward linked industries (here, seafood processors) and setting regional purchase coefficients associated with these industries to zero, the same way as done for the directly impacted industry (as described in section Supply-driven approach). This way, the model does not calculate the effects on downstream industries endogenously because fish processing industries are restricted in terms of the amount of raw fish input. The advantage of this method is that the calculated effects are additive so that the total effects can be consistently derived as a sum of backward and forward linkages. However, to avoid double-counting the value of landings, the direct economic impact of the processing sector is adjusted for just wholesale margins. This means the value of sales by processors excludes the cost of raw fish input, i.e., the sales include only the value added to the sold products.

While the complete path of commercially landed fish includes, besides harvesters and processors, also seafood wholesalers and retailers, and services when it is served in restaurants, it is important to note that there are many seafood substitutes available to buyers. Thus, including economic impacts beyond wholesale in PHMEIA, as opposed to assessing the snapshot contribution to the GDP along its entire value chain, would be misleading when considering that it is unlikely that supply shortage would result in a noticeable change in retail or services level gross revenues (Steinback and Thunberg, 2006). Supplementary snapshot assessment of Pacific halibut contribution to the GDP along the entire value chain, **from the *hook-to-plate***, accounting for the trade balance, is available in IPHC-2021-ECON-06.

Social accounting matrix

The standard IO model depends on the existence of exogenous sectors that are disconnected from the technologically interrelated productive structure and generate final demands for outputs. This includes purchases by households, sales to the government, gross private domestic investment, or export. The input-output framework provides also little insight into the demographics of the workforce that builds the market for supply and demand of labor. All this can be accommodated in the SAM-based model. PHMEIA considers households as an endogenous sector that earns income in return for their labor inputs to production processes and spends that income in a structured fashion (Picek and Schröder, 2018) and accounts for commuting patterns where the labor's place of employment and place of residence differ. It is of particular importance when focusing on industries that employ a considerable share of non-residents for temporary assignments that imply a negative net flow of income to the region and, consequently, impacts on households are not necessarily equal to impacts on earnings in the region. The SAM approach is also used to trace the flow of profits related to non-resident investment in production factors. This accommodates the returns to quotas and permits that should be allocated according to the residency of their beneficial owners rather than their users.

The SAM-based model with endogenous households also allows for a detailed accounting of household income by place of residence, including earnings from other sources (e.g., government transfers, dividends, interest, and rent), outflows to the government (e.g., personal income taxes), and households net savings by region.

The SAM model can be expressed as follows:

$$\mathbf{x}^{\mathrm{SAM}} = (\mathbf{I} - \mathbf{S})^{-1}\mathbf{f}^{\mathrm{SAM}}, \qquad [\,8\,]$$

where $\mathbf{x}^{\mathbf{SAM}}$ is a total production vector, $\mathbf{f}^{\mathbf{SAM}}$ is a vector of SAM exogenous accounts, $\mathbf{S}$ is a matrix of direct SAM coefficients ($\mathbf{S} = (\mathbf{SAM})\widehat{\mathbf{x}^{\mathrm{SAM}}}^{-1}$) and $(\mathbf{I} - \mathbf{S})^{-1}$ is SAM total requirements matrix. SAM total requirements matrix can be used to derive multipliers used in calculation of economic impact metrics.

The PHMEIA model components largely align with these considered in Seung (2014). The SAM-derived total requirement matrix captures induced effects that account for commuting patterns and the flow of investment earnings. The general structure of the adopted SAM matrix is available in Appendix A. The SAM framework also allows for endogenizing additional sectors, for example, government expenditures or savings and investment. This extension of the modeling framework is not considered at this stage.[5]

Adapting SAM to project needs

SAM matrix is typically built from supply and use tables (SUTs). SUTs lay out a detailed picture of the entire economy, providing an overview of the production process and use of commodities, and typically produced by the governmental agencies at the national level to derive components related to the calculation of the GDP.

The national SUTs, however, do not capture the heterogeneity of regions within a single country. This deficiency is problematic as the differences between regions and subnational interdependencies can be substantial. It follows from industries' diversification in terms of the production structure that may be related to the location, availability of resources, or ability to attract talent. A policy that is targeting a specific sector when the reliance on that sector varies between regions will produce unevenly distributed economic effects.

While regional SUTs are informative to policymakers who may be interested in the localized effects of their decisions, these are rarely available. Detailed regional tables are often a product of a specific project with a limited sectoral focus, available for a narrow time frame, and rarely set for routine updating. This is because such products are data-intensive, requiring information on the whole range of industries that comprise the region's economy. Compiling data from all sectors and ensuring its consistency across takes resources and time. Values are not always available; often, this is because there is a mismatch in the categorization of commodities or

[5] Impact on taxes can be still calculated through the use of multipliers described in subsection Economic impact multipliers. These estimates, however, will not include the feedback to the economy related to households and government spending the tax-generated revenue.

industries, and numbers are available only for an aggregate. As a result, timely policy advice based on regional SUTs is rare. Instead, inputs to policy-making decisions tend to be based on tables updated with limited data using a hybrid approach in which superior information (e.g., focused survey, expert opinion) is incorporated into otherwise mechanically updated tables.

The MR-GRAS technique described in Temursho et al. (2020) offers the most advanced approach to updating a partitioned matrix that needs to conform to new row sums, column sums, and, additionally, non-overlapping aggregation constraints.[6] While using row and column constraints is at the core of more traditional updating methods (e.g., RAS method, Lahr and de Mesnard 2004), adding aggregation constraints provides an opportunity to maximize the utilization of available data by making use of the national-level statistics. As a result, the MR-GRA technique can make the multiregional model consistent with aggregated national data[7] and include up-to-date estimates from a limited number of sectors derived from, for example, a focused survey or statistics published by a governmental agency responsible for a specific sector.

PHMEIA adopts a modified MR-GRAS technique that, in addition, imposes the identity of GDP by income and GDP by expenditure at the regional level in the output matrix. As a result, the updated matrix efficiently accommodates regional data on GDP components that are often produced by statistical agencies even when there is no attempt to derive the full set of regional SUTs. For more details on the updating approach, please refer to the article *Method for efficient updating of regional supply and use tables*.

The modified MR-GRAS technique applied in PHMEIA also allows the derivation of balanced tables that disaggregate Pacific halibut sectors from more broadly defined sectors using external information (e.g., landings value, see Data inputs section for details). Although these external data may be fragmentary, research finds that disaggregation of data going into economic impact assessment, even if based on a few real data points, is superior to using aggregates in determining SAM multipliers (Su *et al.*, 2010; Lenzen, 2011; Temursho, Oosterhaven and Cardenete, 2020). Severe aggregation bias occurs, especially if sectors within an aggregate are heterogeneous with regards to their economic and environmental characteristics (Lenzen, 2011).

PACIFIC HALIBUT CASE STUDY

The IPHC is an international organization established by a Convention between Canada and the United States of America that entered into force in 1923. The objective of the Commission is to develop the stocks of Pacific halibut in the Convention waters to those levels which will permit the optimum yield from the fishery and to maintain the stocks at those levels. The responsibilities of the Commission include: (1) establish open or closed seasons for Pacific halibut fisheries, (2) limit the size of the fish and the quantity of the catch to be taken from

[6] The MR-GRAS approach is based on tri-proportional scaling. The algorithm is set to minimize the weighted logarithm of the relative distance between the entries of the new and the old SUTs, subject to row, column and aggregation constraints. To find the solution that accounts for negative entries, the original matrix serving as an initial input to the scaling procedure is decomposed to a matrix containing positive elements and a matrix containing the negative entries' absolute values. What follows is the adjustment procedure consisting of a sequence of computations deriving adjustment multipliers that is set to stop when the multipliers converge to a solution conforming to a preset sufficiently low tolerance level. The last iteration multipliers are used to derive the output SUTs.

[7] For example, data from the National Economic Accounts (NEA). NEA data provide a comprehensive view of national production, consumption, investment, exports and imports, and income and saving. These statistics are best known by summary measures such GDP, corporate profits, personal income and spending, and personal saving.

each area within any season during which fishing is allowed; (3) during both open and closed seasons, permit, limit, regulate or prohibit the incidental catch of Pacific halibut that may be taken, retained, possessed, or landed from each area or portion of an area, by vessels fishing for other species of fish; (4) fix the size and character of Pacific halibut fishing appliances to be used in any area; (5) make such regulations for the licensing of vessels and for the collection of statistics on the catch of Pacific halibut as it shall find necessary to determine the condition and trend of the Pacific halibut fishery and to carry out the other provisions of this Convention; and (6) close to all taking of Pacific halibut any area or portion of an area that the Commission finds to be populated by small, immature Pacific halibut and designates as nursery grounds.

Detailed information about regulations for each IPHC-managed area are available in the IPHC annual publication International *Pacific Halibut Fishery Regulations* running since 1932.

Regulatory environment - Alaska

The Alaska Pacific halibut longline fishery (together with the sablefish longline fishery) is managed by the North Pacific Fisheries Management Council (NPFMC). The fishery is under the individual fishing quota (IFQ) program since 1995. The quota originally assigned to each person was proportional to their historical halibut landings, by regulatory area, during the qualifying period, and are represented as quota shares (QS). QSs were assigned to one of four vessel categories: A - freezer vessels of any length; B - catcher vessels greater than 60ft; C - catcher vessels less than or equal to 60ft for sablefish, or between 35-60ft for halibut; D - catcher vessels less than or equal to 35ft for halibut. Restrictions on transfer, together with use and ownership caps, are designed to maintain the fleet's owner/operator characteristics and prevent consolidation of QSs in the hands of a few participants. The fleet is also subject to a limited fishing season, historically running from March to November, but recently spanning to December.

The IFQ program in Alaska also gives provisions for halibut and sablefish community development quotas (CDQs). These were created to provide western Alaska communities an opportunity to participate in the Bering Sea and the Aleutian Islands fisheries that had been effectively closed to them because of the high capital investment needed to enter the fishery (NPFMC, 2020). Eligible communities can also form nonprofit entities called Community Quota Entities (CQEs) that are authorized to purchase commercial halibut and sablefish QSs and lease them to their residents.

Controls on the charter sector were established in 1975 (two-fish bag limit with no size limit) and remained unchanged for over 30 years, until 2007 in Southeast Alaska and 2014 in Southcentral Alaska (Chan, Beaudreau and Loring, 2018). However, the concerns regarding the sector's growth led to the implementation of the Charter Halibut Limited Access Program (CHLAP) in 2011. Additional measures in the form of trip limits and temporary closures came along the Pacific halibut Catch Sharing Plan (CSP) that was introduced with an intention to stabilize the allocation of Pacific halibut between the commercial and charter sectors. The CSP also authorizes limited annual leases of commercial IFQ for use in the charter fishery as guided angler fish (GAF). This gives anglers an opportunity to retain more or larger halibut than they might have otherwise been entitled to. Under CHLAP, communities[8] may also apply for a Community Charter Halibut Permit (CCHP). Unguided sport fishing

[8] Eligible communities must form a CQE.

for Pacific halibut in Alaska is subject to less restrictive rules than the charter sector. Currently, the daily bag limit is two fish of any size per day per person.

Pacific halibut is an important subsistence fishery in Alaska, where fish are caught for direct personal or family consumption as food or customary trade. Since 2003, fishers participating in the federal subsistence halibut sector must qualify as a recognized rural resident or tribal member to register for a Subsistence Halibut Registration Certification (SHARC) through NOAA (50 CFR 300).

Substantial Pacific halibut volume is also taken as bycatch, particularly in the groundfish fishery, mostly taken by trawlers. These catches used to be subject to fixed allocation, unchanging despite fluctuating regional allocations set based on the stock's condition. On 13 December 2021, the NPFMC's action tied Pacific halibut bycatch limits for the Amendment 80 fleet (groundfish trawlers) to Pacific halibut abundance (Pacific halibut abundance-based management, NPFMC motion C2 Halibut ABM from 13 December 2021). This recommendation is yet to be adopted by the NMFS.

Regulatory environment - British Columbia

In British Columbia, individual vessel quotas (IVQs) were implemented in the halibut "L" licensed fishery in 1991. This stabilized the season and allowed for increased fresh fish sales, better product quality, and a wider choice of processing options for fishers, including the option to directly market the catches to wholesalers, retailers, institutional purchasers, and restaurants (Squires, Kirkley and Tisdell, 1995; Homans and Wilen, 1997; Hackett *et al.*, 2005). Since the introduction of IVQs, gradually more flexibility was introduced to the scheme. Limited temporary transferability was introduced in 1993 and full temporary and permanent transferability in 1999. Currently, the transferability between "L" license holders is only restricted by the minimum and maximum holdings on the license and the minimum unit of transfer – 1 lb. There is evidence of increasing control over Pacific halibut fisheries by processors, who doubled their ownership of quota between 1996 and 2016 (Edwards and Pinkerton, 2019).

Apart from "L" license fishery, in the effort to repatriate fishing opportunities to Indigenous people, an indigenous communal "FL" license was introduced in the 1990s. In 2018, combined holdings of "FL" designation accounted for about 16% of the Pacific halibut allocation to British Columbia (IPHC area 2B). Much of the increase can be attributed to the government buyback of "L" licenses and transferring them to "FL" designation occurring since 1997. First Nations members in British Columbia also have access to a separate Pacific halibut fishery for food, social, and ceremonial purposes.

Up to 2003, the Canadian sport anglers were restricted only by bag and possession limits. Since 2004, a fixed share of the Canadian portion of Pacific halibut TAC is allocated to recreational fishing. Season length adjustments, reduced bag and possession limits, and area closures are used to maintain the sport catch within its allocation. Since 2019, Fisheries and Oceans Canada (DFO) is also testing a program that provides recreational harvesters an opportunity to retain halibut in excess of the size and daily possession limits under the Tidal Waters Sport Fishing License by leasing quota from a commercial sector. The Experimental Recreational Halibut Program (XRQ), however, has been put on hold in 2020 due to the covid-19 outbreak. The program resumed in 2021.

Regulatory environment – US West Coast

The overall limit for area 2A is set by the IPHC and distributed between user groups according to the Catch Sharing Plan (NOAA, 2020) set by Pacific Fishery Management Council (PFMC). This plan allocates 35% of the area 2A TAC to US treaty Indian tribes in the state of Washington in subarea 2A-1, and 65% to non-Indian fisheries in Area 2A.

Pacific halibut directed commercial fishery on the US West Coast remains the last non-tribal derby fishery for halibut. It operates based on 10-hour openings with catch restrictions based on vessel size and a requirement to obtain a license from the IPHC. In 1995, an option to opt for the incidental catch fishery during the salmon troll fishery was introduced, and in 2001, the retention of incidentally-caught halibut during the longline sablefish fishery north of Point Chehalis, Washington.

Since 1995, non-treaty fishers had to also choose between participating in commercial and charter fishery. The charter fishery in IPHC Regulatory Area requires a license from the IPHC and is managed by bag and possession limits. In-season adjustments to opening dates keep the west coast recreational fishery at or near its overall catch limit.

The Council has recently taken steps to transition routine management of the non-Indian commercial directed Pacific halibut fishery from IPHC to the Council and NMFS (PFMC, 2020).

In Washington state, thirteen tribes exercise treaty rights to obtain an allocation of the total Pacific halibut from the Indian treaty pool. The CSP gives provisions for a tribal commercial fishery and a ceremonial and subsistence fishery. Halibut taken for ceremonial and subsistence purposes may not be offered for sale or sold.

Fluctuations in abundance and fisheries output

The Pacific halibut Fishery Constant Exploitation Yield (FCEY), as adopted by the Commission at the time for each year, declined substantially, from a peak of over 76 mil. net lbs in 2004 to volumes fluctuating between 27 and 30 mil. net lbs since 2014 (**Figure 2**). The majority of the Pacific halibut stock biomass, and therefore the fishery yield, is located in the Gulf of Alaska, primarily in the IPHC regulatory area 3A. FCEY captures opportunities available to the stock users (i.e., fishers).

Currently, the Pacific halibut stock is estimated to be fully exploited, with recent levels of fishing intensity at or slightly below target, due to challenging recent fishery conditions. The stock is estimated to have been declining since 2016 and is currently at 33% of the unfished state. The spawning biomass is projected to continue to decrease slightly over the next three years. This relatively flat trajectory, following a period of low recruitment years from 2006-2011, is based on a 2012 cohort strongly represented in the 2021 FISS and fishery observations. As this cohort matures over the next 7 years it is expected to largely stabilize the stock and fishery near current levels. Size-at-age remains low relative to fluctuations observed over the last 100 years, resulting in reduced yield (on the order of 50%) for the same number of fish harvested in previous decades; however, younger Pacific halibut (< age-12) have shown some increase in size-at-age over the last 5 years. The distribution of the stock, and therefore available yield, is measured each year via the Fishery-Independent Setline Survey (IPHC, 2021), varies each year, with trends in the last 2 years increasing in the central portion of the stock (Biological Region 3, IPHC Regulatory Areas 3A-3B) and decreasing in Biological Regions 2 and 4 (IPHC Regulatory Areas 2A-2C, 4A, 4CDE).

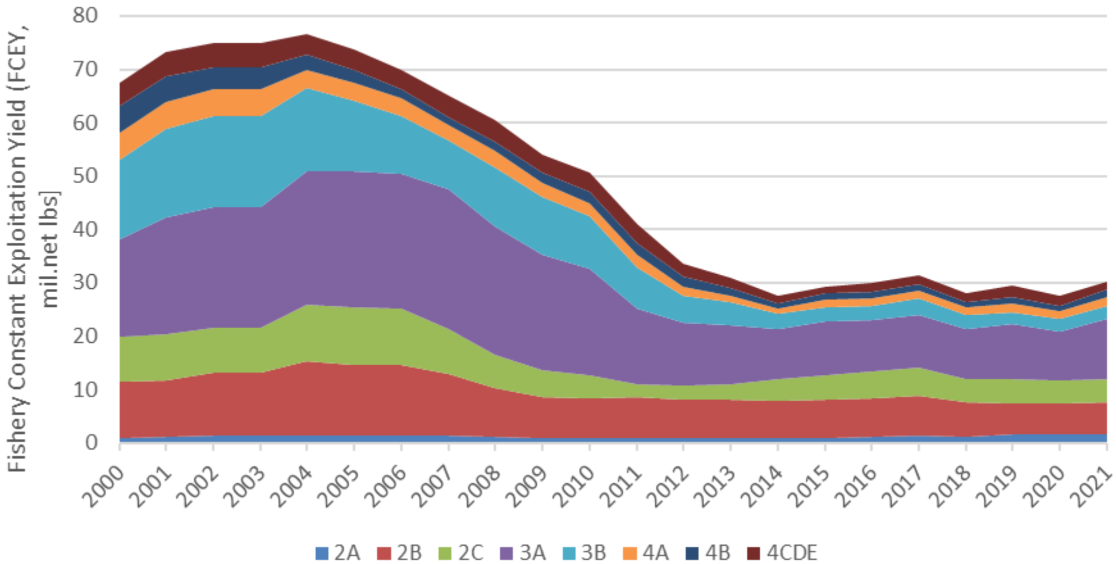


Figure 2: Pacific halibut Fishery Constant Exploitation Yield (FCEY, millions of net pounds) for each IPHC Regulatory Area (200-2021, table IPHC-2020-TSD-013), as adopted by the Commission at the time for that year. 2018 IPHC Regulatory area limits 'suggested' by the Commission and subsequently adopted by the contracting parties.

Size limits and U32 fish

Pacific halibut commercial fishery is subject to 32-inch minimum size limit (IPHC Fishery Regulations, section 19). However, since 2020 the IPHC sells Pacific halibut less than 32-inch (U32) that has been caught as a part of the FISS design. These fish, although limited in number, provide the first direct information on the price for U32 Pacific halibut for comparison with the price of fish larger than 32 inch (O32), as well as the critical price ratios found in the IPHC's analysis of size limits (**Table 1**, IPHC-2020-IM096-09).[9]

Table 1: Pacific halibut U32 vs. U32 price ratio (2020-2021).

	2020			2021		
	p U32	p O32	price ratio	p U32	p O32	price ratio
Coastwide	$4.16	$4.77	87%	$5.66	$6.91	82%
2A	*NA*	*NA*	*NA*	$3.45	$5.72	60%
2B	$5.70	$5.91	96%	$7.00	$8.12	86%
2C	$4.16	$4.57	91%	$6.23	$6.70	93%
3A	$3.72	$4.39	85%	$6.29	$6.97	90%
3B	$3.82	$4.43	86%	$5.84	$6.04	97%
4A-E	*NA*	*NA*	*NA*	$4.92	$5.46	90%

Notes: *NA* indicates that the survey design did not cover the specified IPHC Regulatory Area.

[9] The 2020 analysis found that if the relative price for U32 Pacific halibut is at least 63% of the price of current catch of O32 fish, then the fishery as a whole is projected to achieve equal or increased value if the minimum size limit was removed.

MODEL SETUP

The PHMEIA model is a multiregional SAM-based model developed with the specific purpose of assessing the economic contribution of Pacific halibut resource to the economy of the United States and Canada. The model reflects the interdependencies between eleven major sectors and two Pacific halibut-specific sectors.[10] The extended model (referred here as PHMEIA-r) introduces to the SAM also the saltwater charter sector that is disaggregated from the services-providing industry. The PHMEIA-r estimates assume that the economic impact of Pacific halibut charter fishing is equivalent to estimating the total economic loss resulting from the saltwater charter sector in each region shrinking by share of Pacific halibut effort in total effort. The results for the charter sector, however, should be interpreted cautiously because of the uncertainty on how much of the saltwater angling effort directly depends on Pacific halibut.[11]

The list of industries considered in the PHMEIA and PHMEIA-r models, as well as the primary commodities they produce, is available in **Table 2**. Production by these industries is allocated between three primary Pacific halibut producing regions, as well as residual regions to account for cross-boundary effects of fishing in the Pacific Northwest:

- Alaska (AK),
- US West Coast (WOC – including WA, OR, and CA),
- British Columbia (BC),
- rest of the United States (US-r),
- rest of Canada (CA-r), and
- rest of the world (ROW).

The ROW region in the model is considered exogenous. This implies that the trade relations with the ROW are unaffected by the changes to the Pacific halibut sectors considered in this project. While the full inclusion of the ROW component[12] would allow for assessment of impact outside Canada and the United States if trade with ROW was to be considered responsive to changes in Pacific halibut sector activity, this is not typically seen in the literature.

[10] Derived use of commodities by Pacific halibut sectors is appended to SUTs and subtracted from production by general fishing and processing industries.

[11] Additional analysis of the demand for Pacific halibut recreational trips is proposed in the *IPHC 5-year program of integrated research and monitoring* (2022-26) (IPHC-2021-IM097-12). Current results rely on the available statistics that do not necessarily reflect the willingness to substitute the target species. Estimates of the charter sector dependence on Pacific halibut can be also improved through participation of charter business owners in the IPHC economic survey. See Discussion and conclusions for details.

[12] ROW component could be constructed using, for example, World Input-Output Tables (WIOT, Timmer *et al.*, 2015).

Table 2: Industries and commodities considered in the PHMEIA and PHMEIA-r models.

	Industry	Primary commodity produced
1	Pacific halibut fishing	Pacific halibut
2	Other fish and shellfish fishing	Other fish and shellfish(1)
3	Agriculture and natural resources (ANR)	Agriculture and natural resources
4	Construction	Construction
5	Utilities	Utilities
6	Pacific halibut processing	Seafood
7	Other fish and shellfish processing	Seafood
8	Food manufacturing (excluding seafood manufacturing)	Food (excluding seafood)(2)
9	Manufacturing (excluding food manufacturing)	Manufactured goods (excluding food)
10	Transport	Transport
11	Wholesale	Wholesale
12	Retail	Retail
13	Services (including public administration)	Services (including public administration)
14	Saltwater charter sector(3)	Saltwater fishing trips

Notes: (1)In the case of Canada, other fish and shellfish commodity includes, besides wild capture production, also aquaculture output produced by the aquaculture industry that is a part of the ANR industry. Other fish and shellfish processing industry in the USA component, on the other hand, draws more on the ANR commodity that includes aquaculture output. While this misalignment between model components is not concerning as linking these is based on trade of aggregated seafood commodity, the SUTs are adjusted so that the Canadian and US model components are better aligned. (2)There is a slight misalignment between model components related to the allocation of beverage and tobacco manufacturing products that, in some cases, are considered non-durable goods and lumped with the food commodity. In the case of the USA component, this misalignment is corrected with the use of additional data available from the Annual Survey of Manufactures (ASM) (US Census, 2021a). (3)Saltwater charter sector extension included in PHMEIA-r model. Model results rely on the estimated share of the sector output that directly depends on Pacific halibut.

In this model, all wild capture production, including all Pacific halibut harvest, is assumed to be supplying the seafood processing industry (Pacific halibut commodity supplying Pacific halibut processing industry). This implies a broader scope of the processing sector that also includes entities responsible for product preparation and packaging. Under this assumption, Pacific halibut and other harvested species are sold to other industries or final users only as a seafood commodity[13] as opposed to a fish commodity. Leonard and Watson (2011) note that about 30% of fish harvested in the US West Coast flow directly to the seafood wholesale sector, but no data to make such a distinction are available to the Secretariat, and simplifying assumptions are made. At this stage, the model also omits the economic benefit of Pacific halibut not sold but retained by commercial fishers for personal consumption.

The model adopts exogenous changes to Pacific halibut processing based on constant margins for calculation of effects related to forward-link industries. This means the model assumes a proportional change between the Pacific halibut processing sector and the Pacific halibut fishing sector in each region. The model omits Pacific halibut impacts beyond the processing sector for reasons explained in subsection Forward linkages.

The model components are derived for the period 2014-2020, adopting the MR-GRAS technique (method details in section Adapting SAM to project needs). Extending the model to 2020 illustrates the Covid-19 impact on the Pacific halibut fisheries. The PHMEIA-r extension is available up to 2019 due to data availability lag. All values

[13] This is the reason why both industry 6 and 7 are assigned seafood as a primary commodity produced. This also implies a different total number of industries (13) and commodities (12) considered in the model.

are in producer prices, in current US dollars (Canadian dollars).[14] The additional details on each model component are available in the following two subsections: Base model for the United States and Base model for Canada. The subsection Linking model components explains how the model components are assembled into an integrated multiregional SAM model. The following subsections in the Data inputs section explain how Pacific halibut sectors are incorporated into the SAM matrix.

In addition to economic impact related to Pacific halibut sectors, PHMEIA-derived multipliers are used to estimate economic impact related to marine angler expenditures on fishing trips (travel, lodging, other trip-related expenses) and durable goods (rods, tackle, boat purchase, other fishing equipment and accessories, second home, or additional vehicle purchase).

DATA INPUTS

Base model for the United States

The matrix depiction of the economy of the United States is based on data published by the US Bureau of Economic Analysis (BEA, 2021a) supplemented with BEA Regional Data resources (BEA, 2021c), data from United States Census Bureau's Annual Survey of Manufactures (ASM; US Census, 2021) and Quarterly Census of Employment and Wages conducted by the US Bureau of Labour Statistics (QCEW; BLS, 2021).

The national SUTs from BEA's Input-Output Accounts Data (last updated in November 2021, include revised 2016-2019 data and the first release of 2020 data) are disaggregated into regional tables (AK, WOC, and US-r) using the method described in Adapting SAM to project needs and data from the species-based SAM developed by Seung, Waters, and Taylor (2019). The regional SAM used for updating, calibrated for 2014, is a partitioned matrix that consists of make, use, value added, and final demand tables for multiple Southwest Alaska regions, rest of Alaska, Alaska's at-sea operations, US West Coast, rest of the US, and data on exogenous accounts (capital account, government account and rest of the world account describing US imports and exports). For the purpose of PHMEIA, all Alaska regions, all fishing industries but the Pacific halibut fishing industry, all processing industries but the Pacific halibut processing industry, and all marine species besides Pacific halibut are aggregated. Aggregation of marine species implies two fisheries-sourced commodities – Pacific halibut and other fish and shellfish. Although the original regional model is calibrated for 2014, using the same set of data for updating the tables also for this year ensures model consistency over the years.

The ASM data, which includes statistics by state on employment, payroll, supplemental labor costs, cost of materials consumed, operating expenses, value of shipments and value added for manufacturing industries provides additional detail for disaggregation of the seafood processing sector from the food manufacturing sector included in the SUTs. The QCEW data supplements employment statistics published by the BEA (SAEMP25N: Total Full-Time and Part-Time Employment by NAICS Industry).

BEA regional data are also used to build into the model the household accounts. The model utilizes data on personal consumption expenditures (table SAPCE1), value added and income (SAGDP2N: GDP by state; SAGDP4N: Compensation of Employees, SAINC5N Personal Income by Major Component and Earnings by

[14] Following BEA's definition, current-dollar estimates are valued in the prices of the period when the transactions occurred - that is, at "market value." Also referred to as "nominal estimates" or as "current-price estimates."

NAICS Industry;[15] SAGDP3N: Taxes on production and imports less subsidies; SAGDP7N: Gross operating surplus[16]), and supplementary data on personal income taxes (table SAINC50), disposable income (SAINC30: Economic Profile) and gross flow of earnings (table SAINC91). The earnings outflows are split between destination regions using the average state-to-state flow reported by the Internal Revenue Service (IRS, 2020), and allocated between destination regions using BEA data on International Transactions (BEA, 2021b). Details on household accounts[17] by region are available in **Table 3** for 2019. Data for the remaining years in the model can be supplied upon request.

Table 3: Household accounts – USA 2019 [USD].

	AK	WOC	US-r	Source/table
[1] Employee compensation	29,108	2,069,338	9,361,006	SAGDP4N/SUTs
[2] Social contributions	3,224	248,685	1,202,296	SAINC5N/SAINC6N
[3] Net earnings from labor ([1] – [2])	25,8964	1,820,652	8,158,710	-
[4] Proprietors' income	3,164	295,311	1,302,138	SAINC5N
[5] Adjustment for residence	-197	-2,576	6,326	SAINC91
[6] Net earnings by place of residence ([3]+[4]+[5])	28,831	2,113,388	9,467,174	-
[7] Net property income(1)	8,498	645,265	2,999,795	SAINC5N
[8] Government transfers	7,965	486,609	2,644,479	SAINC5N
[9] Personal income ([6]+[7]+[8])	45,294	3,245,262	15,111,449	-
[10] Personal income taxes	3,394	451,234	1,751,589	SAINC50
[11] Disposable income ([9]-[10])	41,900	2,794,028	13,359,860	- (SAINC30)
[12] Households' expenditure	37,780	2,465,313	11,925,580	SAPCE1
[13] Household net savings ([11]-[12])	4120	328,715	1,434,280	-

(1)Includes dividends, interest, and rent.

Base model for Canada

The structure of the Canadian economy is based on data published by Statistics Canada (Statistics Canada, 2021b). Canada is one of the few countries that produce annual SUTs at the national and sub-national (by province) levels. Provincial SUTs are identical in structure to the national tables with one exception - the provincial tables include estimates of interprovincial trade. Consequently, the import column in the supply table and the export column in the final uses table are split into two columns each, to show international imports/exports and interprovincial imports/exports. To be compatible with the SUTs for the United States, Canadian tables are adjusted to producer prices[18] and converted to USD using exchange rates published by the Organisation for Economic Co-operation and Development (OECD, 2020a). Moreover, the tables are adjusted so that commodity MPG114000 (*Fish, crustaceans, shellfish and other fishery products*) is split between wild

[15] Note that earnings minus compensation of employees equals proprietors' income.

[16] Note that values in the SAGDP7N table need to be adjusted for proprietors' income derived from tables SAGDP4N and SAINC5N.

[17] Household accounts presents data on disposable income, spending, savings, debt and financial assets of households.

[18] Canadian SUTs are given in basic prices with trade and transportation margins allocated to relevant trade and transportation industries. *Use table: Taxes on products* is used to adjust the use tables to producer prices. To derive tables in producer prices, *Use table: Taxes on products* is used to adjust value for taxes on products, while subsidies on products are allocated proportionally to use.

capture fishery products and aquaculture products, with aquaculture products reallocated as an output of the ANR industry.

The most recent release of the SUTs by Statistics Canada includes tables up to 2018 (updated in September 2021). While there is no need to apply MR-GRAS technique to disaggregate Canadian SUTs into regions[19] as these are available by province, this technique is used to update the 2018 tables with a limited set of statistics that comprise these tables that are available for 2019 and 2020 from other Statistics Canada resources:

- Table 36-10-0402-01: *Gross domestic product (GDP) at basic prices, by industry, provinces and territories* (Statistics Canada, 2021j)
- Table 36-10-0221-01: *Gross domestic product, income-based, provincial and territorial, annual* (includes data on employee compensation, employer social contributions, and net mixed income) (Statistics Canada, 2021h)
- Table 16-10-0048-01: *Manufacturing sales by industry and province, monthly* (Statistics Canada, 2021e)
- Table 16-10-0117-01: *Principal statistics for manufacturing industries, by North American Industry Classification System (NAICS)* (Statistics Canada, 2021f)
- Table 12-10-0098-01: *Trade in goods by exporter characteristics, by industry of establishment* (Statistics Canada, 2021c)
- Table 25-10-0021-01: *Electric power, electric utilities and industry, annual supply and disposition* (Statistics Canada, 2021g)
- Table 14-10-0023-01: *Labour force characteristics by industry, annual* (Statistics Canada, 2021d)

Additionally, to fully account for the effects of personal income generated by industries and the feedback it provides to the economy, the household accounts were constructed using:

- Table 36-10-0432-01: *Detailed household final consumption expenditure - sales taxes and expenditure excluding sales taxes, provincial and territorial, annual* (reports on the flow of earnings) (Statistics Canada, 2021k)
- Table 36-10-0450-01: *Revenue, expenditure and budgetary balance - General governments, provincial and territorial economic accounts* (includes data on income taxes and government transfers to households) (Statistics Canada, 2021l)
- Table 36-10-0224-01 *Household sector, current accounts, provincial and territorial, annual* (includes data on net property income and other transfers related to households) (Statistics Canada, 2021i)

Details on Canadian household accounts by region are available in **Table 4** for 2019. Data for the remaining years in the model can be supplied upon request.

[19] As done for the SUTs representing the economy of the United States.

Table 4: Household accounts - Canada 2019 [USD].

	BC	CA-r	Source/table
[1] Employee compensation	114,990	769,984	36-10-0221-01
[2] Social contributions	14,463	105,690	36-10-0221-01
[3] Net income from labor ([1] – [2])	100,527	664,294	- (36-10-0221-01)
[4] Net mixed income	32,998	123,989	36-10-0221-01
[5] Adjustment for residence	2,513	-7,987	36-10-0432-01
[6] Net earnings by place of residence ([3]+[4]+[5])	136,037	780,296	-
[7] Net property income(1)	13,433	99,072	36-10-0224-01
[8] Government transfers	21,553	153,328	36-10-0450-01
[9] Personal income ([6]+[7]+[8])	174,336	1,029,972	-
[10] Personal income taxes	27,403	183,212	36-10-0450-01
[11] Disposable income ([9]-[10])	147,336	846,759	-
[12] Households' expenditure	146,318	833,144	36-10-0432-01(2)
[13] Household net savings ([11]-[12])	1,017	13,615	-

(1)Includes net property income and net of other transfers to and from households (e.g. related to non-profit institutions serving households and corporations). (2)Values reported here are adjusted for taxes on products calculated with MR-GRAS.

Linking model components

The two separate model components[20] that describe the economies of Canada and the United States are linked using the method suggested by Bachmann, Roorda, and Kennedy (2015) (details in section *Linking multiple regions*). Accordingly, international linkages are established through trade matrices. These, in turn, are constructed based on available trade statistics (Statistics Canada, 2021a; US Census, 2021b) and data on international transactions (BEA, 2021b; Statistics Canada, 2021g). For industries with no regional trade statistics available (some services), a split between destination regions is done based on regional GDP estimates. Interstate (for the USA) and interprovincial (for Canada) trade matrices are estimated as parts of each model component.

SAM matrix is used to calculate induced SAM-type effects, i.e., induced effects that take into account the flow of earnings between regions. Details on flows related to earnings from Pacific halibut sectors are provided in the following sections.

Pacific halibut commercial sectors

An essential input to the PHMEIA model is data on production structure (i.e., data on the distribution of revenue between profit and expenditure items) of investigated sectors. In the fisheries sector, the gross revenue (**Figure 3**) is the landed value of the catch, which in the case of the Pacific halibut fleet will include Pacific halibut catch and non-directed catch of other species (e.g., sablefish, lingcod, rockfish). The gross revenue must cover the cost of leasing the quota (when allowed, i.e., for Pacific halibut, this applies to British Columbia), operational

[20] Each model component comes in the form of a collection of matrices. This includes make matrix, use matrix, final demand matrix, and value added matrix for each region, as well as interstate (for the USA) and interprovincial (for Canada) transaction matrices that connect regions within each component.

costs, annual fixed costs, labour costs (crew share and captain share), and EBITDA (earnings before interest, taxes, depreciation, and amortization – long-run costs plus net profit[21]).

The model also incorporates the production structure for the Pacific halibut processing sector. The processing sector is supplied directly by Pacific halibut wild capture production and included in the model to account for the forward linkages in the estimated economic impact (details in section Forward linkages).

<table>
<tr><td rowspan="17">Gross revenue</td><td></td><td colspan="2">Lease fees</td><td rowspan="12">Short-run costs</td></tr>
<tr><td rowspan="16">After-lease revenue</td><td rowspan="5">Operational costs</td><td>License fees</td></tr>
<tr><td>Fuel</td></tr>
<tr><td>Bait & ice</td></tr>
<tr><td>Gear</td></tr>
<tr><td>Monitoring</td></tr>
<tr><td rowspan="4">Fixed costs</td><td>Insurance</td></tr>
<tr><td>Moorage</td></tr>
<tr><td>Maintenance</td></tr>
<tr><td>Other</td></tr>
<tr><td rowspan="2">Labor costs</td><td>Crew share</td></tr>
<tr><td>Captain share</td></tr>
<tr><td rowspan="5">EBITDA</td><td>Amortization</td><td rowspan="4">Long-run costs</td></tr>
<tr><td>Depreciation</td></tr>
<tr><td>Taxes</td></tr>
<tr><td>Interest</td></tr>
<tr><td>Net profit</td><td></td></tr>
</table>

Figure 3: Fishing sector cost and earnings categories. Adapted from Edwards (2019).

The US component of the model uses as a base for Pacific halibut fishing and processing in Alaska the data from the species-based SAM developed by Seung, Waters, and Taylor (2019) updated using annual estimates of landing value and wholesale value. Alaska's landings data are collected from mandatory trip tickets by the Alaska Department of Fish and Game (ADFG), then consolidated and disseminated (as aggregates) by the Alaska Fisheries Information Network (AKFIN, 2021). Commercial Operator's Annual Report (COAR, 2021) reports on the by species statewide raw input purchase cost and wholesale value of the processed seafood. COAR data on Pacific halibut are also available by COAR Areas (ADFG, personal communication), supplementing the county-level analysis for Alaska.

Pacific halibut-specific production structure for the WOC region is adapted from estimates for the West Coast provided directly by the authors of the NOAA input-output model for the Pacific Coast fisheries (Leonard and Watson 2011; Pacific halibut estimates not published). Then, the fisheries portion of the WOC component of the model is updated using data on Pacific halibut fishing in Washington, Oregon, and California (reported collectively as WOC) collected by the Washington Department of Fish and Wildlife (WDFW), Oregon Department of Fish and Wildlife (ODFW), and California Department of Fish and Wildlife (CDFW), respectively. Each of these state agencies requires submitting fish tickets reporting on Pacific halibut sales. These data are processed and disseminated by the PacFIN (PacFIN, 2021). No data on the wholesale value of Pacific halibut are routinely

[21] The SAM matrix incorporates net profit as proprietors' income. Proprietors' income is the excess of revenue over explicit production cost of owner-operated businesses.

collected for the US West Coast. The model uses the latest (2017) NOAA estimates on species-specific processor markups suggesting that for every dollar spent on Pacific halibut, the processors deliver USD 1.15 worth of product.

British Columbia's Pacific halibut commercial fishing production structure is based on average operational and fixed cost available in the literature (Edwards and Pinkerton, 2020) adjusted for quota leasing estimated from values published in Castlemain (2019). The production structure is used in the model in conjunction with annual estimates of landing value. Data on British Columbia's commercial fisheries landed volume and value are published in the *British Columbia Seafood Year In Review* (BCSYIR) by Canada's Ministry of Agriculture (AgriService BC, 2020) and are based on data received from fish slips collected by the DFO.

As no secondary data are available on British Columbia's Pacific halibut processing production structure, the allocation of expenditures for this sector follows general production structure in the *Seafood product preparation and packaging* sector adjusted for wages reported for Pacific halibut processing in BC (AgriService BC, 2018). The year-to-year changes in the scale of Pacific halibut processing operations are assessed based on the wholesale value for halibut published in the BCSYIR*.* These estimates, in turn, are based on the provincial Annual Fish Production Schedule (AFPS) survey which is sent to all British Columbia processers, receivers (buyers), and custom clients (all seafood sellers). Worth noting is that while the wholesale of Pacific halibut increased from 2018 to 2019, the *Seafood product preparation and packaging* sector in British Columbia is shrinking, noting a 21% drop in contribution to GDP over the same period, as reported by Statistics Canada (Statistics Canada, 2021j).

Data on commercial landing value (available for all regions for 1951-2020, **Figure 4**) suggest a considerable increase in Pacific halibut output driven by Alaska fisheries since the 1980s. However, revenue has been decreasing throughout the last decade. The statistics for recent years (years included in the model) are available in **Table 5**.

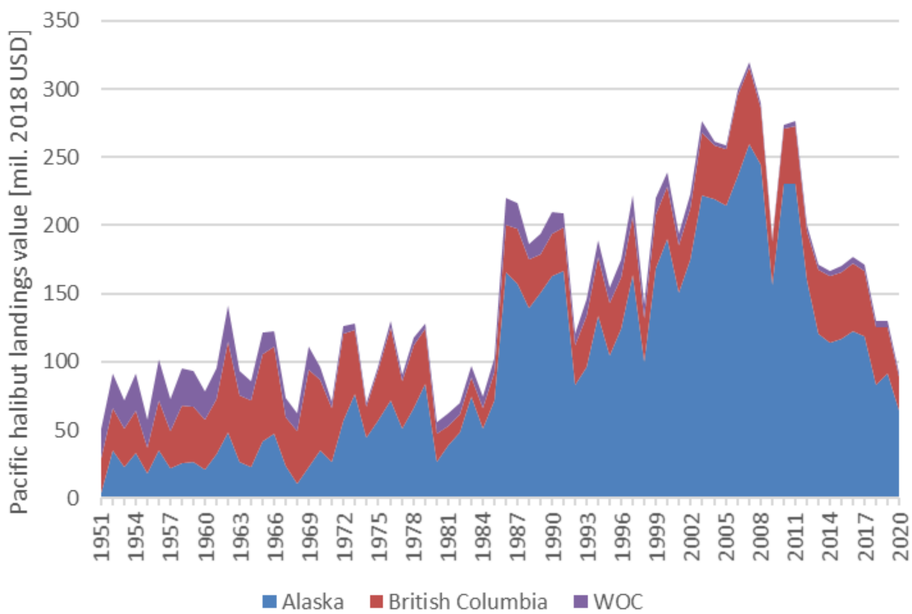


Figure 4: Pacific halibut landings value (1951-2020) in 2018 USD.

Table 5: Summary of available data on Pacific halibut landings and wholesale value.

Region	2014	2015	2016	2017	2018	2019	2020	Unit	Source
Pacific halibut commercial landings value									
AK	105.3	112.0	118.9	117.1	88.0	94.1	66.6	mil. USD	AKFIN
BC	46.9	53.8	58.3	58.9	44.1	46.4	33.3	mil. CAD	Province of BC
WOC	3.7	3.9	4.6	4.6	4.2	5.0	3.3	mil. USD	PacFIN
Pacific halibut wholesale value									
AK	109.9	133.8	138.9	136.6	110.5	108.6	78.3	mil. USD	COAR
BC	106.9	98.5	94.9	70.4	65.9	75.1	64.6	mil. CAD	AgriService BC
WOC	1.17(1)	1.12(1)	NA	1.15(1)	NA	NA	NA		NOAA

Notes: NA indicates that the value is not available. All monetary values in current USD/CAD, as reported in the cited source. (1)No wholesale value data available. Instead, the table reports on markup values for Pacific halibut.

To report on the direct economic impact in terms of the number of jobs, the model also utilizes the available employment estimates. Data on employment in major fisheries in Alaska, including Pacific halibut fisheries, is compiled on a monthly basis by the Alaska Department of Labor and Workforce Development (AK DLWD, 2021). Share of nonresident wages in fisheries is reported annually in the report *Nonresidents Working in Alaska* (Kreiger and Whitney, 2021). Statistics Canada (2021d) reports annually on employment in *Fish, hunting and trapping* sector, but no estimates specific to the Pacific halibut fishery are available. No specific estimates on jobs in Pacific halibut fishing are available for the US West Coast states, and these are derived as a share of the total employment in fishing reported in *Fisheries Economics of the United States* (NOAA, 2021a).

In terms of employment in processing, AK DLWD reports on the number of resident and non-resident workers in the Alaska seafood industry, as well as the associated wages (AK DLWD, 2021). Estimates of employment in seafood processing in the lower 48 are available from the *Quarterly Census of Employment and Wages* (BLS, 2021). Pacific halibut supported share of processing employment is derived based on the portion of the wholesale value associated with Pacific halibut products. Detailed data on employment and wages in British Columbia seafood processing are available via AgriService BC series of publications *British Columbia Fish Processing Employment* (AgriService BC, 2018). The statistics are reported by species, with estimates based on the additional information each company provides on the species groups that are processed in the facility and the estimated percent of jobs attributed to each group. The latest report from 2018 includes data up to 2016.

Cross-regional flows of earnings

The model specifies the flow of earnings related to Pacific halibut sectors. If the vessel or quota share is owned by a nonresident, the returns to that property or holding leak away from the area of resource extraction towards the owner's place of residence. The outflow of earnings also occurs when wages are paid to nonresidents. Pacific halibut-specific earnings flows are accommodated in the SAM model through transaction matrices (i.e., Te21 or Te12 in Appendix A). Flows specific to Pacific halibut are depicted in Appendix B.

In 2020, about 37% of Alaska quota share units were reported as owned by residents of other states, mainly Washington, about 23%, but this includes also landlocked states. Moreover, about 16% of vessels fishing halibut (under IFQ or CDQ license) were registered as owned by a resident of a state other than Alaska. Most of Alaska's harvest is landed in state (97% in 2019 and 2020), although some is delivered to ports in Washington or Oregon. Detailed statistics on the structure of beneficial ownership of Pacific halibut fishing in Alaska have been compiled using eLandings data and information available CFEC Public Search Application (CFEC, 2021b, 2021a), and are available in **Table 6**. Landing values from fish tickets matched with permit owner and vessel owner information were also used to derive flows related to profits in the PHMEIA SAM matrix. When the residence of the permit owner and vessel owner differs, the model applies a fifty-fifty split.

In case of Canada, the cross-provincial transfer of benefits related to harvest profit is less pronounced. While the distribution issue is present, it is more of a question whether the quota owner is an active participant or investor (Edwards and Pinkerton, 2019). Most of the non-participants live in British Columbia, although many in the lower mainland, far from fishing grounds (UBC, personal communication). According to DFO's Fishing License Statistics, no vessel holding a Pacific halibut quota is registered as foreign, but it is important to note that there is no rule against it (House of Commons Canada, 2019).

The majority of the commercial licenses in the WOC region are held by residents of Washington, Oregon, and California (99%), implying that the vast majority of profits are retained within the region.

Table 6: Beneficial ownership of AK Pacific halibut fishery in 2020.

Vessel owner's state of residence	Permit (quota) owner's state of residence	Landed value [mil. USD]	Unique vessels	Unique permits	Revenue share	Landed in AK
AK	AK	40.7	572	903	67.7%	100%
AK	WOC	2.9	36	40	4.8%	98.5%
AK	US-r	1.3	21	21	2.2%	100%
WOC	AK	1.2	14	19	2.0%	100%
WOC	WOC	11.3	68	90	18.8%	87.3%
WOC	US-r	1.7	7	8	2.8%	94.6%
US-r	AK	0.2	4	6	0.4%	100%
US-r	WOC	*	*	*	*	*
US-r	US-r	0.6	10	11	1.0%	100%

Note: Compiled using eLandings data on the value of landings and information from the CFEC Public Search Application. Includes only landings under IFQ and CDQ management program. *Indicates values removed to preserve confidentiality (less than three vessels or permits).

The flow of earnings is also associated with labor compensation. When wages are paid to non-residents, the majority of that money will flow to the place of their primary residence. While no statistics on the composition of employment in the Pacific halibut fisheries sector are available for the regions considered in the model, some notable general statistics are worth mentioning. According to the AK DLWD, nonresidents made up 20.8% of Alaska's workforce in 2019 and earned 15.3% of wages (Kreiger and Whitney, 2021). This share is considerably higher, reaching 61.2%, for the fishing sector. However, the preliminary results from the IPHC economic survey focused on the Pacific halibut fleet suggest more local employment in this part of the fishing sector. Consequently, PHMEIA assumes the following composition of the labor force (in terms of wages) in the Pacific halibut fishing sector: 78% Alaska residents, 20% residents of the US West Coast and 2% residents of other US states. Due to the currently low sample size, the adopted estimates on the cross-state flow of wages in the Pacific halibut fishing sector are subject to change. Kreiger and Whitney (2021) also report that nonresidents made up 68.3% of the 2019 workforce in the *Seafood processing* sector. The model adopts the same share to Pacific halibut processing, assuming there is no significant difference in the operations of processing plants depending on the species. The nonresident origin is assumed to follow the general trends reported by the Internal Revenue Service (IRS, 2020).

No equivalent estimates were identified for British Columbia or the US West Coast. The model applies no earnings flows related to the residency of employees in these two regions.

Cross-county flows in Alaska

According to 2020 data from eLandings combined with information on vessels and permits available via CFEC (details in **Table 7**), the county of landing matched the county of vessel owner residence for about 48.5% worth of Alaskan harvest. When it comes to the residence of the permit owner, it matched the county of landing for 46.1% harvest value. Vessel homeport matched about 50.0% worth of landings. The direction of the flow of benefits from the landing area to vessel owner residence, quota holder residence, and vessel homeport location is depicted in **Figure 5**. Here, the inner circle represents the county where the fish was landed, and the outer circle represents the county where (1) the vessel owner resides, (2) where the quota owner resides, and (3) the vessel homeport is located. The width of the ring section represents the estimated value of landings.

Table 7: Cross-regional and cross-county flow of benefits related to the residence of the vessel owner, the permit owner, and vessel homeport. Based on 2020 data.

	Landing value	Value by the residence of the vessel owner	Change vs. landing value	Value by the residence of the quota holder	Change vs. landing value	Value by vessel homeport location(1)	Change vs. landing value
Aleutians East	5.69	0.62	-89.2%	0.67	-88.3%	1.23	-78.4%
Aleutians West	7.04	1.44	-79.6%	1.81	-74.3%	4.52	-35.9%
Anchorage	0	0.77	+	1.42	+	0.37	+
Bristol Bay	*	0	NA	0	NA	0	NA
Dillingham	0.05	0.06	25.7%	0.06	25.7%	0.06	25.7%
Fairbanks North Star	0	*	+	*	+	0	+
Haines	*	1.02	NA	0.72	NA	0.38	NA
Hoonah-Angoon	1.64	0.76	-53.7%	0.65	-60.6%	0.97	-40.9%
Juneau	5.81	2.96	-49.1%	2.87	-50.5%	6.04	4.0%
Kenai Peninsula	16.81	12.50	-25.6%	10.44	-37.9%	11.69	-30.5%
Ketchikan Gateway	0.82	0.81	-0.9%	0.89	9.3%	1.05	27.8%
Kodiak Island	6.29	6.97	10.7%	5.74	-8.8%	8.30	31.9%
Lake and Peninsula	0	*	+	*	+	*	+
Matanuska-Susitna	0	2.01	+	1.30	+	*	+
Nome	0.57	0.57	0.0%	0.57	0.0%	0.49	-13.8%
Petersburg	3.79	6.32	66.6%	6.58	73.5%	7.15	88.5%
Prince of Wales-Hyder	0.51	0.52	1.9%	0.55	7.8%	0.61	18.4%
Sitka	1.07	1.92	79.1%	1.79	67.7%	2.04	91.2%
Southeast Fairbanks	0	1.14	+	1.04	+	*	+
Skagway	*	0	NA	*	NA	0	NA
Valdez-Cordova	3.53	1.26	-64.2%	1.95	-44.9%	1.78	-49.6%
Wrangell	1.16	1.25	7.7%	1.15	-1.1%	1.10	-5.3%
Yakutat	3.68	1.95	-47.0%	1.83	-50.1%	1.61	-56.3%
WOC	1.57	14.22	803.4%	14.33	810.7%	10.34	556.7%
US-r	0	0.96	+	3.60	+	0	+

Notes: * indicates confidential values, representing less than three vessels; + represents a positive flow when the landing base was zero. (1)Vessel homeport was not identified for about USD 228,600 worth of landings.

(1) Landing area vs. vessel owner residence (2) Landing area vs. permit owner residence (3) Landing area vs. vessel homeport location

Figure 5: Direction of the flow of benefits from the landing area to (1) vessel owner residence, (2) quota holder residence, and (3) vessel homeport location. Plots use 2020 data.

The majority of the Pacific halibut buyers (according to the 2020 data) were located in Alaska (97.8% in terms of value); 2.2% worth of harvest went to out-of-state buyers and could not be traced further. Within Alaska, 99.7% of buyers were shorebased processors. Processing typically occurs in the buyer's location. Only about 10.9% of the harvest in terms of landing value went through custom processing, of which 23.9% was in a place different to the location of the buyer, typically right where it was landed (100%). The remaining harvest (i.e., not going through custom processing) matched the landing county for about 91.4% of landings in terms of value, with the remainder going through buying stations located at the landing location.

Following the flow of revenues further, about 58.9% worth of harvest purchased by shorebased processors was purchased by shorebased processors that listed as a point of contact a county other than the location of the processing facility. What is more, 96.3% of the above value can be traced to processors with a point of contact on the US West Coast. Note that the share here was calculated based on the original landing value and does not account for variation in wholesale value dependent on the type of produced outputs.

Figure 6 depicts the flow of revenue from the harvest location to the processor point of contact. Here, nods represent spatial aggregations:

- blue – harvest by IPHC Regulatory Areas;
- red – county of the landing site;
- yellow – if ordered, county of the custom processing;
- green – county of the reported buyer (location of the buying station not included in the figure);
- purple – location of the Fisheries Business License holder (based on the contact address).

Ribbons represent flows in terms of the estimated value of landings (in mil. USD; not adjusted for value added through processing):

- blue ribbons represent the flows from harvest grounds to landing sites in Alaska;
- grey ribbons represent the flows between nodes that are located in the same Alaskan county;
- orange ribbons represent the flows between nodes that are located in different counties;
- red ribbons represent the flows out of Alaska.

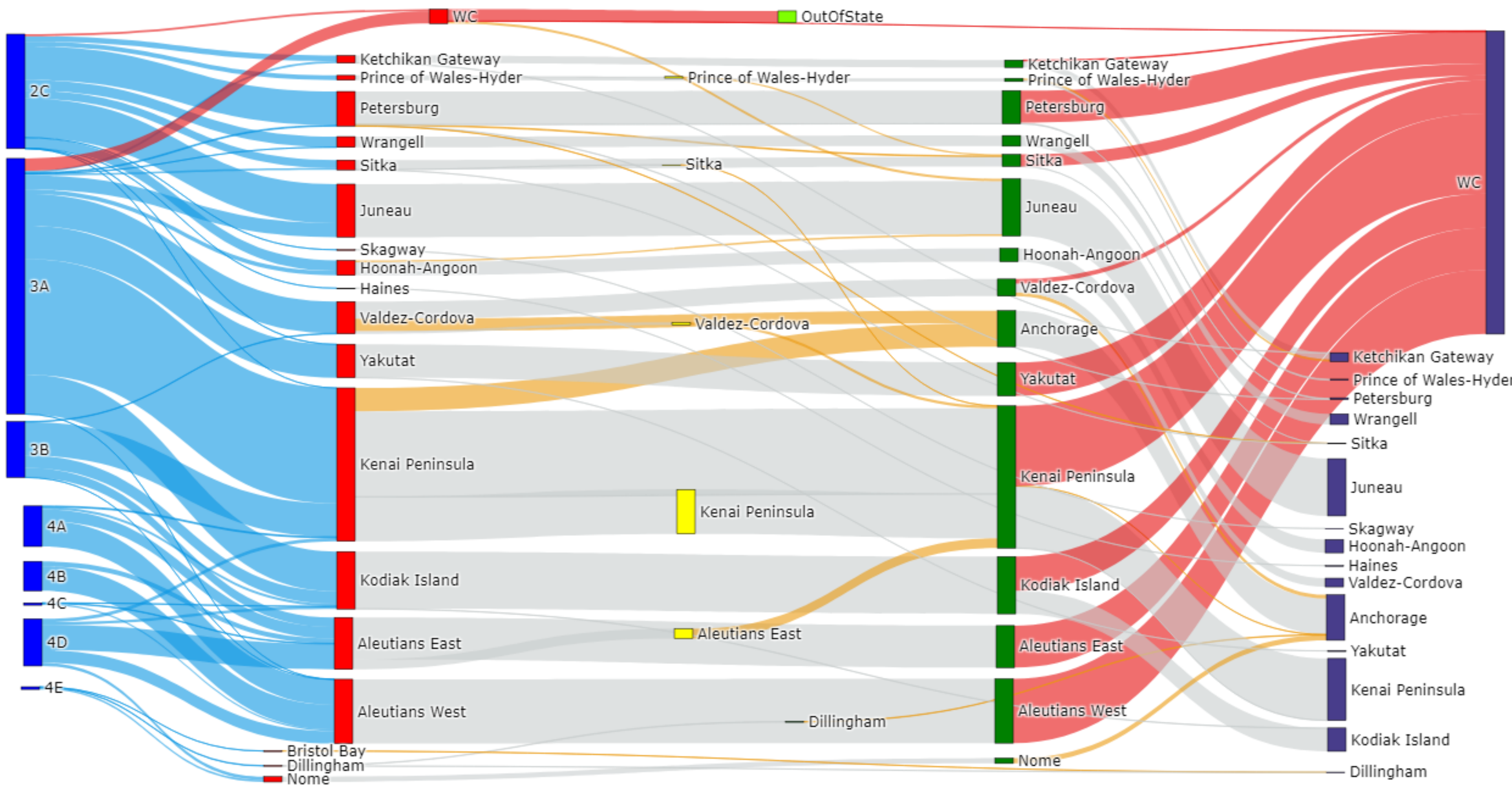


Figure 6: Flow of Pacific halibut harvest from harvest location to buyer's headquarters. Plot uses 2020 data.

Pacific halibut recreational fishing

PHMEIA-r expands the PHMEIA model and incorporates into the SAM matrix production structure for saltwater charter fishing. Using the estimated share of charter fishing effort directly dependent on Pacific halibut, the extended PHMEIA-r provides estimates of the economic impact of the Pacific halibut charter sector.

Production structure for the charter sector in Alaska is adopted from Seung and Lew (2017) and updated using results of the latest cost, earnings, and employment in the Alaska saltwater sport fishing sector survey (Lew and Lee, 2019). Alaska charter owners are regularly surveyed on their costs and earnings (Alaska Saltwater Sport Fishing Charter Business Cost and Earnings Survey). The survey was previously administered in 2012, 2013, 2014, and 2016 to collect data on the 2011-2013 and 2015 seasons. The latest survey, administered in 2018, describes the 2017 fishing season. The earnings are then allocated between regions according to the ownership structure of Alaskan Charter Halibut Permits (CHPs) derived in terms of the number of endorsed anglers. The adopted in the model flow of earnings for the charter sector is depicted in **Figure 7**. No statistics on labor composition in the charter sector were identified.

The annual variation in sport fishing participation is derived from the Alaska Sport Fishing Survey that the Sport Fish Division of the ADFG conducts annually to estimate sport fishing total harvest, total catch and participation in the number of anglers, the number of days fished, and the number of trips by type (bottomfish, salmon, mix).[22] Pacific halibut share is estimated as a share of bottomfish trips in total saltwater angler trips. This excludes mixed trips as it is assumed that these would still take place even if Pacific halibut was excluded from the choice set. Share of resident charterer angler-days is based on Marine Recreational Information Program (MRIP) query results (NOAA, 2021c). Non-residents anglers are then distributed between regions outside Alaska based on the report by Southwick Associates (2014).

[22] Estimated number of trips by type is available for 2010-2014 in Powers and Sigurdsson (2016). The more recent estimates were provided to the IPHC directly by the ADFG. General recreational effort statistics are available through the ADFG website (ADFG, 2021).

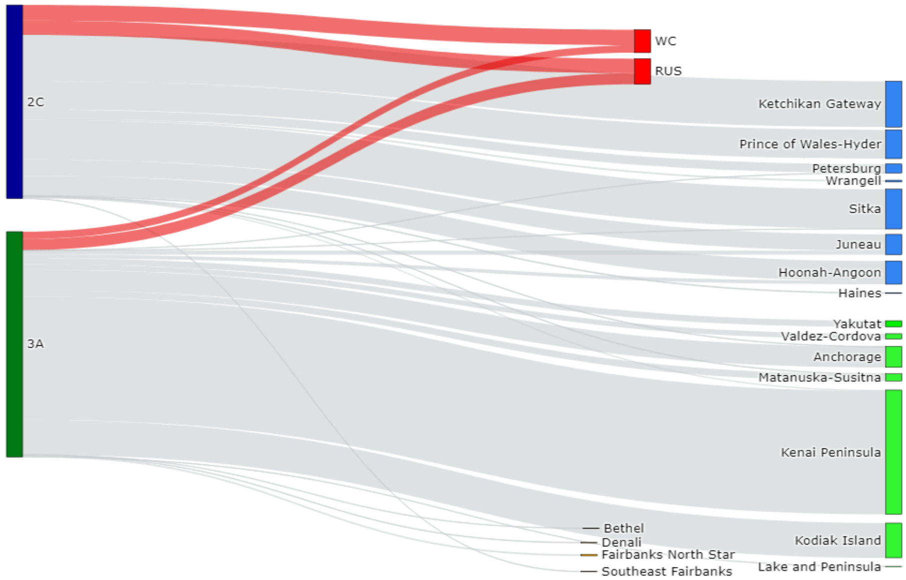


Figure 7: Ownership structure in Alaska charter sector. Plot uses 2020 data.

On the US West Coast, marine recreational fishing is monitored by the Pacific Coast Recreational Fisheries Information Network (RecFIN, 2021). RecFIN surveys include the Ocean Sampling Program and Puget Sound Sampling Program, administered in Washington, the Ocean Recreational Boat Survey and Shore and Estuary Boat Survey, administered in Oregon, and the California Recreational Fishing Surveys. Participation in the recreational fishery is reported in terms of the number of angler trips and the number of boat trips per region, mode, and trip type. Trip type is defined in terms of target species.

For the charter sector in the WOC region production structure, the PHMEIA-r model utilizes data from the NOAA input-output model for the Pacific Coast fisheries (Leonard and Watson, 2011) for distribution of revenue estimates updated using trends reported by RecFIN. WOC revenue for the guided sector is assessed based on the values reported in the report *The Economic Contribution of Marine Angler Expenditures in the United States* (Lovell, Steinback and Hilger, 2013), using the charter fees and crew tips expenditure categories.

Pacific halibut share is derived based on the share of angler-trips designated as halibut trips by RecFIN (in 2019, 0.9% for charter sector, 1.8% for the recreational sector overall). The Pacific halibut earnings are assumed to be mostly retained within the WOC region as 99% of 2A Pacific halibut sport licenses are held by residents of Washington, Oregon, and California. The out-of-state participation rate is derived from the MRIP query.

Catch and effort data for recreational fishing in British Columbia is collected using the Internet Recreational Effort and Catch (iREC) reporting program. The program collects information every month from randomly selected participants on fishing activity including kept and released catch of over 80 species of finfish and shellfish, as well as effort information by date, area, and fishing method. Canadian catch and effort data is also collected via logbooks, lodge manifests, and recreational creel surveys.

Effort estimates for British Columbia are used to approximate annual changes in revenue reported for 2015 in DFO's nation-wide *Survey of Recreational Fishing in Canada* (DFO, 2019). Revenue for the guided sector is assessed based on the results for the anglers' expenditures on the package deals and fishing services. The distribution of BC revenue between expenditure items follows estimates for the WOC region. Recreational sector dependence on Pacific halibut was estimated using BC annual recreational limit and general estimates for the IPHC Regulatory Area 2A.

Demand for goods and services related to anglers' fishing trips, both guided and unguided, also contributes to the economy. In addition to economic impact related to Pacific halibut sectors, PHMEIA-derived multipliers are used to estimate economic impact related to marine angler expenditures on fishing trips (travel, lodging, other trip-related expenses) and durable goods (rods, tackle, boat purchase, other fishing equipment and accessories, second home, or additional vehicle purchase).

Periodically, all anglers in the United States are surveyed about their annual expenditures on saltwater recreational fishing. The latest survey covering both trip-based expenditures (e.g., ice, bait, and fuel) and cost of fishing equipment and other durable goods (e.g., fishing rods, fishing tackle, and boats) was conducted in 2011 (Lovell, Steinback and Hilger, 2013). A reduced scope survey, inquiring only about expenditures on durable goods, was conducted last in 2014 (Lovell *et al.*, 2016).[23]

BC Stats reports on key indicators for sport fishing, including GDP, revenue, employment, and wages associated with sport fishing activities in *British Columbia's Fisheries and Aquaculture Sector* report, but the latest data are available for 2016 (Sun and Hallin, 2018). The revenues therein are based on the *Survey of Recreational Fishing in Canada* conducted in 2015 (DFO, 2019). The survey targets all individuals identified in the provincial and territorial recreational fishing license databases and inquiries about direct expenditures associated with their fishing trips.

Table 8 summarizes available recreational fishing statistics, including data on participation, revenue, and expenditures in all Pacific halibut producing regions.

[23] Expenditures on durable goods accounted for 33% and 66% of the total expenditures in 2011 in Alaska and WOC, respectively.

Table 8: Recreational fishing statistics – available data on participation, revenue and expenditures.

Region	2014	2015	2016	2017	2018	2019	2020	Unit	Source
Effort – saltwater recreational fishing									
AK	876.5	890.1	782.4	811.9	773.7	829.7	565.6	1000 angler-trips	(NOAA, 2021c)
BC	NA	2,014.3	*NA*	*NA*	*NA*	*NA*	*NA*	1000 angler-days	(DFO, 2019)
WOC(1)	2,844.8	2,939.3	2,664.3	2,733.0	1,796.8	1,832.6	1,389.8	1000 angler-trips	(RecFIN, 2021)
Effort - saltwater party/charter/guided fishing									
AK	248.9	253.8	255.1	260.3	262.4	262.6	*NA*	1000 angler-days	ADFG
BC	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	-	-
WOC(1)	653.2	713.1	657.0	667.2	654.4	670.8	452.1	1000 angler-trips	(RecFIN, 2021)
Participation in Pacific halibut recreational fishing									
AK-guided(2)	199.4	199.4	205.0	205.7	210.5	210.3	191.6(3)	1000 angler-days	(Webster and Powers, 2020)
AK-unguided	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	-	-
BC	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	-	-
WOC-charter(4)	5.4	5.8	5.7	6.9	5.6	5.9	4.57	1000 angler-trips	(RecFIN, 2021)
WOC-private(4)	18.9	20.7	26.2	28.2	27.3	26.2	23.55	1000 angler-trips	(RecFIN, 2021)
Business revenue from saltwater recreational fishing									
AK	*NA*	116.1(5)	*NA*	111.5(5)	*NA*	*NA*	*NA*	mil. USD	(Lew and Lee, 2018, 2019)
BC	598.2	626.9(6)	655.7	*NA*	*NA*	*NA*	*NA*	mil. CAD	(Sun and Hallin, 2018; DFO, 2019)
WOC(7)	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	-	-
Expenditures on saltwater recreational fishing									
AK	115(8)	122.4(5)	*NA*	89.2(5)	*NA*	*NA*	*NA*	mil. USD	(Lovell *et al.*, 2016; Lew and Lee, 2018, 2019)
BC	*NA*	578.1	*NA*	*NA*	*NA*	*NA*	*NA*	mil. CAD	(DFO, 2019)
WOC	2219(8)	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	mil. USD	(Lovell *et al.*, 2016)

Notes: *NA* indicates that the value is not available. All monetary values in current USD/CAD, as reported in the cited source. (1)Includes estuary fishing. (2)Effort here is defined as angler-days with recorded bottomfish hours or harvest of at least one halibut. However, because mix trips are commonplace in Alaska, the PHMEIA-r model adopts the share of reported bottomfish trips (excluding mix trips) vs. all saltwater trips, to calculate the share of Pacific halibut dependent effort. (3)Forecast. (4)In general this could include California halibut (species not specified), although no halibut trips are reported for California. (5)Includes only the charter sector. (6)Revenue for the guided sector in the PHMEIA-r model is assessed based on the results of DFO's Survey of Recreational Fishing in Canada, and follows from the estimates on the anglers' expenditures on the Package Deals and Fishing Services. (7)Revenue for the guided sector in the PHMEIA-r model is assessed based on the values reported in the report *The Economic Contribution of Marine Angler Expenditures in the United States* (Lovell, Steinback and Hilger, 2013), using the following expenditure categories: charter fees and crew tips. (8)Includes only expenditures on durable goods. These accounted for 33% in Alaska and 66% in WOC of the total expenditures in 2011 (Lovell, Steinback and Hilger, 2013).

MODEL RESULTS

The PHMEIA model results suggest that Pacific halibut commercial fishing's total estimated impact in 2019 amounts to USD 195.9 mil. (CAD 259.9 mil.) in earnings,[24] including an estimated USD 52.5 mil (CAD 69.7 mil) in direct earnings in the Pacific halibut commercial fishing sector and USD 12.2 mil. (CAD 16.1 mil.) in the processing sector, and USD 179.1 mil (CAD 237.6 mil.) in household income.[25] The results also suggest that Pacific halibut commercial fishing contributed USD 279.7 mil. (CAD 371.1 mil.) to the GDP of Canada and the United States, created over 5,000 jobs and is linked to over USD 550 mil. (CAD 730 mil) of output of Canadian and American economy (**Table 9**). This is about 4.1 times the fishery output value of USD 134.1 mil. (CAD 177.9 mil.) recorded for 2019.

Table 9: Economic impact of Pacific halibut commercial fishing (2019).

	Value in mil. USD*	Value in mil. CAD	Value (in mil. USD/CAD) per 1 mil. USD/CAD of output
Value of landings	134.1	177.9	-
Economic impact - output**	550.9	731.0	4.1
Economic impact – contribution to the GDP	279.7	371.1	2.1
Economic impact – earnings	195.9	259.9	1.5
Economic impact – wages	145.2	192.6	1.1
Economic impact - employment	5058		37.7/28.4
Household income	179.1	237.6	1.3

*With exception of employment, which is reported in number of jobs.**Adjusted for processing value added only; does not include the fish buying cost.

Detailed results are provided for 2019 as this represents a more typical year for the economy. The estimates for 2020 suggest that Pacific halibut commercial sectors' contribution to households decreased by 25%, and output related to Pacific halibut commercial fishing decreased by 27%. **Figure 8** depicts EI estimates for Pacific halibut commercial fishing for 2014-2020 in comparison with landed value. To make the values comparable over time, the estimates are adjusted for inflation and expressed in 2020 USD.[26] The figure also reports on Pacific halibut contribution to personal income in Alaska as a share of total income. This has been decreasing from ca. 0.5% in 2014-2017 to 0.3% in 2020.

[24] Earnings include both employee compensation and proprietors' income.

[25] Income reflects earnings adjusted for any transfers, including interregional spillovers, i.e., income is related to the place of residence, not the place of work.

[26] The adjusted estimates use the GDP deflator based on data published by the Organisation for Economic Co-operation and Development (OECD, 2021).

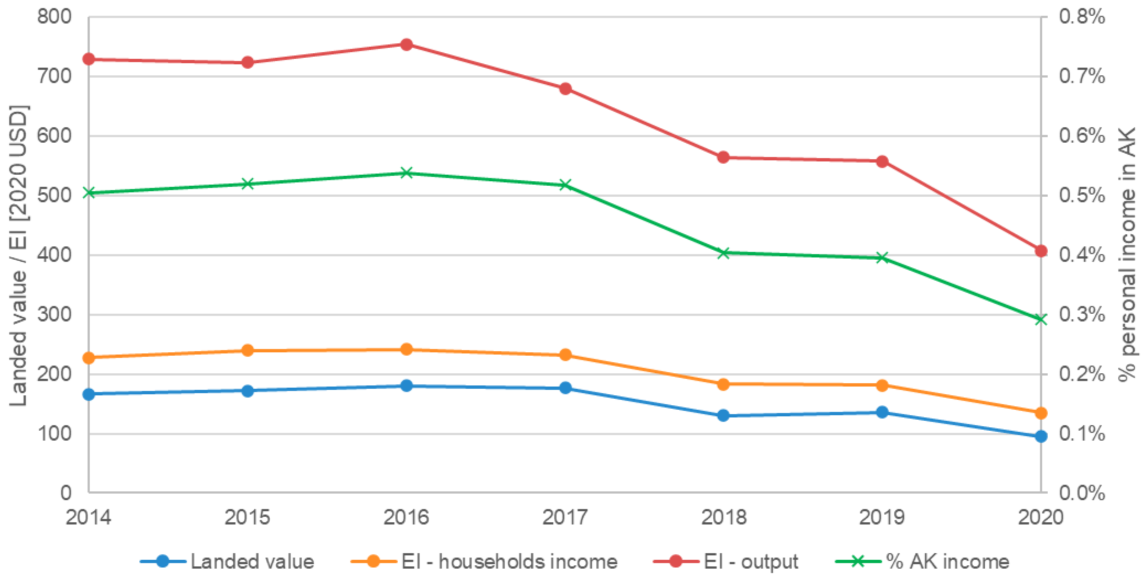


Figure 8: Pacific halibut commercial fishing EI estimates for 2014-2020 in comparison with landed value in mil 2020 USD, and Pacific halibut contribution to personal income in Alaska as a share of total income (secondary axis).

The charter sector contribution to economic activity is estimated at USD/CAD 3.4 per one USD/CAD spent on party/charter fishing services, adding to USD 132.6 mil (CAD 176.0 mil) economic impact in terms of output. The total contribution of the Pacific halibut charter sector to household income is assessed at USD 42.2 mil. (CAD 55.9 mil.) for 2019 (**Table 10**, including a comparison with the commercial sector). Accounting for angler expenditures on fishing trips and durable goods adds another USD 104.7 mil. (CAD 139.0 mil.) to the impact of recreational fishing on households' welfare. This translates into 19% less per 1 USD/CAD of output for the charter sector and 45% less for the recreational sector overall in comparison with the commercial sector when looking at impact per USD/CAD of landed value (for the commercial sector) and USD/CAD spent (for the recreational sector, including trip costs and expenditures on durable goods). This is not surprising since the commercial sector's production supports not only suppliers to the harvesting sector, but also the forward-linked processing sector (thus, also households employed by these sectors). Recreational sector results, on the other hand, to a large degree are driven by expenditures on goods that are often imported, consequently supporting households elsewhere.

A somewhat different picture emerges when comparing EI per pound of Pacific halibut removal counted against allowed catch by area in the stock assessment. This measure is 63% higher for the charter sector, and more than double for the recreational sector overall when compared with the commercial sector. These differences, however, are less pronounced when focusing only on the EI retained within the harvest region (56% and 139%, respectively).

The Pacific halibut recreational fishing total contribution to economic activity stands at USD 463.4 mil. (614.8 mil). Adding the commercial sector, the total economic activity linked to the Pacific halibut sectors is estimated at USD 1,014 mil. (CAD 1,346 mil), and contribution to households at USD 326 mil. (CAD 432 mil.). See Appendix C for the full set of results.

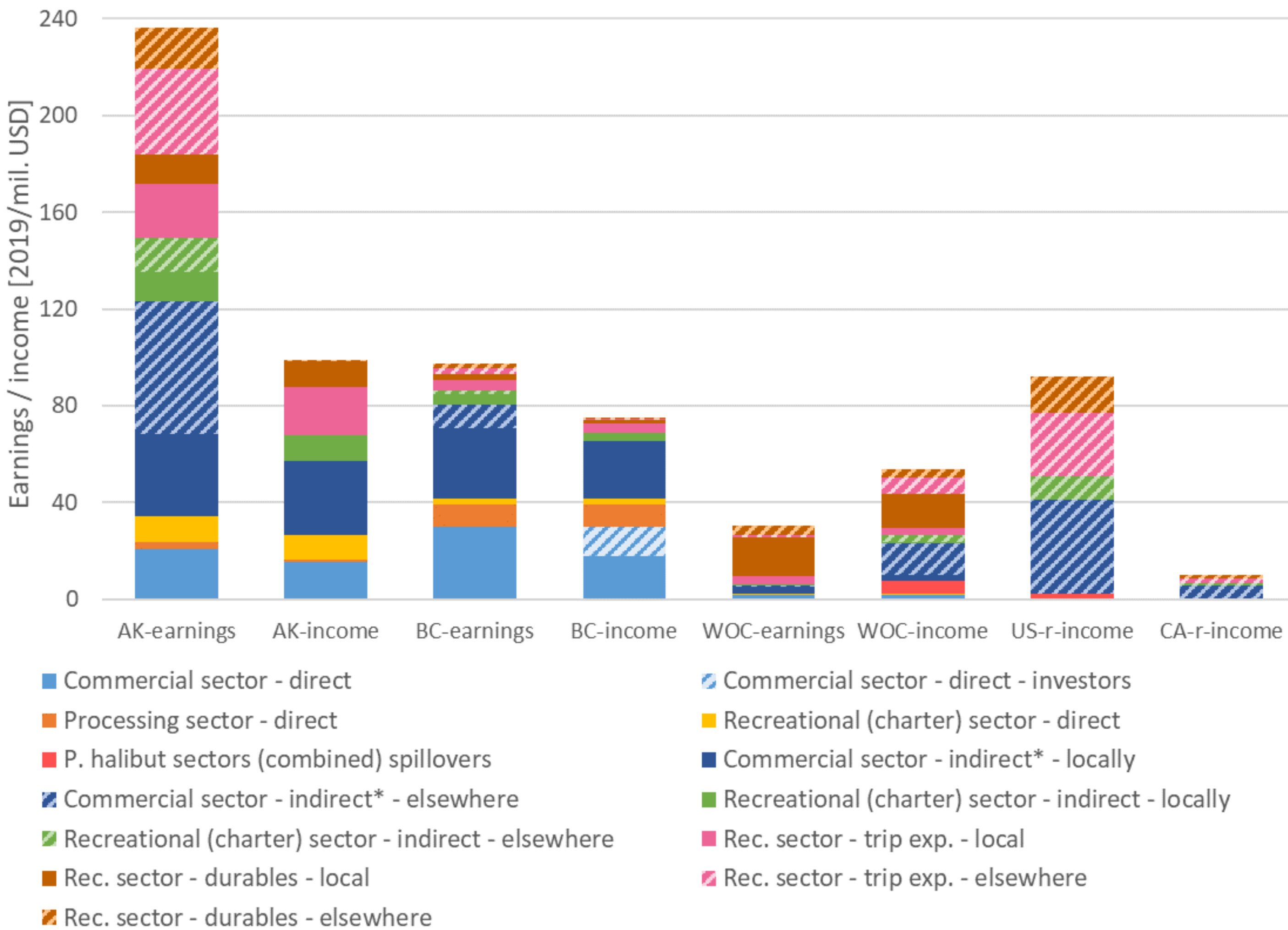
It should also be noted, however, that this analysis should not be used as an argument in sectoral allocations discussions because, as a snapshot analysis, it does not reflect the implications of shifting supply-demand balance. Participation in sport fishing does not typically scale in a linear fashion with changes to harvest limits.

Table 10: Economic impact on households.

Economic impact	Unit	Commercial	Charter[(1)]	Recreational
EI on households	Total in mil. USD/CAD	179.1/237.6	42.2/55.9	146.9/194.9
EI locally (excludes spillovers)	Total in mil. USD/CAD	114.1/151.4	27.6/36.6	79.0/104.9
EI on households	USD/CAD per 1 USD/CAD of landed value/ 1 USD/CAD spent	1.34	1.08	0.74[(2)]
EI locally (excludes spillovers)	USD/CAD per 1 USD/CAD of landed value/ 1 USD/CAD spent	0.85	0.71	0.40[(2)]
EI on households	USD/CAD per 1 lb of removals	7.4/9.8	12.0/15.9[(3)]	20.9/27.7
EI locally (excludes spillovers)	USD/CAD per 1 lb of removals	4.7/6.2	7.3/9.7[(3)]	11.2/14.9

Notes: [(1)] This includes only the economic impact generated through businesses offering charter trips, i.e., it excludes the impact of angler expenditures other than charter fees. [(2)]In A considerable share of angler expenditures originates from import, which drives the estimate down. [(3)]Charter sector impact per 1 lb of removals was based on EI on households for Alaska where removals estimates are clearly divided between guided and unguided sectors.

Figure 9 depicts elements of the impact of Pacific halibut commercial and recreational fishing on household earnings and income, highlighting the importance of considering cross-regional flows related to Pacific halibut. Earnings estimates (bars with '-earnings' suffix) summarize economic impact by place of work (i.e., where the fishing activity occurs), while income estimates (bars with '-income' suffix) reflect earnings after adjustments for cross-regional flows, i.e., provide estimates by the place of residence of workers, business owners, or owners of production factors (i.e., quota or permit owners). These results can be compared with EI expressed in terms of output, that is the total production linked (also indirectly) to the Pacific halibut sectors (**Figure 10**). The figure distinguishes between the impact by fishery (i.e., by region where the fishing activity occurs, bars with '-fishery' suffix) and impact by region (i.e., by region where the impact is realized; bars with '-region' suffix).

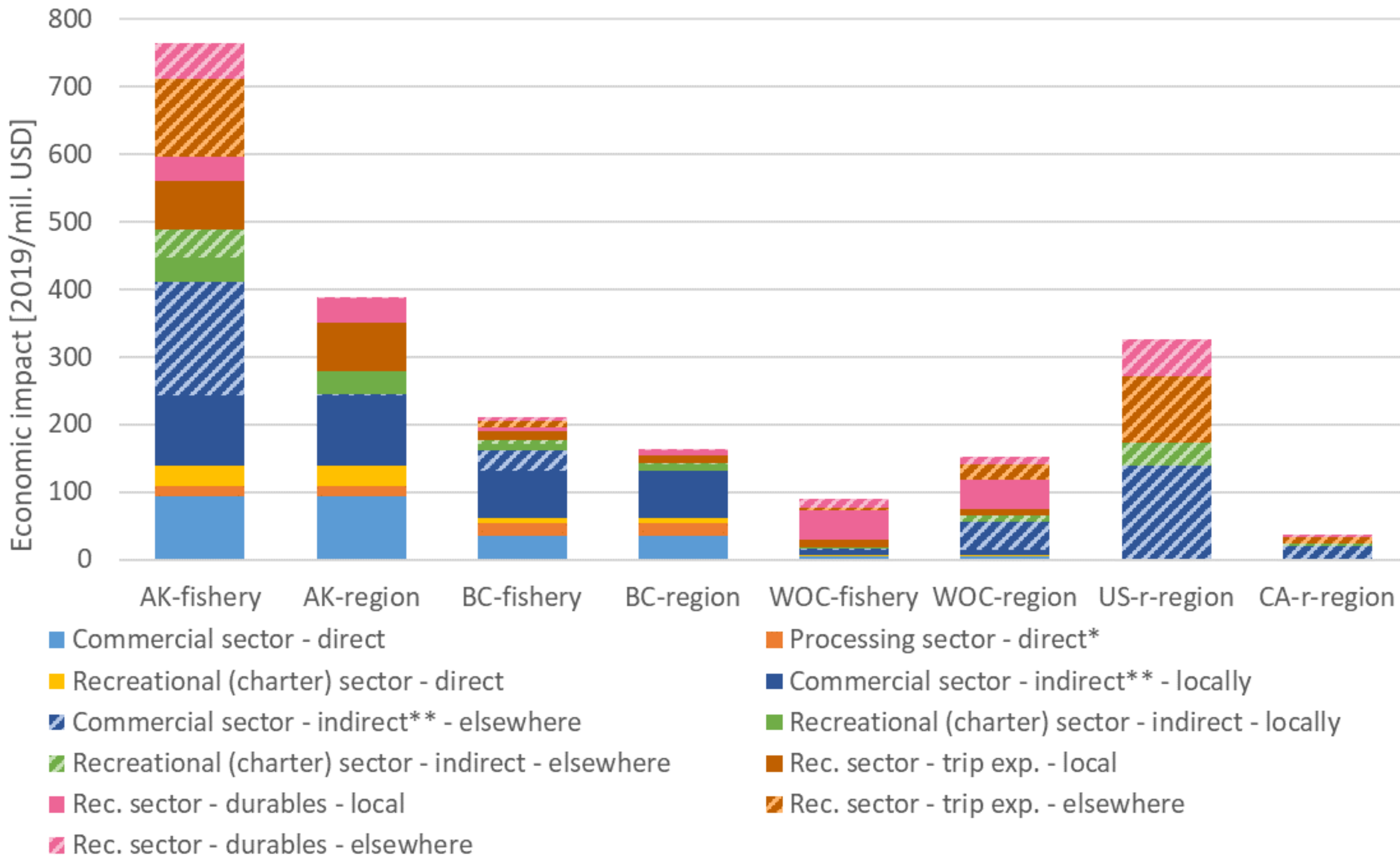


Notes: Legend description available in Box 1. Figure omits the impact on ROW (marginal).*Commercial indirect impact includes processing.

Figure 9: Pacific halibut impact on household earnings and income (2019).

Box 1: Figure 9 legend description

a) **Commercial sector – direct**: includes earnings and income directly attributable to the Pacific halibut commercial fishing sector within the indicated region.
b) **Commercial sector - direct – investors**: indicates the share of the income described in **Commercial sector – direct** that is retained in the region, but flows from the fishing sector to investors. This component captures the value of the leased quota paid to non-fishing stakeholders.
c) **Processing sector – direct**: includes earnings and income directly attributable to the Pacific halibut processing sector within the indicated region.
d) **Recreational (charter) sector – direct**: includes earnings and income directly attributable to businesses offering Pacific halibut sport fishing within the indicated region.
e) **P. halibut sectors (combined) spillovers**: include income attributable to Pacific halibut sectors (commercial fishing, processing, sport fishing) that leaks from the region where the activity occurs as a result of cross-regional flows.
f) **Commercial sector - indirect* - locally**: includes combined indirect and induced impact on earnings and income resulting from changes in business-to-business transactions and personal income caused by Pacific halibut commercial and processing sector. This component includes only EI resulting from fishing activity in the specified region occurring locally (i.e., in the same region).
g) **Commercial sector - indirect* - elsewhere**: as above, but includes impact on earnings resulting from fishing activity in the specified region occurring elsewhere (‘-earnings’ bars), and impact on income resulting from fishing activity elsewhere realized in the specified region (‘-income’ bars).
h) **Recreational (charter) sector - indirect – locally**: includes combined indirect and induced impact on earnings and income resulting from changes in business-to-business transactions and personal income caused by the Pacific halibut charter sector. This component includes only EI resulting from fishing activity in the specified region occurring locally (i.e., in the same region).
i) **Recreational (charter) sector - indirect – elsewhere**: as above, but includes impact on earnings resulting from fishing activity in the specified region occurring elsewhere (‘-earnings bars), and impact on income resulting from fishing activity elsewhere realized in the specified region (‘-region’ bars).
j) **Rec. sector - trip exp. – local**: includes an estimate of the economic contribution of Pacific halibut-dependent angler trip expenditures on earnings and income that is realized locally, i.e., within the region where the fishing activity is occurring.
k) **Rec. sector - trip exp. – elsewhere**: includes an estimate of the economic contribution of Pacific halibut-dependent angler trip expenditures to earnings elsewhere (‘-earnings’ bars) or income within the indicated region realized as a result of fishing activity elsewhere (‘-income’ bars).
l) **Rec. sector - durables – local**: includes an estimate of the economic contribution of Pacific halibut-dependent angler expenditures on durable goods on earnings and income that is realized locally, i.e., within the region where the fishing activity is occurring.
m) **Rec. sector - durables – elsewhere**: includes an estimate of the economic contribution of Pacific halibut-dependent angler expenditures on durable goods to earnings elsewhere (‘-earnings’ bars) or income within the indicated region realized as a result of fishing activity elsewhere (‘-income’ bars).



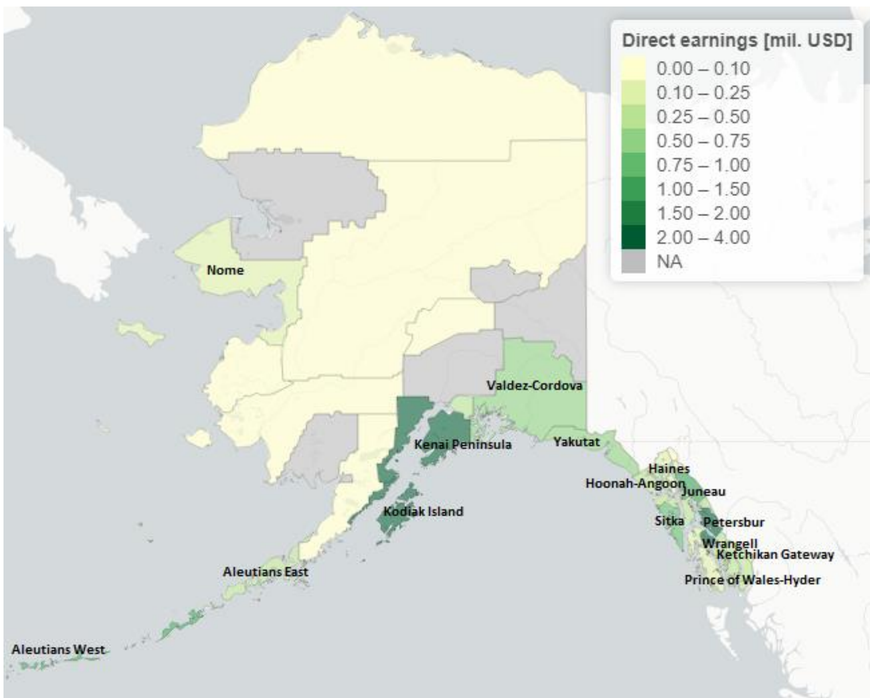
Notes: Legend description available in Box 2. The figure omits the impact on the ROW (marginal). *Adjusted to the wholesale mark-up and does not include fish buying cost; **Commercial indirect impact includes processing.

Figure 10: Pacific halibut economic impact in terms of output (2019).

Box 2: Figure 10 legend description

a) **Commercial sector – direct**: includes direct output of the Pacific halibut commercial fishing sector, which is equivalent to the landing value or value of sales by Pacific halibut directed commercial fisheries. This component is equal in the 'by fishery' and 'by region' EI estimate.
b) **Processing sector – direct***: includes direct output of the Pacific halibut processing sector (wholesale value) adjusted to include only the wholesale mark-up. This means that the estimate does not include the fish buying cost, avoiding this way double counting the landing value of the Pacific halibut commercial sector in the EI estimate. This component is equal in the 'by fishery' and 'by region' EI estimate.
c) **Recreational (charter) sector – direct**: includes value of direct sales by businesses offering services in the form of guided Pacific halibut recreational (sport) fishing (charter boats, fly-in loges, package deals, etc.). The estimate intends to capture the share of output by the sport fishing sector that depends on the Pacific halibut resource availability, i.e., it is adjusted for mixed target species offers. This component is equal in the 'by fishery' and 'by region' EI estimate.
d) **Commercial sector - indirect** - locally**: includes combined indirect and induced impact resulting from changes in business-to-business transactions and personal income caused by Pacific halibut commercial and processing sector. This component includes only EI resulting from fishing activity in the specified region occurring locally (i.e., in the same region). This component is equal in the 'by fishery' and 'by region' EI estimate.
e) **Commercial sector - indirect** - elsewhere**: as above, but includes EI resulting from fishing activity in the specified region occurring elsewhere (i.e., in the regions other than the fishing area specified; '-fishery' bars), and EI resulting from fishing activity elsewhere occurring in the specified region ('-region' bars).
f) **Recreational (charter) sector - indirect – locally**: includes combined indirect and induced impact resulting from changes in business-to-business transactions and personal income caused by the Pacific halibut charter sector. This component includes only EI resulting from fishing activity in the specified region occurring locally (i.e., in the same region). This component is equal in the 'by fishery' and 'by region' EI estimate.
g) **Recreational (charter) sector - indirect – elsewhere**: as above, but includes EI resulting from fishing activity in the specified region occurring elsewhere (i.e., in the regions other than the fishing area specified; '-fishery' bars), and EI resulting from fishing activity elsewhere occurring in the specified region ('-region' bars).
h) **Rec. sector - trip exp. – local**: includes an estimate of the economic contribution of marine angler trip expenditures (travel, lodging, other trip-related expenses) that is realized locally, i.e., within the region where the fishing activity is occurring, and can be attributed to Pacific halibut fishing opportunities. This component is equal in the 'by fishery' and 'by region' EI estimate.
i) **Rec. sector - trip exp. – elsewhere**: includes an estimate of the economic impact of marine angler trip expenditures (share attributed to Pacific halibut) that is realized elsewhere ('-fishery' bars) or realized within the indicated region as a result of fishing activity elsewhere ('-region' bars).
j) **Rec. sector - durables – local**: includes an estimate of the economic contribution of marine angler expenditures on durable goods (rods, tackle, bout purchase, other fishing equipment and accessories, second home, or additional vehicle purchase) that is occurring locally, i.e., within the region where the fishing activity is occurring, and can be attributed to Pacific halibut fishing opportunities. This component is equal in the 'by fishery' and 'by region' EI estimate.
k) **Rec. sector - durables – elsewhere**: includes an estimate of the economic impact of marine angler expenditures on durable goods (share attributed to Pacific halibut) that is realized elsewhere ('-fishery' bars) or realized within the indicated region as a result of fishing activity elsewhere ('-region' bars).

PHMEIA model also informs on the economic impact by county (limited to Alaska), highlighting regions where communities may be particularly vulnerable to changes in the access to the Pacific halibut resource. In 2019, from USD 23.7 mil. (CAD 31.4 mil.) of direct earnings from Pacific halibut commercial sectors in Alaska, 70% was retained in Alaska.[27] These earnings were unevenly distributed between Alaskan counties, as shown in the map below (**Figure 11**, see also **Table 11**). The most direct earnings per dollar landed are estimated for Ketchikan Gateway, Petersburg, and Sitka countries, while the least for Aleutians East, Yakutat, and Aleutians West counties. Low earnings per 1 USD of Pacific halibut landed in the county are a result of the outflow of earnings related to vessels' home base, vessels' ownership, and quota ownership, processing locations, and processing companies' ownership.



Notes: According to the PHMEIA estimates, Alaska retained 70% of direct earnings within the state.

Figure 11: County-level estimates of direct earnings in the Pacific halibut commercial sectors in Alaska in 2019.

[27] Community effects assessment is currently limited to Alaska. The feasibility of a similar assessment for other regions is under investigation. For example, Canadian quotas (L fishery), which are vessel-based, can be allocated based on vessel owner's residency, searchable in the Canadian Register of Vessels available through Transport Canada's Vessel Registration Query System.

Table 11: County-level estimates of direct earnings in the Pacific halibut commercial sectors in Alaska in 2019.

County	Estimated earnings from Pacific halibut commercial sectors (fishing and processing)	Earning per 1 USD of Pacific halibut landed in the county	Change in % value of landings vs. % estimated earnings
Aleutians East	0.28	**0.057**	-
Aleutians West	1.27	**0.114**	-
Anchorage	0.41	NA	+
Bristol Bay	c	NA	+
Dillingham	c	c	c
Fairbanks North Star	c	NA	+
Haines	0.15	NA	+
Hoonah-Angoon	0.34	0.173	-
Juneau	1.46	0.210	+
Kenai Peninsula	**3.93**	0.151	-
Ketchikan Gateway	0.32	**0.412**	+
Kodiak Island	**2.71**	0.311	+
Lake and Peninsula	c	NA	c
Matanuska-Susitna	c	NA	+
Nome	0.18	0.238	+
Petersburg	**2.38**	**0.371**	+
Prince of Wales-Hyder	0.19	0.309	+
Sitka	0.89	**0.358**	+
Skagway	c	NA	+
Southeast Fairbanks	c	NA	+
Valdez-Cordova	0.68	0.147	-
Wrangell	0.45	0.183	-
Yakutat	0.55	**0.097**	-

Notes: Counties with no Pacific halibut landings or earnings from Pacific halibut sectors omitted. Full economic impact omitted, pending research on cross-county commodity flows in Alaska. c – masked to preserve confidentiality; NA – not applicable (no landings reported for the given county).

ECONOMIC IMPACT VISUALIZATION TOOL

The Model results section focuses mainly on the economic impact on households' prosperity (income by place of residence) as the most meaningful metric to the general population. The economic impact is also often expressed in terms of output, that is the total production linked (also indirectly) to the evaluated sector. However, the economic impact can be expressed with various other metrics, including compensation of employees, contribution to the GDP, and employment opportunities, and derived for just a subset of sectors. Regulators and stakeholders may also be interested in assessing various combinations of regional allocations of mortality limits. Thus, the PHMEIA and PHMEIA-r are accompanied by the economic impact visualization tool[28] designed to display the full set of model results. The use of this application can be guided by the PHMEIA app manual (IPHC-2021-ECON-04).

[28] The tool is available at: http://iphcecon.westus2.cloudapp.azure.com:3838/ModelApp_azure/ (full link for printed version).

The latest release of the app (January 11, 2022) also translates harvest allocations by IPHC Regulatory Area to county-level estimates of direct earnings using data described in subsection Cross-county flows in Alaska. While the community impact assessment is currently limited to Alaska, the feasibility of improving the model resolution for other regions is considered in the *IPHC's 5-year program of integrated research and monitoring (2022-26)* (IPHC-2021-IM097-12).

ECONOMIC IMPACT OF SUBSISTENCE FISHING

Previous research suggested that noncommercial or nonmarket-oriented fisheries' contribution to national GDP is often grossly underestimated, particularly in developing countries (e.g., Zeller, Booth, and Pauly 2006). Subsistence fishing is also important in traditional economies, often built around indigenous communities. Wolfe and Walker (1987) found that there is a significant relationship between the percentage of the native population in the community and reliance on wildlife as a food source in Alaska. However, no comprehensive assessment of the economic contribution of the subsistence fisheries to the Pacific northwest is available. The only identified study, published in 2000 by Wolfe (2000), suggests that the replacement value of the wild food harvests in rural Alaska may be between USD 131.1 and 218.6 million, but it does not distinguish between different resources and assumes equal replacement expense per pound. Aslaksen et al. (2008) proposed an updated estimate for 2008 based on the same volume, noting that transportation and food prices have risen significantly between 2000 and 2008, and USD 7 a pound is a more realistic replacement value. This gives the total value of USD 306 million, but the approach relies upon the existence of a like-for-like replacement food (in terms of taste and nutritional value), which is arguably difficult to accept in many cases (Haener *et al.*, 2001) and ignores the deep cultural and traditional context of the Pacific halibut in particular (Wolfe, 2002). A more recent study by Krieg, Holen, and Koster (2009) suggests that some communities may be particularly dependent on wildlife, consuming annually up to 899 lbs per person, but no monetary estimates are derived. Moreover, although previous research points to the presence of sharing and bartering behavior that occurs in many communities (Wolfe, 2002; Szymkowiak and Kasperski, 2020), the economic and cultural values of these networks have yet to be thoroughly explored.

All-sectors-encompassing quantitative assessment of the economic impact of the Pacific halibut resource necessitates the development of a methodological approach for the remaining sources of Pacific halibut mortality, including subsistence fishing. Methods adopted for the commercial and charter sector are not adequate for this portion of the harvest. As a part of the socioeconomic study, the IPHC established a collaboration with the Alaska Fisheries Science Center (AFSC) and the Alaska Department of Fish and Game (ADF&G), and will be participating in the following project: Fish, Food, and Fun: Exploring the Nexus of Subsistence, Personal Use, and Recreational Fisheries in Alaska (SPURF project). The SPURF project aims to understand the intersection of Alaska subsistence, personal use, and marine recreational fisheries in fulfilling household food needs and contribute to an improved understanding of the economic and social values of non-commercial Alaska fisheries. The project commenced in Fall 2021.

DISCUSSION AND CONCLUSIONS

The PHMEIA model fosters stakeholders' better understanding of a broad scope of regional impacts of the Pacific halibut resource. Leveraging multiple sources of socioeconomic data, it provides helpful insights for designing policies with desired effects depending on regulators' priorities. By tracing the socioeconomic impacts cross-regionally, the model accommodates the transboundary nature of the Pacific halibut and supports joint management of a shared resource, such as the case of collective management by the IPHC. Moreover, the study informs on the vulnerability of communities to changes in the state of the Pacific halibut stock throughout its range, highlighting regions particularly dependent on economic activities that rely on Pacific halibut. A good understanding of the localized effects is pivotal to policymakers who are often concerned about community impacts, particularly in terms of impact on employment opportunities and households' welfare. Fisheries policies have a long history of disproportionally hurting smaller communities, often because potential adverse effects were not sufficiently assessed (Carothers, Lew, and Sepez 2010; Szymkowiak, Kasperski, and Lew 2019).

The results suggest that the revenue generated by Pacific halibut at the harvest stage accounts for only a fraction of economic activity that would be forgone if the resource was not available to fishers in the Pacific Northwest. On average, in 2019, one USD/CAD of Pacific halibut commercial landings was linked to over four USD/CAD-worth economic activity in Canada and the United States and contributed USD/CAD 1.3 to households. In the recreational sector, one USD/CAD spent by recreational anglers was linked to USD/CAD 2.3 circulating in the economy and USD/CAD 0.7 impact on households. The total economic activity linked to Pacific halibut sectors is estimated at USD 1,014 mil. (CAD 1,346 mil), and contribution to households at USD 326 mil. (CAD 432 mil.), highlighting how important Pacific halibut is to regional economies. The estimates of county-level earnings in Alaska were unevenly distributed, but most importantly to resource managers and policymakers, the model suggests that the local earnings were often not aligned with how much was landed within the county.

Understanding the complex interactions within the fisheries sectors is now more important than ever considering how globalized it is becoming. Local products compete on the market with a large variety of imported seafood. High exposure to international markets makes seafood accessibility fragile to perturbations, as shown by the covid-19 outbreak (OECD, 2020b). Pacific halibut contribution to households' income dropped by a quarter throughout the pandemic. While signs of strong recovery were present in 2021 (Fry, 2021), the study calls attention to Pacific halibut sectors' exposure to external factors beyond stock condition. Fisheries are also at the forefront of exposure to the accelerating impacts of climate change. For example, a rapid increase in water temperature off the coast of Alaska in the mid-2010s, termed *the blob*, is affecting fisheries (Cheung and Frölicher, 2020) and may have a profound impact on Pacific halibut distribution.

Integrating economic approaches with stock assessment and management strategy evaluation (MSE) can assist fisheries in bridging the gap between the current and the optimal economic performance without compromising the stock biological sustainability. Economic performance metrics presented alongside already developed biological/ecological performance metrics bring the human dimension to the IPHC scientific products, adding to the IPHC's portfolio of tools for assessing policy-oriented issues. Moreover, the study can also inform on socioeconomic drivers (human behavior, human organization) that affect the dynamics of fisheries, and thus contribute to improved accuracy of the stock assessment and the MSE (Lynch, Methot and Link, 2018). As such, it can contribute to research integration at the IPHC (as presented in the *IPHC's 5-year program of integrated research and monitoring 2022-26,* IPHC-

2021-IM097-12) and provide a complementary resource for the development of harvest control rules, thus directly contributing to Pacific halibut management.

It is important to note, however, that the model continues to rely heavily on secondary data sources[29] such as NOAA or DFO surveys that did not necessarily target specifically Pacific halibut users or were not collected annually. As such, the model results are conditional on the adopted assumptions for the components for which data inputs were imputed or derived from broader scope surveys (as described in section Data inputs). While the Secretariat made the best use of data collection programs of national and regional agencies, academic publications on the topic, and grey literature reporting on fisheries in Canada and the United States, more accurate results can be achieved by incorporating into the model primary economic data collected directly from members of Pacific halibut-dependent sectors. The IPHC has been collecting economic data directly from stakeholders since 2020 through a web-based survey. More details on the survey can be found on the IPHC website. However, it should be recognized that the project was challenged by the COVID-19 pandemic that impacted particularly the components directly dependent on the inputs from stakeholders. Should the Commission wish to continue improving the PHMEIA, the Secretariat will introduce a modified strategy for primary data collection following the 2021 fishing season, including further simplification of the surveys. The Secretariat is also cautiously optimistic regarding engagement with stakeholders on socioeconomic data collection in post-covid times aimed at better characterization of the Pacific halibut sectors' economic impact.

Lastly, while the quantitative analysis is conducted with respect to components that involve monetary transactions, Pacific halibut's value is also in its contribution to the diet through subsistence fisheries and importance to the traditional users of the resource. To native people, traditional fisheries constitute a vital aspect of local identity and a major factor in cohesion. One can also consider the Pacific halibut's existence value as an iconic fish of the Northeast Pacific. While these elements are not quantified at this time, recognizing such an all-encompassing definition of the Pacific halibut resource contribution, the IPHC echoes a broader call to include the human dimension into the research on the impact of management decisions, as well as changes in environmental or stock conditions. The Secretariat is also anticipating being able to provide additional details on the economics of subsistence fishing as a part of reporting on the SPURF project (as described in section Economic impact of subsistence fishing).

FURTHER WORK

Looking forward, the Secretariat identified several tasks that would enhance the PHMEIA's ability to support the management of the Pacific halibut resource in fulfillment of the Commission's mandate. These are incorporated into the *IPHC's 5-year program of integrated research and monitoring (2022-26)* (IPHC-2021-IM097-12).

Expanding the static SAM model to a computable general equilibrium model

Relaxing the assumption of fixed technical coefficients by specifying these coefficients econometrically as a function of relative prices of inputs is one of the most compelling extensions to the static SAM-based model. Such models, generally referred to as computable general equilibrium (CGE) models, require

[29] That is data collected by other parties, not the IPHC.

research to develop credible functional relationships between prices and consumption that would guide economic agents' behavior in the model. The CGE approach is a preferred way forward when expanding the model usability and applying it in conjunction with the Pacific halibut management strategy evaluation. In addition, the dynamic model is well suited to analyze the impact of a broad suite of policies or external factors (e.g., climate change) affecting the stock over time.

Improving the spatial granularity of the SAM model

Extending the community analysis beyond a simplified approach relying on the calculated multiplier effects and local exposure to the region's Pacific halibut economic impact to a full community level (or any other spatial scale) SAM-based model requires identifying the economic relationships between different sectors or industries (including both seafood and non-seafood industries) within each broader-defined region, this including deriving estimates on intra-regional trade in commodities and flow of earnings. This extension of the current model has a great potential for more accurate estimates of the community effects. Detailing the geography of impacts of the Pacific halibut fisheries, paying particular attention to quantifying leakage of economic benefits from communities strongly dependent on fisheries, will provide a coherent picture of the exposure of fisheries-dependent households by location to changes in resource availability.

Study of recreational demand

It is important to note that while it is reasonable to assume that changes in harvest limits have a relatively proportional impact on production by commercial fishers (unless these are dramatic and imply fleet restructure or a significant shift in prices), the effects on the recreational sector are not so straightforward. A separate study estimating changes in saltwater recreational fishing participation as a response to the changing recreational harvest limits applicable to Pacific halibut is necessary to assess policy impacts in the recreational sector rather than provide a snapshot of economic impact. Such studies typically require surveying recreational fishers, but adoption of alternative approaches can be also assessed.

Study of demand for Pacific halibut products

Catches can be converted to revenues, but one has to determine what price to multiply harvests by. Since price fluctuates with harvest levels, pragmatic assessment of harvest limits changes needs to be supplemented with a model of demand for Pacific halibut. The demand-adjusted prices provide more economics-sound projections of gross revenues in the sector. The demand model (e.g., Synthetic Inverse Demand System) can also be used to estimate final consumer benefits from changing Pacific halibut harvests and prices (i.e., consumer surplus).

Analysis of Pacific halibut value chain

In 2021, fresh Alaskan Pacific halibut fillets routinely sold for USD 24-28 a pound, and often more, downtown Seattle (e.g., USD 38 at Pike Place Market). Pacific halibut dishes at the restaurants typically sell for USD 37-43 for a dish including a 6oz fish portion. The complete path of landed fish, from the hook to the plate, includes, besides harvesters, processors, and wholesalers, also retailers, and services. Pacific halibut is primarily sold to upscale retail outlets and white-tablecloth restaurants, resulting in a high price markup in the supply chain.

Understanding the formation of the price paid by final consumers (end-users) is an important step in assessing the contribution of Pacific halibut to the GDP along the entire value chain. However, it is important to note that there are many seafood substitutes available to buyers. Thus, including economic impacts (as defined in the Introduction section) beyond processors and wholesalers could be misleading when considering that it is unlikely that supply shortage would result in a noticeable change in retail or services level gross revenues (Steinback and Thunberg, 2006). Moreover, isolating data on Pacific halibut wholesale, retail and services[30] is challenging given the limited availability of relevant statistics.

While economic impact multipliers (type of analysis requested in the economic study terms of reference) do not typically account for the sectors beyond processing because of the availability of substitutes, the suitability of alternative approaches can be considered. At the same time, the EI estimates herein are supplemented by analysis focused on the formation of mark-ups for Pacific halibut products (see Pacific halibut market profile in IPHC-2021-ECON-06).

Uncertainty in the PHMEIA model

The PHMEIA model results focus on the magnitude of the Pacific halibut contribution to the economy and its spatial distribution. To increase confidence in the PHMEIA results, the model needs to consider sources of input variations and the cumulative effect of interactions among them. The natural next step is to conduct sensitivity analysis to account for the uncertainties in the system. The current framework would benefit from proposing methods for calculating the range (confidence intervals) of impacts from input variations within a PHMEIA framework, explicitly accounting for multiple sources of input variations.

ACKNOWLEDGEMENTS

The report was written by Barbara Hutniczak with helpful comments from colleagues at the IPHC.

The author would like to acknowledge inputs from multiple agencies of Contracting Parties: NOAA (Chang Seung, Dan Lew, Jerry Leonard), ADFG (Sarah Webster, James Hasbrouck, Bill Romberg), DFO (Maureen Finn), and B.C. Ministry of Agriculture (Kevin Romanin, James Dalby, Katie Fraser, Fatemeh Mokhtarzadeh).

The author would also like to thank Forrest Braden (SEAGO), Brian Richie (Alaska Charter Association), Owen Bird (Fishing Institute of BC), Martin Paish and Chuck Ashcroft (Sport Fishing Advisory Board) for participation in discussions on the charter survey, and all IPHC economic survey participants who contributed to date to the assessment of the importance of the Pacific halibut resource to the economy of Canada and the United States of America.

[30] Note, this this refers to production structure, not mark-up within sector. Production structure here refers to the distribution of revenue between profit, labor compensation, business tax liabilities, and expenditure items.

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APPENDIX A

		Region 1 (R1)						Region 2 (R2)						Exogenous accounts
		Industries	Commodities	LAB	PROP	Earnings	Households (HH)	Industries	Commodities	LAB	PROP	Earnings	Households	
Region 1 (R1)	Industrie s		V1											
	Com.	U1					Households' expenditure (R1)		T12					Government's expenditure Investment
	LAB	Employee compensation (R1) – LAB1												
	PROP	Proprietors' income (R1) – PROP1												
	Earn.			Net income from LAB1	Net income from PROP1							Inflow of earnings from region 1 to region 2 (Te12)		
	HH					Net earnings by place of residence (R1)								Government transfers Net property income
Region 2 (R2)	Industrie s								V2					
	Com.		Trade matrix – import by R1 from R2 (T21)					U2					Households' expenditure (R1	Government's expenditure Investment
	PROP							LAB2						
	PROP							GOS2						
	Earn.					Leakage/outflow of earnings from region 1 to region 2 (Te21)				Net income from LAB2	Net income from GOS2			
	HH											Net earnings by place of residence (R2)		Government transfers Net property income
Exogenous accounts		Taxes on production and imports GOS* (R1)		Social contributions (R1)			Personal income taxes Households' net savings (R1)	Taxes on production and imports GOS* (R2)		Social contributions (R2)			Personal income taxes Households' net savings (R2)	

Notes: GOS* represents gross operating surplus minus proprietors' income, i.e., consumption of fixed capital (CFC), corporate profits, and business current transfer payments (net).

APPENDIX B

		Region 1 (R1)									
		Industries	Commodities	LAB^{Ph} (Pacific halibut sectors)	$PROP^{Ph}$ (Pacific halibut sectors)	LAB (other sectors)	PROP (other sectors)	Earnings from LAB^{Ph}	Earnings from $PROP^{Ph}$	Earnings from other sectors	Households
Region 1 (R1)	Industries		V1								
	Commo-dities	U1									Households' expenditure (R1)
	LAB^{Ph} (Pacific halibu	Employee compensation in Pacific halibut sectors (R1) – $LAB^{Ph}1$									
	$PROP^{Ph}$ (Pacific	Proprietors income in Pacific halibut sectors (R1) – $PROP^{Ph}1$									
	LAB (other sectors)	Employee compensation in other sectors (R1) – LAB1									
	PROP (other sectors)	Proprietors income in other sectors (R1) - PROP1									
	Earnings from LAB^{Ph}			Net income from $LAB^{Ph}1$							
	Earnings from $PROP^{Ph}$				Net income from $PROP^{Ph}1$						
	Earnings from other sectors					Net income from LAB1	Net income from PROP1				
	House-holds							Net earnings from $LAB^{Ph}1$ by place of residence (R1)	Net earnings from $PROP^{Ph}1$ by place of residence (R1)	Other net earnings by place of residence (R1)	
Region 2 (R2)	(includes only outflows)							↓ Leakage related to out-of-state employment	↓ Leakage related to out-of-state quota or permit ownership and processing plant ownership	↓ Leakage of other earnings from region 1 to region 2	

APPENDIX C

Economic impact (EI) [2019]	Commercial sector			Charter sector			Recreational sector			Sum	
	In mil. USD[1]	In mil. CAD	R[2]	In mil. USD[1]	In mil. CAD	R[2]	In mil. USD[1]	In mil. CAD	R[2]	In mil. USD[1]	In mil. CAD
Value of landings/amount spent	134.1	177.9	-	38.9	51.6	-	198.3	263.1	-	-	-
EI - output[3]	550.9	731.0	4.1	132.6	176.0	3.4	463.4	614.8	2.3	1014	1346
EI - contribution to the GDP	279.7	371.1	2.1	66.5	88.2	1.7	266.2	353.2	1.3	546	724.3
EI – earnings	195.9	259.9	1.5	46.0	61.1	1.2	164.3	218.1	0.8	360	477.9
EI – wages	145.2	192.6	1.1	34.5	45.8	0.9	105.4	139.8	0.5	251	332.4
EI - employment	5058	-	38 (28)	2207	-	57 (43)	3948	-	20 (15)	9006	-
Household income	179.1	237.6	1.3	42.2	55.9	1.1	146.9	194.9	0.7	326	432

(1)With exception of employment, which is reported in number of jobs. (2)R – indicates value in USD (CAD) per 1 USD (CAD) of landed value (for the commercial sector) or USD (CAD) spent (for the charter and recreational sector; recreational sector includes trip costs and expenditures on durable goods). (3)For the commercial sector, adjusted for processing value added only; does not include the fish buying cost.