PHMEIA MODEL SETUP

PREPARED BY: IPHC SECRETARIAT (B. HUTNICZAK; 8 NOVEMBER 2021)

PURPOSE

The purpose of this document is to provide details on the Pacific halibut multiregional economic impact assessment (PHMEIA and PHMEIA-r) models setup. The document supplements general information on the IPHC economic study available in the economic research section of the IPHC website.

ECONOMIC IMPACT METRICS

The supply and use tables (SUTs) focus on measuring the productive structure of the economy. They trace the production of commodities (both goods and services) by domestic industries, combined with imports, through their use as intermediate inputs or as final consumption, investment, or exports. The system provides a measure of value added by industry - total output less intermediate inputs. These tables can be used to calculate economy-wide gross domestic product (GDP). The supply and use tables can also be used to build an input-output (IO) model (Leontief 1966).

The IO model is used to investigate how changes in final demand or supply (using modified IO model, see details in Leung and Pooley 2002) affect economic variables such as output, income and employment or value added that provides an assessment of the sector's contribution to the GDP in a region. This is known as impact analysis.

The IO model typically accounts for three economic impact (EI) components:

- The **direct EIs** are the deliveries by domestic industries and imports necessary to satisfy final demand expenditures on products and services.
- The **indirect EIs** provide an estimate of the changes to the production related to expenditures on goods and services used in the production process of the directly impacted industry.
- The **induced EIs** cover production and imports associated with the spending of earnings on consumption.

Changes in the domestic output, unless fully substituted by imports, lead to adjustments in industries relying on this output for their own production. **Forward linkages** describe the effects on the industries for which the affected sector is a supplier, defining its relations with the *downstream* industries. While early attempts to include forward linkages in the calculation of economic impacts have been criticized for the lack of economic foundation, recent methodological advances (e.g., Seung 2014, 2017) allow for such extension.

To accommodate an increasing economic interdependence of regions and nations, the model also accounts for cross-regional effects. Policies or any other exogenous changes generate an economic impact not only in the region where they are observed but also in the regions that have economic ties with the region subjected to the change. A multiregional IO model accounts for that. The general structure of the input to the multiregional IO model is available Appendix A.

The standard input-output framework provides little insight into the roles of labor, households, and the social institutions of the economy. Adopting the model extended to a so-called social accounting matrix (SAM), the calculated effects account for factors such as earnings and their disposition, and the demographics of the workforce. This is important when assessing industries that employ a considerable share of nonresidents or generate profits that are spent elsewhere. The SAM-based model with endogenous households allows for detailed accounting of household income by place of residence, including income from other sources (e.g., government transfers, dividends, interest, and rent), outflows to the government (e.g., personal income taxes), and households net savings. The structure of SAM with endogenized households is available in Appendix B.[1] The model components associated with household accounts largely align with these considered in Seung (2014).

Technical details on the use of SAM for the calculation of economic impact are available in IPHC-2021-ECON-03.

PHMEIA MODEL

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.[2] These include the Pacific halibut fishing sector, as well as the forward-linked Pacific halibut processing sector. While the complete path of 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). Snapshot assessment of Pacific halibut contribution to the GDP along the entire value chain, from the ***hook-to-plate***, is available in IPHC-2021-ECON-06.

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 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

[1] SAM framework also allows for endogenizing additional sectors, for example, state and local government. This can be used to analyze the economic impact related to state/local taxes and welfare transfers.
[2] Derived use of commodities by Pacific halibut sectors is appended to SUTs and subtracted from production by general fishing and processing industries.

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.[3]

The list of industries considered in the PHMEIA and PHMEIA-r models, as well as the primary commodities they produce, is available in **Table 1**. 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)
- Rest of the world (ROW)[4]

The adopted methodology is an extension from the multiregional SAM model for Southwest Alaska developed by Seung, Waters, and Taylor (2019) (see IPHC-2021-ECON-03 for details on adopted methodology) and draws on a few decades' worth of experience in developing IO models with applications to fisheries (see IPHC-2021-ECON-01).

The model also adopts a recently published multiregional generalized RAS (MRGRAS) updating technique (Temursho, Oosterhaven, and Cardenete 2020) to develop an up-to-date model that can incorporate partial information on its components while continuing to conform to the predefined balanced structure. This technique can make the multiregional model consistent with aggregated national data and include up-to-date estimates from a limited number of focus sectors. For more details on the updating approach, please refer to the article *Method for efficient updating of regional supply and use tables*.

Table 1 Industries and commodities considered in the PHMEIA and PHMEIA-r models.

[3] 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.

[4] 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 allows 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.

	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. However, this misalignment between model components is not concerning as linking these is based on the trade of aggregated seafood commodity. (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 2021). (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.

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).

FISHERIES-RELATED MODEL COMPONENTS

Fisheries data inputs are described in detail in IPHC-2021-ECON-02-R02. The following two sections describe the use of these data in building the model.

Pacific halibut commercial sectors

In the fishereis sector, the gross revenue (Figure 1) is the landed value of the catch, which in the case of 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 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[5]).

The model also incorporates production structure for Pacific halibut processing sector.

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

Gross revenue		Lease fees		Short-run costs
	After-lease revenue	Operational costs	License fees	
			Fuel	
			Bait & ice	
			Gear	
			Monitoring	
		Fixed costs	Insurance	
			Moorage	
			Maintenance	
			Other	
		Labour costs	Crew share	
			Captain share	
		EBITDA	Amortization	Long-run costs
			Depreciation	
			Taxes	
			Interest	
			Net profit	

Figure 1: Fishing sector cost and earnings categories. Adapted from (Edwards 2019).

The US components of the model use as a base the data from the species-based SAM developed by Seung, Waters, and Taylor (2019). As the original model did not include Pacific halibut-specific production structures for the WOC region. These are adopted 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).

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 Castlemain (2019). 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 by the Province of BC (AgriService BC 2018).

The model also 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 is through transaction matrices (i.e., Te21 or Te12 in Appendix B). Flows specific to Pacific halibut are depicted in Appendix C.

In this model, all wild capture production, including all Pacific halibut harvest, is assumed to be supplying the seafood processing industry (Pacific halibut 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 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 and simplifying assumption is 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, adopting the method described in Seung (2014, 2017). 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 also omits Pacific halibut impacts beyond the processing sector. As noted by Steinback and Thunberg (2006), there are many seafood substitutes available to buyers. Thus, including impacts beyond processors could be misleading considering that it is unlikely that supply shortage would result in a noticeable change in retail or services level gross revenue.

Pacific halibut charter fishing

PHMEIA-r incorporates into the SAM also the 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). The West Coast component utilizes data from the NOAA input-output model for the Pacific Coast fisheries (Leonard and Watson 2011).

British Columbia's charter fishing sector's production structure is derived based on results of the latest *Survey of Recreational Fishing in Canada* (DFO 2019).

The model also accommodates cross-regional flows derived based on the residence of charter business owners (available for Alaska) and available statistics on labor composition in the charter sector.

NON-FISHERIES DATA INPUTS

The US component of the model uses as a base the SAM developed by Seung, Waters, and Taylor (2019). The base SAM is updated using data published by the US Bureau of Economic Analysis (BEA) supplemented with BEA Regional Data resources, data from United States Census Bureau's Annual Survey of Manufactures (ASM) and Quarterly Census of Employment and Wages (QCEW).

The model components describing the Canadian economy are based on SUTs published by Statistics Canada supplemented with data from Monthly Survey of Manufacturing, Labour Force Survey and Survey of Household Spending.

The multiregional model is assembled adopting a method suggested by Bachmann, Roorda, and Kennedy (2015). Accordingly, international linkages are established through trade matrices. These, in turn, are constructed based on available trade statistics (mainly US Census trade data

and Canadian International Merchandise Trade Database). For industries with no regional trade statistics available (some services), distribution from the base model is adopted for the country of origin, and split between destination regions is done based on regional GDP estimates.

The general flow of earnings is derived from national accounts and allocated using IRS tax stats and BEA data on International Transactions with details by country.

The ROW region in the model is considered exogenous. This implies that the trade relations with the ROW are not affected by the changes to the Pacific halibut sector considered in this project. However, the inclusion of the ROW component, constructed using World Input-Output Tables (WIOT), would allow for assessment of impact also outside Canada and the United States if trade with ROW was to be considered responsive to changes in Pacific halibut sector activity.

FINAL REMARKS

It is important to note that the model continues to rely heavily on secondary data sources,[6] and as such, the results are conditional on the adopted assumptions for the components for which up-to-date data are not available (details on fisheries data inputs are available in IPHC-2021-ECON-02-R02). That said, the Secretariat strives to make 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 is collecting economic data directly from stakeholders since 2020 through the web-based survey. More details on the survey can be found on the IPHC website.

Looking forward, the Secretariat also identified several tasks that will enhance the study'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).

REFERENCES

AgriService BC. 2018. *British Columbia Fish Processing Employment 2016*.

Bachmann, Chris, Matthew J. Roorda, and Chris Kennedy. 2015. "Developing a Multi-Scale Multi-Region Input-Output Model." *Economic Systems Research* 27(2):172–93.

Castlemain. 2019. *Analysis of Commercial Fishing Licence, Quota, and Vessel Values: Prepared for Fisheries and Oceans Canada, Pacific Region*.

DFO. 2019. *Survey of Recreational Fishing in Canada, 2015*.

Edwards, Danielle N. 2019. "Addressing Questions on the Social and Economic Outcomes of an Individual Transferable Quota Fishery."

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

Edwards, Danielle N. and Evelyn Pinkerton. 2020. “Priced out of Ownership: Quota Leasing Impacts on the Financial Performance of Owner-Operators.” *Marine Policy* 111.

Leonard, Jerry and P. Watson. 2011. “Description of the Input-Output Model for Pacific Coast Fisheries.” *NOAA Technical Memorandum NMFS-NWFSC* 111(April).

Leontief, Wassily. 1966. *Input-Output Economics*. New York: Oxford University Press.

Leung, Pingsun and Sam Pooley. 2002. “Regional Economic Impacts of Reductions in Fisheries Production: A Supply-Driven Approach.” *Marine Resource Economics* 16(4):251–62.

Lew, Daniel K. and Jean Lee. 2019. “Costs, Earnings, and Employment in the Alaska Saltwater Sport Fishing Charter Sector, 2017.” *NOAA Technical Memorandum NMFS-AFSC* 398.

Seung, Chang K. 2014. “Estimating Effects of Exogenous Output Changes: An Application of Multi-Regional Social Accounting Matrix (MRSAM) Method to Natural Resource Management.” *Regional Science Policy & Practice* 6(2):177–93.

Seung, Chang K. 2017. “A Multi-Regional Economic Impact Analysis of Alaska Salmon Fishery Failures.” *Ecological Economics* 138:22–30.

Seung, Chang K. and Daniel K. Lew. 2017. “A Multiregional Approach for Estimating the Economic Impact of Harvest Restrictions on Saltwater Sportfishing.” *North American Journal of Fisheries Management* 37(5):1112–29.

Seung, Chang K., Edward Waters, and Michael L. Taylor. 2019. “Developing a Multi-Regional Social Accounting Matrix (MRSAM) for Southwest Alaska Fisheries.” *NOAA Technical Memorandum NMFS-AFSC* 399.

Steinback, Scott R. and Eric M. Thunberg. 2006. “Northeast Region Commercial Fishing Input-Output Model.” *NOAA Technical Memorandum NMFS-NE* 188.

Temursho, Umed, Jan Oosterhaven, and Manuel Alejandro Cardenete. 2020. “A Multiregional Generalized RAS Updating Technique.” *Spatial Economic Analysis* 2.

US Census. 2021. “Annual Survey of Manufactures.” *United States Census Bureau*. Retrieved (https://www.census.gov/programs-surveys/asm.html).

APPENDIX A

		Region 1 (R1)		Region 2 (R2)		Final demand	**Total outputs**
		Industries	Commodities	Industries	Commodities		
Region 1 (R1)	Industries		Make matrix (R1) – V1				Total industry output (R1) – x1
	Commodities	Use matrix (R1) – U1			Transaction matrix (region 1 to region 2) – T12	Final demand (R1) – FD1	Total commodity output (R1) – q1
Region 2 (R2)	Industries				Make matrix (R2) – V2		Total industry output (R2) – x2
	Commodities		Transaction matrix (region 2 to region 1) – T21	Use matrix (R2) – U2		Final demand (R2) – FD2	Total commodity output (R2) – q2
Value added		Value added (R1) – VA1		Value added (R2) – VA2			
Total inputs		Total industry input (R1) - x1	Total commodity input (R1) – q1	Total industry input (R2) – x2	Total commodity input (R2) – q2		

APPENDIX B

		Region 1 (R1)						Region 2 (R2)						Exogenous accounts
		Industries	Commodities	LAB	PROP	Earnings	Households (HH)	Industries	Commodities	LAB	PROP	Earnings	Households	
Region 1 (R1)	Industries		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)	Industries								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 C

		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 halibut sectors)	Employee compensation in Pacific halibut sectors (R1) – LAB^{Ph}1									
	PROP^{Ph} (Pacific halibut sectors)	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	