

ECONOMIC CONTRIBUTIONS OF THE VIRGINIA SEAFOOD INDUSTRY



VIRGINIA AGRICULTURAL EXPERIMENT STATION
VIRGINIA SEAFOOD AGRICULTURAL
RESEARCH AND EXTENSION CENTER
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Economic contributions of the Virginia seafood industry

About the Project

The economic benefits of the seafood supply chain to the overall state economy demonstrate the magnitude and reach of the Virginia seafood industry. Watermen, aquaculture farmers, processors, and distributors sustain jobs and support other economic sectors operating within and beyond our Commonwealth that amplify their contribution to our economy. This study measured the combined impact of the different levels of the seafood supply chain on the Virginia Commonwealth's economy.

Authors

Fernando H. Gonçalves, Jonathan van Senten, Michael H. Schwarz and Shraddha Hegde

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Cover photo: Virginia watermen wild harvesting oysters in Tangier Island, VA by Keri Rouse for Virginia Tech

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About the Virginia Seafood AREC

The Virginia Seafood Agricultural Research and Extension Center provides education, scientific and technical guidance, support, and leadership to the commercial seafood and aquaculture industries throughout Virginia and the United States.

About SEAMaR

The Seafood Economic Analysis and Marketing Research (SEAMaR) team at VSAREC spans areas of business development, policy, marketing, and economics.



Virginia Seafood AREC
15 Rudd Lane
Hampton, VA 23669
757-727-4861

www.arec.vaes.vt.edu/arec/virginia-seafood

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Executive Summary

This report provides an assessment of the Virginia seafood supply chain and summarizes the results of an economic contribution analysis with quantitative estimates of the total economic benefits (direct, indirect from support sectors, and induced effects from additional household spending) of the Virginia seafood industry. We identified the specific economic sectors in Virginia that are supported by various seafood activities.

This project was executed in four phases. Phase 1 consisted of gathering secondary data from various sources to obtain records of the number of commercial licenses and permits held within the State to aid with the development of a contact list. Phase 2 of the project was to outline the specific data required to do a comprehensive economic contribution analysis of the seafood industry in Virginia for the year 2019. Existing data were evaluated to determine what data gaps existed. Phase 3 consisted of field surveys to obtain primary data on expenditures from watermen, aquaculture farmers, processors, and distributors for the economic contribution analysis. Phase 4 was the development and execution of the economic impact model using the IMPLAN online system using the analysis-by-parts approach. For the completion of Phase 4, the state package IMPLAN dataset was purchased from The IMPLAN Group (IMPLAN, Inc., North Carolina) for Virginia for the most recent year available (2020) including 2019. The IMPLAN datasets include matrices of all economic sectors and include coefficients of the interactions among those sectors. A separate industry spending model was specified for each level of the Virginia seafood supply chain; reflective of different cost structures. We created customized expenditure patterns in Microsoft Excel, developing standardized enterprise budgets for watermen, aquaculture farmers, processors, and distributors of the Virginia seafood industry. The expenditures of these activities were converted into spending coefficients and coded by the appropriate North American Industry Classification System (NAICS) sector codes. The coded expenditure patterns were then imported into IMPLAN online system, relevant models were created, and those models were run and analyzed.

Highlights

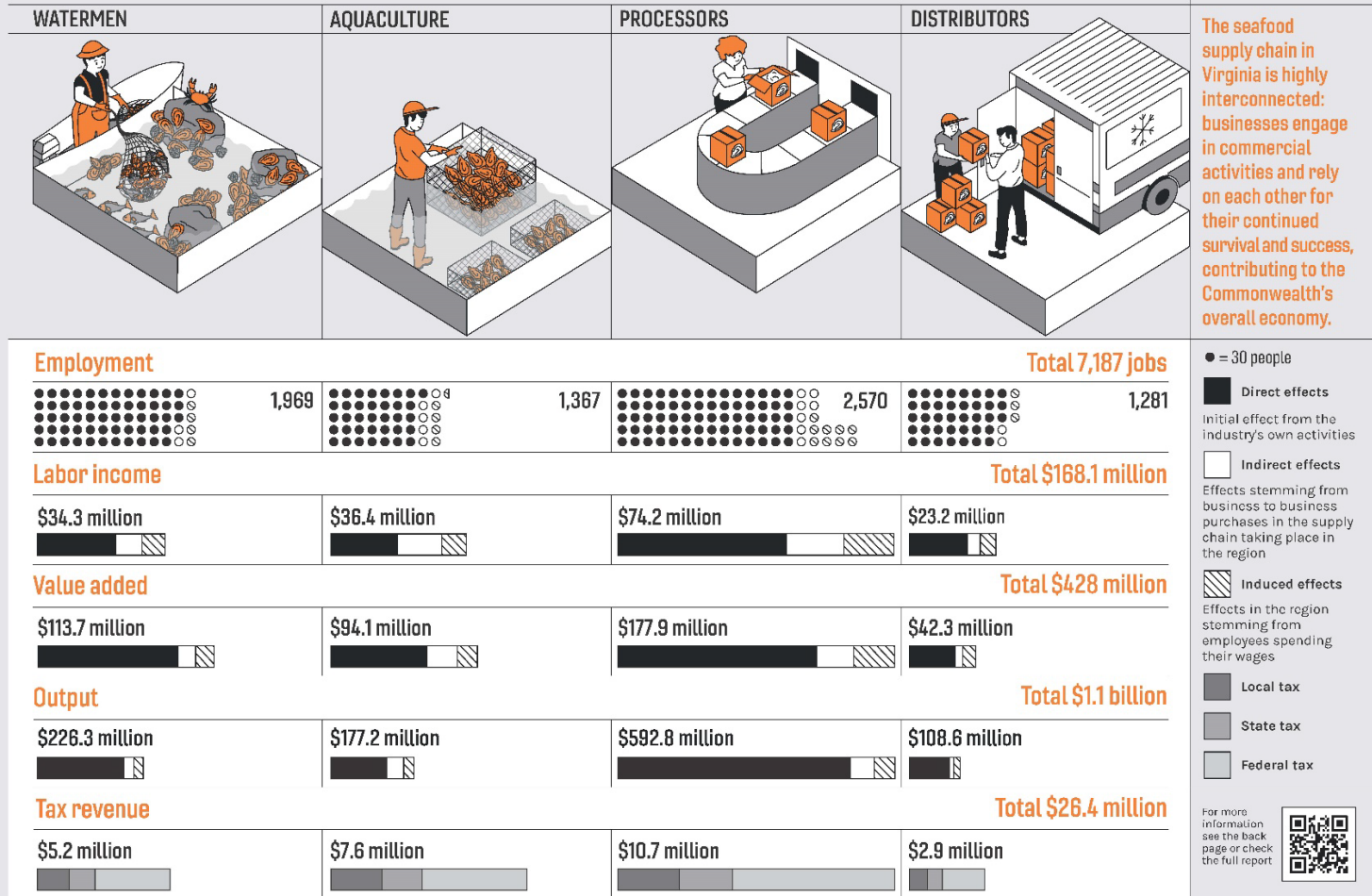
- The Virginia seafood industry provides valuable employment opportunities for watermen, aquaculture farmers, processors, distributors, and others in coastal areas.
- The total economic output effect of the Virginia seafood industry was estimated at \$1.1 billion in 2019 from Virginia economic activities only. Economic leakages and spillovers were excluded from the model.
- The total employment effect of the Virginia seafood industry was estimated to benefit 7,187 people; with a direct effect of 6,050 jobs, indirect effect of 523 jobs, and induced effect of 614 jobs.
- In 2019, the Virginia seafood industry generated over \$26 million in tax revenue from local, state and federal taxes.
- The Virginia seafood industry supports a wide variety of other economic sectors, from polystyrene foam product manufacturing, boat building, sporting and athletic goods manufacturing, commercial and industrial machinery and equipment repair and maintenance through direct expenditures by seafood businesses. Non-depository credit intermediation, owner-occupied dwellings, and real estate sectors are supported as wages and salaries paid to employees throughout the seafood supply chain multiply in Virginia's economy.
- Retail and restaurant services were not included in this analysis.

Visual summary - infographic

ECONOMIC CONTRIBUTIONS OF THE VIRGINIA SEAFOOD INDUSTRY IN 2019: \$1.1 BILLION

Economic effects in the state of Virginia only. Retail and restaurant services are not included.

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Visual summary - infographic

ECONOMIC CONTRIBUTIONS OF THE VIRGINIA SEAFOOD INDUSTRY IN 2019: \$1.1 BILLION

Economic effects in the state of Virginia only. Retail and restaurant services are not included.

	WATERMEN	AQUACULTURE	PROCESSORS	DISTRIBUTORS	TOTALS
Employment	1,969	1,367	2,570	1,281	7,187
Direct effects	1,743	1,073	2,089	1,145	6,050
Indirect effects	101	161	210	51	523
Induced effects	125	133	271	85	614
Labor income	\$34,313,744	\$36,441,948	\$74,174,637	\$23,189,800	\$168,120,129
Direct effects	\$21,010,110	\$17,836,629	\$45,349,506	\$15,515,125	\$99,711,370
Indirect effects	\$7,124,609	\$12,029,561	\$15,466,851	\$3,496,137	\$38,117,158
Induced effects	\$6,179,025	\$6,575,758	\$13,358,280	\$4,178,538	\$30,291,601
Value added	\$113,682,985	\$94,084,161	\$177,904,164	\$42,333,871	\$428,005,182
Direct effects	\$90,508,386	\$61,516,724	\$127,758,567	\$29,469,935	\$309,253,612
Indirect effects	\$11,120,857	\$19,743,479	\$24,087,262	\$4,713,381	\$59,664,979
Induced effects	\$12,053,743	\$12,823,958	\$26,058,335	\$8,150,555	\$59,086,591
Output	\$226,282,561	\$177,200,126	\$592,764,852	\$108,620,531	\$1,104,868,070
Direct effects	\$184,268,786	\$119,657,312	\$497,769,653	\$86,054,955	\$887,750,706
Indirect effects	\$21,720,513	\$35,951,827	\$51,124,196	\$8,843,384	\$117,639,920
Induced effects	\$20,293,262	\$21,590,987	\$43,871,003	\$13,722,192	\$99,477,444
Tax revenue	\$5,153,434	\$7,614,467	\$10,749,280	\$2,928,208	\$26,445,389
Local tax*	\$1,223,269	\$1,976,523	\$2,391,161	\$696,679	\$6,287,632
State tax	\$1,013,845	\$1,557,919	\$2,064,370	\$579,463	\$5,215,597
Federal tax	\$2,916,320	\$4,080,025	\$6,293,750	\$1,652,066	\$14,942,160

*includes sub-county general, sub-county special districts, and county level

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Introduction

Virginia is home to the Chesapeake Bay, the largest estuary in the United States, where freshwater from rivers and streams mixes with salt water from the ocean. This ecosystem has significant ecological, social, historical, cultural, and economic value. The relationship between the Chesapeake Bay and fishing activities dates back to indigenous Powhatan tribes that introduced Chesapeake Bay oysters to the English settlers and colonists in the early 1600s. The seafood industry started to organize as more people were demanding oysters and bay products, which necessitated boats to collect them from bars farther out into the rivers and the Bay (The Mariner's Museum, 2002). As the fourth-largest producer of seafood in the United States, Virginia has a long history and tradition of working waterfronts and maritime economic activity. Virginia seafood landings accounted for 393,065,090 pounds in 2019, with a dockside value of over \$184.2 million. Similarly, the Virginia aquaculture industry has continued to grow and was, as of 2019, the largest producer of hard clams nationwide and the largest producer of oysters along the U.S. Atlantic coast. All seafood supply chain levels from producers, processors, wholesalers, distributors, retailers, and consumers are found in Virginia. Many of these businesses engage in commercial activities with one another and rely on additional goods and services provided by other entities in Virginia for their continued survival and success. It is exactly this interconnected nature of the seafood industry that helps to contribute to the Commonwealth's overall economy.

Economic impact v. Economic contributions

Economic impact and economic contributions are commonly confused terms, and this section aims to clarify the differences between these two types of economic analysis that use input-output models.

In a typical economic impact analysis, the analyst is modeling a new firm or a change in the level of Output of a given firm. In such cases, the Direct Effect is the new firm's total Output or the existing firm's change in Output. Therefore, it is likely (and logical) that the industry in which that firm belongs will experience total impacts that exceed the direct impacts - that is, the industry will experience indirect and induced effects that stem from the direct effects (IMPLAN, 2022). In summary, the economic impact analysis is used to measure the effects of the creation or expansion event of a business that changes the output.

An economic contribution analysis is an extraction method to measure the indirect and induced effects that the current levels of Output of an existing industry as a whole have on other industries in the selected region. In other words, the only "effects" that the industry of interest should experience are the direct effects (e.g., current Output), while other industries in the region experience indirect and induced effects associated with (i.e., in support of) the direct effects in the industry under study (IMPLAN, 2022).

There is a need to quantify and document the economic contributions of Virginia's seafood industry to the Commonwealth. While previous economic impact studies have focused on quantifying the effects of one segment of the industry, capturing the total combined effect across all levels of the supply chain would be a new undertaking for Virginia; one that would help to shed light on the impacts beyond the producer level. The present study is focused on estimating the overall existing direct, indirect, and induced effects of the Virginia seafood industry in 2019 utilizing an extraction method by surveying industry stakeholders. Therefore, this present study is an economic contribution analysis to the Virginia seafood industry.

Methods

Identification of Required Data and Gaps

To complete a comprehensive economic contribution analysis of the seafood industry in Virginia for the year 2019, the first step was to identify the specific data required and outline areas where data were deficient. This was considered phase 1 of the project and it consisted primarily of information gathering activities to determine all of the Virginia seafood supply chain elements. This included consultation with seafood industry members, extension agents, and State agency personnel to ascertain the number of business entities participating in the various levels of the seafood supply chain.

We consulted authorities and State agencies overseeing seafood and business activities within the State of Virginia (Virginia Marine Resources Commission, Virginia Department of Agriculture and Consumer Services, Virginia Marine Products Board, Virginia Department of Game and Inland Fisheries, NOAA Fisheries, Virginia Watermen's Association, Virginia Department of Health, etc.) for records of the number of commercial licenses and permits held within the State. These data were requested to verify the number of participating businesses at the different levels of the seafood supply chain; i.e. the number of aquaculture farms, fishing licenses, distributors, processors, etc. Detailed data were requested for the annual harvest landings reported for 2019.

We prepared a summary of the various elements of the Virginia seafood supply chain and the respective number of participants at each level. In addition, this phase of the project resulted in the identification of the gaps in the data needed to be able to produce a comprehensive economic contribution analysis of the Virginia seafood industry.

Supply chain data

The seafood industry in Virginia has developed a supply chain that includes the following levels: watermen/ fishermen, commercial harvesters, aquaculture farms, packing/processing plants, and wholesalers/distributors. Each level of the supply chain provides essential marketing functions that are necessary for the seafood sold to satisfy end consumers who purchase seafood. Given the different functions performed at each level of the supply chain, the labor, sales, and expenditure patterns differ across the various levels.

The Virginia seafood industry is complex and affected by numerous agencies that serve and regulate seafood businesses from each level of the supply chain. In order to facilitate comprehension of interactions between seafood businesses in Virginia and complete the data gathering process, we attempted to summarize and characterize the Virginia seafood supply chain.

Data for direct effects

In economic contribution analysis, direct economic effects primarily include the total economic output from the primary industries. In the case of the Virginia seafood industry, the direct effects include total sales from watermen, aquaculture farms, processors, and distributors. We used the value published by NMFS-NOAA (2022) of \$184 million to address watermen's output in 2019. This value has been used by numerous agencies and was obtained by data mining existing reporting programs. The output for the other categories were estimated from the survey responses. Direct effects also require data on labor income that includes income to both proprietors and employees. The survey requested the total cost with payroll, that includes both proprietors and employee's income. The percentage of sales

and employment in and out of state were requested to account for economic leakages in the direct effects because this study is focused on the economic contributions to the state of Virginia only.

Removing economic leakages from the model means not accounting for imported products (from abroad or out of state) purchased by the Virginia seafood industry since those do not generate additional direct effects in Virginia production and are considered economic spillover.

Expenditure data

Expenditure data was necessary for each of the four levels of the Virginia seafood supply chain. There are also various levels of expenditure data. Capital investment expenditure data was needed on the types, size, and total initial purchase of equipment and construction of infrastructure necessary for each of the levels of the seafood supply chain. For each of those items, the initial purchase price and years of useful life were requested in order to calculate the annual depreciation values, which were included in the spending patterns for the year of 2019. In addition to the capital investment expenditures, there are annual operating cost expenditures that include the costs of operating supplies, fishing gear, nets, bait, seed or larvae, fuel, packaging, labels, electricity, and all the other costs associated with running each business at each supply chain level. In addition, we requested the percentage of inputs that were purchased in Virginia and outside of Virginia to address effects of economic leakages from imports. The Appendix section of this report contains a copy of the survey instrument utilized to obtain expenditure data for typical types of equipment for a seafood business at each level of the supply chain. The expenditure patterns for species raised in Recirculating Aquaculture System (RAS) (tilapia and trout), and in raceways (trout) were used based on the existing enterprise budgets developed by Engle et al. (2020). We adjusted these budgets to integrate the spending pattern model for the aquaculture businesses.

Survey Design and Data Collection

To generate comprehensive estimates of the economic contributions of the Virginia seafood industry, it was necessary to gather data from each level of the supply chain. Thus, a survey was developed utilizing the Virginia Tech Qualtrics online survey platform targeting economic information from watermen, aquaculture farms, processors and distributors. The survey was submitted to the Virginia Tech Institutional Review Board (IRB) to ensure it followed appropriate research guidelines to protect respondents from any risks by participating in the study. The IRB review concluded that this research did not constitute human subject's research (VT HRPP protocol number 21-433). The survey instrument was pre-tested and reviewed with at least one member of the industry from each level of the seafood supply chain. After their review, we adjusted the survey to include any missing typical equipment and structure necessary for seafood businesses in order to obtain good representation of the data necessary to develop the economic contribution model. The model of expenditure patterns is based on intermediate inputs, employee compensation and total output with the respective local purchase coefficients.

Any data collected during this research study will be kept confidential by the researchers. The researchers coded the transcripts using a pseudonym. All data collected for this project have been stored on a password-protected computer that uses advanced hard drive encryption. Upon the conclusion of this study and publication of results, financial data that were collected from individual respondents during survey activities will be destroyed.

Scope of data collection

The survey design took into consideration adequate statewide representation of the business entities from which data were collected to ensure that estimated economic impacts would be as comprehensive and accurate as possible; and ensuring that there were adequate numbers of observations for each level of the seafood supply chain in the overall dataset, due to the differences in expenditure and revenue patterns.

The appendix section of this report provides templates of the survey used to obtain the data from businesses from each level of the seafood supply chain. Each line item was summed up across individual businesses to obtain the values that were converted into the form necessary for building the economic impact models in IMPLAN.

Recruitment of participants and Survey activities

Contact lists were developed with the aid of industry lists, the Virginia Marine Resource Commission, the Virginia Marine Product Board, and the Virginia Department of Agriculture and Consumer Services. Web searches were performed to try and identify additional information (such as contact information, location, etc.). The target populations were notified about the study and its intended goals in advance of initiating any survey activities. These communications took place in an organized and planned effort. We produced a short video (<https://bit.ly/3tTsIGA>) to provide information in an effective way to stimulate voluntary participation in the survey. The leadership of the Virginia Watermen Association suggested this format as an effective way to share information with the industry. Recruitment efforts included email communications (1,598 contacts), physical mail postage (1,044 for which no email contact information was available) with flyers (see Appendix for recruitment materials), telephone contact was attempted with every entity on the contact lists to inform them of the study, confidentiality of their participation and data, and to request their participation. In addition to the recruitment efforts, in-person meetings were carried out by appointment. The research team participated in business meetings with the Virginia Watermen Association and the Shellfish Growers of Virginia for a public presentation of the ongoing study to stakeholders. During the Virginia Aquaculture Conference, in Newport News in January, 2022, flyers were distributed to every participant at the event, and a presentation of the characterization of the Virginia supply chain was given. Recruitment efforts were continuous during the event at the VSAREC and VMPB booths and common areas for networking.

The effects of the COVID-19 pandemic did contribute to challenges in completing this study as it was originally designed. All recommended precautions were taken for the safety of participants and our research team during data collection activities. Entities that agreed to participate in the study were interviewed by appointment via videoconference (Zoom) and/or telephone as well as in person by project personnel at a time and location of their choosing, following the CDC protocols in effect at the time.

Survey responses were recorded and coded to protect respondent identities and to preserve confidentiality. Survey activities continued for a period of 205 days from 09/21/2021 to 04/14/2022, with repeated attempts to contact members of the target populations. Upon conclusion of survey activities, data were entered into Microsoft Excel templates for data cleaning and further analysis.

Response rates

Table 1 summarizes the development of the list frame for the survey activities. The initial contact lists for watermen and aquaculture farms were provided by VMRC, based on the number of licenses issued for the state of Virginia. This was narrowed down to obtain only active license holders, by using NOAA's criteria to designate commercial operations as those with annual sales greater or equal to \$1,000. This criterion helped focus the contact list for watermen to commercially active entities. For aquaculture, VMRC issued 521 individual licenses and the census of aquaculture reported 191 aquaculture farms in Virginia. Processors and distributors were the categories that presented high levels of vertical integration, and therefore, classifying businesses as one or the other proved challenging. The report Fisheries Economics of the United States, 2019 (NMFS-NOAA, 2022) reported the existence of 112 seafood operations in Virginia divided into 34 processors and 78 distributors. The list frame developed to account for the non-responses to the survey in this study considered the combined total number of operations of 112 (NMFS-NOAA, 2022). However, the number of processors and distributors is different from NOAA's report. This study considered 76 processors and 36 distributors that were estimated based on the percentage of expenditures dedicated to processing and distribution obtained from the survey responses applied to the vertically integrated entities.

Table 1. List frame development, Virginia economic impact survey for 2019.

Supply chain level	Initial contact list (no.)	Sources for initial list	List frame (no.)	Sources for list frame
Watermen	11,638	VMRC, 2019	1528*	VMRC, 2019
Aquaculture Farms	521**	VMRC, 2019	191	USDA-NASS, 2018
Processors	34	NMFS-NOAA, 2022	76	Survey***
Distributors	78	NMFS-NOAA, 2022	36	Survey***

*Number of active watermen that reported production in excess of \$1,000 in 2019.

**Number of licenses issued in comparison to number of farms.

*** Estimated based on the % of expenditures in each level, when vertically integrated, considering 112 processors and distributors combined from NMFS-NOAA (2022).

Table 2 summarizes the survey response rates and coverage. We obtained a total of 150 responses from 167 participants that provided information via survey online or in person. 17 participants were not considered because responses were blank or did not provide relevant information to this study. The response rate was calculated by dividing the number of respondents from surveys by the number of total entities in the list frame. The coverage rate was calculated by aggregating the total sales by respondents from the survey and dividing by the total sales of each level of the supply chain, according to the sources for the list frame listed in Table 1.

Table 2. Coverage and response rates, Virginia economic impact survey for 2019.

Supply chain level	List frame (no.)	Completed (no.)	Response rate (%)	Coverage rate (%) [*]
Watermen	1528	78	5.10%	8.72%
Aquaculture Farms	191	54	28.27%	81.65%
Processors	76	12	15.79%	16.07%
Distributors	36	6	16.67%	16.07%

^{*}Coverage rate based on total estimated output surveyed, except for watermen`s output that used NMFS-NOAA (2022) data.

Economic contributions assessment - Theory of input-output modelling

An economy can be divided into two parts, a set of basic and non-basic (service sector) activities (Kaliba and Engle, 2004). The basic sector of the economy results in an influx of money through trade, while the non-basic activities develop within that economy as income generated in the basic sector is spent on local goods and services (Kaliba and Engle, 2004). The Virginia seafood industry is a basic sector of the economy, producing a product in Virginia that is consumed locally and exported to other areas.

An IMPLAN-based IO approach was used for this project employing the 2019 IMPLAN database. The database consisted of matrices of technical coefficients that account for the backward and forward linkages related to all economic activities in Virginia. IMPLAN models generate linear production functions that relate outputs from a particular industry to the inputs required for that level of output. The model assumes a linear relationship between the total output q from sector i , expressed through a generalized IO model framework as the sum of goods and services sold to other sectors, z_{ij} , and to that sold to the final demand sector, f_i . This can be functionally expressed as:

$$q_i = \sum_1^N (z_{ij} + f_i)$$

The variable z_{ij} (intermediate sales to all sectors j) is a unique linear function of output of q_j (output of intermediate industries); which when divided by q_j results in a matrix of the technical coefficients of the input output model. i and j can take values from 1 to N . Inversion of the matrix allows for representation of the input-output model:

$$q = [I - A]^{-1} * F = \begin{pmatrix} m_{ij} & \dots & m_{ij} \\ \vdots & \ddots & \vdots \\ m_{ij} & \dots & m_{ij} \end{pmatrix} * F = M * F$$

where I is an identity matrix, A is a technical coefficient matrix generally obtained by dividing z_{ij} by q_j , and m_{ij} is the supply-chain interaction coefficients in the multiplier matrix M . However, in this present study, we obtained A by dividing z_{ij} by z_j because we were able to obtain itemized information of only commodity purchases, separate from labor costs, and taxes (IMPLAN, 2022). F is the matrix of final demand for all sectors in the given economy. Therefore, the output multiplier for each sector j , can be obtained by dividing M by i . These multipliers capture the economic effects (rates of change) resulting from basic production

level and allow for estimation of the direct, indirect, and induced effects of spending activities in the Virginia seafood industry within each of the levels of the supply chain. Similar to the multiplier for output, multipliers for employment, labor income, and value addition depict the rate of changes of those variables in the economy due to their economic effect in basic level production (Hegde et al., 2021).

The input-output model is further expanded upon through the addition of a SAM (social accounting matrix), which allows for a better description of economic activities within the defined study area (Kaliba and Engle, 2004). The SAM incorporates the transactions between all the different participants within an economy, allowing for a more complete understanding of the mechanisms behind the generation of household income (Kaliba and Engle, 2004). Utilization of the IMPLAN online system allows for the combination of the input-output model and social accounting matrix in a user friendly and highly adaptable manner, producing estimates of the direct, indirect, and induced economic impacts for the Virginia seafood industry.

A simple way to define direct, indirect and induced effects was suggested by Kaliba and Engle (2004). The direct effects are the ones accumulated within the particular industry being investigated. For example, the direct employment or sales by seafood firms. The indirect effects are experienced by related industries through linked sectors. For example, purchases of fuel by watermen that affect the bigger petroleum refining and production industry. The induced effects are the changes in household expenditures from income changes in the related sectors. For example, salaries paid that lead to additional economic activity through the purchase of homes, utilities, groceries, etc.

Data

Data on the expenditures of Virginia seafood stakeholders were obtained from a survey completed over the summer of 2021 to capture the economic impact of 2019, pre-COVID-19. Participation in the study was confidential, as are all individual respondent data. For additional details on the survey activities that gathered these data, please see the Appendix section of this report that contains the survey used for each of the supply chain levels of the Virginia seafood industry. Watermen, Aquaculture farmers, processors, and distributors have different expenditure patterns, as was observed in the respondent data. Therefore, one set of spreadsheets and models was developed for each of the supply chain levels of the Virginia seafood industry. Respondent data were aggregated to develop a standardized enterprise budget for each activity.

Accounting for Non-Responses

Estimation of the economic contribution of the entire Virginia seafood industry requires accounting for the revenue and expenses from watermen, aquaculture farmers, processors and distributors that did not participate in the survey. Values for non-respondents were estimated by adjusting for the total number of operations identified in the list frame (Table 2) for each category. Expenses for nonparticipating seafood businesses were estimated to account for the cost structure of the average business size where we used the criteria of small, medium and large based on revenue of up to \$1 million, between \$1 million and \$9.9 million and over \$10 million, respectively.

Vertically integrated seafood businesses, especially processors and distributors, were

submitted to an analysis of their cost structure. To establish the proportional distribution of revenue, employment, and employee compensation, we analyzed the percentage of expenditures that falls under processing or distribution activities and, therefore, estimated the number of processors and distributors.

The direct effects of these activities were adjusted for the percentage of sales that remained in the state of Virginia, as reported by respondents. Results from these three activities, while included in the overall estimate of economic contributions of the Virginia seafood industry will not be presented or discussed individually, in order to protect the confidentiality of respondents.

Analysis by parts

County-level IMPLAN datasets were purchased from The IMPLAN Group (IMPLAN, Inc., North Carolina) for Virginia for the year 2019. IMPLAN contains a database for the industries of commercial fishing (industry 17), seafood product preparation and packaging (industry 92), and truck transportation (industry 417). IMPLAN does not contain a dedicated sector for aquaculture; instead, aquaculture is grouped with animal production, except cattle and poultry, and eggs (industry 14). In addition, industry 417 (Truck transportation) is not exclusive to seafood distribution. Even though we are able to address watermen, processors, and distributors to the industries 17, 92, and 417, and attribute aquaculture to industry 14, to more accurately estimate the impacts of the Virginia seafood industry, an analysis by parts (ABP) approach was used. The ABP approach allows for dividing the effects of an industry into its individual components, budget expenditures, and income. This allows for greater flexibility and customization of the model. ABP allows for the specification of commodity inputs, specification of a proportion of local labor income, specification of local purchases, and the use of IMPLAN's special spending patterns (Hegde et al., 2021). In order to successfully employ this model, the direct effects of the Virginia seafood industry needed to be determined first. These direct effects were obtained from the respondent data and adjusted for non-response, as described previously. To calculate the direct effects for value-added, we used labor income per worker information obtained from the survey along with IMPLAN's Industry averages data for Taxes on Production & Imports (TOPI), and Other Property Income (OPI).

To calculate the indirect effects, an industry spending pattern was created to reflect seafood business expenditures for each level (watermen, aquaculture farmers, processors, and distributors). The coefficients were calculated by dividing the cost of a determined input by the total costs of all of the intermediate inputs for each level and then assigned to the respective NAICS (North American Industry Classification System) sector codes and the corresponding IMPLAN commodity codes. One industry spending pattern was created for each activity; namely watermen, aquaculture farmers, processors, and distributors. Expenses with seafood purchases from processors and distributors were not considered in the spending patterns. The seafood produced by watermen and aquaculture farmers is their revenue and it cannot be double counted as expenses for processors and distributors. Therefore, the expenses with seafood purchases were not included in the processors' and distributors' spending patterns. The ABP approach facilitates delineating the economic contribution of all levels of the seafood supply chain, allowing for capturing the complete revenue generation at each supply chain level while avoiding double counting the sales generated at each level by counting it only once as ex-gate revenue and not again as an expense in the respective forward linkages (Hegde et al., 2021). In order to estimate the induced effect of the seafood industry in Virginia, a labor income value was added to the

model to account for employee compensation. Again, one labor income value was specific for each activity (watermen, aquaculture farmers, processors, and distributors). The scenarios for the economic impact model having been developed, the model was run without any scale modification. Figure 1 provides a visual explanation of the components of output and how IMPLAN treats these components to calculate the economic effects.

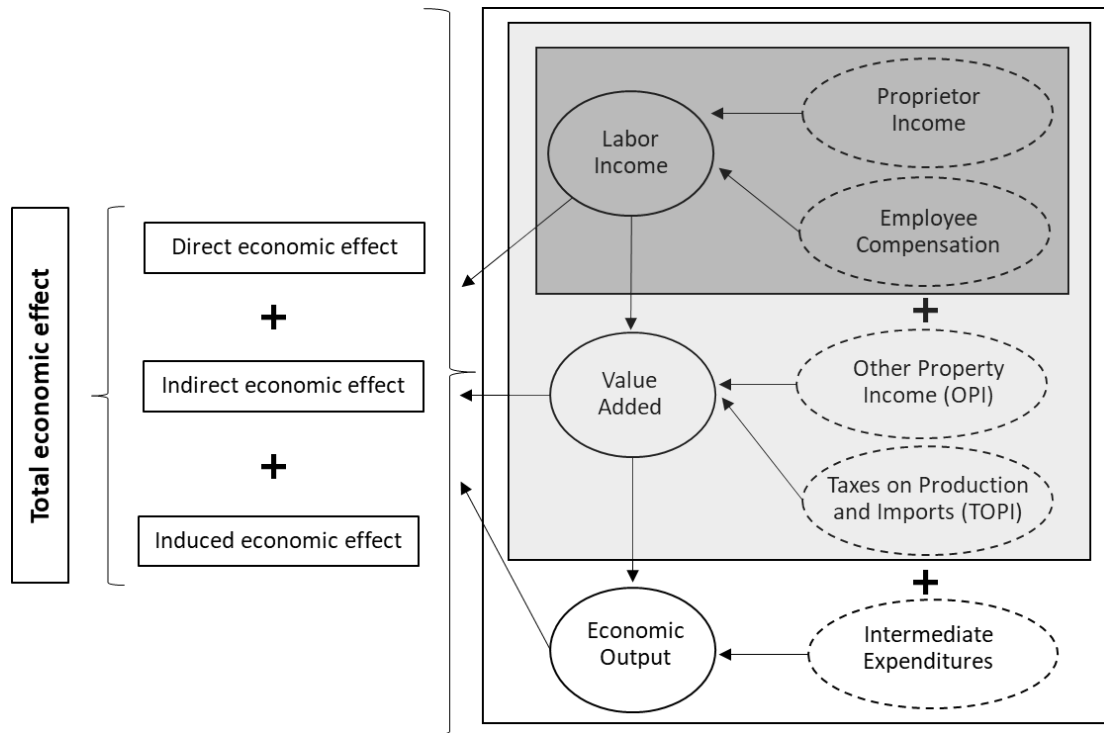


Figure 1. Conceptual diagram of components of output and types of economic effects used in IMPLAN. Adapted from Hegde et al., 2021

Study Area Characteristics

Virginia is a “Mid-Atlantic” state, bordered by Maryland, the District of Columbia, North Carolina, Tennessee, Kentucky, West Virginia, and the Atlantic Ocean. The state of Virginia is home to more than eight million residents and the state had a gross regional product in 2019 of \$561 billion. Table 3 summarizes relevant socio-economic facts and metrics regarding the state of Virginia.

Table 3. Virginia 2019 state metrics.

Category	Measure/Quantity
Land area (square miles) ¹	39,597.80
Population	8,535,519
Total households	3,263,452.26
Persons per household	2.60
Civilian labor force	64.0%
Total employment ¹	5,365,605

Gross Domestic Product (\$) ¹	\$561,524,010,662
Per Capita Income (\$)	\$39,278
Difference in per capita income from U.S. average	+\$3,894
Percent poverty	9.2%
Number of industries ¹	508

(United States Census Bureau, 2019)

¹ (IMPLAN, 2019)

Most of the seafood production is concentrated in Eastern Virginia which presents 5 distinct regions: The Northern Neck, the Middle Peninsula, the Virginia peninsula, Southern Virginia, and the Eastern shore (Figure 2). Each region is surrounded by the rivers Potomac, Rappahannock, York, and James which connect to the Chesapeake Bay and the Atlantic Ocean.



Figure 2. Virginia state and the Eastern Virginia regions

Survey respondents were distributed across these regions with 22% of respondents located in the Northern Neck, 18% from the Middle Peninsula, 17% from the Virginia Peninsula, 13% from Southern Virginia, and 29% from the Eastern shore. The Eastern shore obtained the highest participation rate, especially due to the number of aquaculture farms as observed in Table 4.

Table 4. Percentage of respondents of each region

Supply chain level	Northern Neck	Middle Peninsula	Virginia Peninsula	Southern Virginia	Eastern Shore
Watermen	25%	25%	17%	12%	21%
Aquaculture Farms	21%	13%	13%	10%	44%
Processors & Distributors	20%	13%	27%	23%	17%

Tables 5 and 6 present a truncated summary of the top 15 industries that are included in the economic base of Virginia's economy sorted by greatest to least output and employment, respectively. All of the dollar figures on the following tables are inflation-adjusted to the 2019-dollar value and were rounded to the nearest whole number.

Table 5. Economic base of Virginia sorted by Output and Employment.

Description / Industry	Employment (no.)	Employment (%)	Output (\$ Million)	Output (%)
Total	5,365,605	100	\$929,354,256,026	100
Owner-occupied dwellings	0	0.00	\$52,174,386,618	5.61
Other real estate	188,358	3.51	\$38,544,903,079	4.15
Employment and payroll of federal govt, non-military	171,180	3.19	\$30,932,603,926	3.33
Management of companies and enterprises	83,76	1.56	\$21,568,375,076	2.32
Computer systems design services	141,269	2.63	\$21,012,780,272	2.26
Employment and payroll of federal govt, military	149,240	2.78	\$20,575,127,673	2.21
Hospitals	105,208	1.96	\$19,072,840,202	2.05
Scientific research and development services	77,597	1.45	\$17,876,397,212	1.92
Tenant-occupied housing	36,847	0.69	\$17,090,433,252	1.84
Insurance carriers, except direct life	34,175	0.64	\$16,440,449,810	1.77
Management consulting services	92,533	1.72	\$16,104,752,991	1.73
Monetary authorities and depository credit intermediation	35,328	0.66	\$14,476,522,639	1.56
Offices of physicians	92,067	1.72	\$14,354,498,165	1.54
Architectural, engineering, and related services	73,476	1.37	\$14,122,826,143	1.52
Employment and payroll of local govt, education	174,563	3.25	\$13,197,121,643	1.42
Tobacco product manufacturing	2,309	0.04	\$13,175,918,666	1.42
Nondepository credit intermediation and related activities	45,516	0.85	\$11,828,566,303	1.27
Data processing, hosting, and related services	20,520	0.38	\$11,429,239,254	1.23
Limited-service restaurants	147,093	2.74	\$11,210,923,990	1.21
Custom computer programming services	69,498	1.30	\$11,166,400,367	1.20
Employment services	105,044	1.96	\$11,150,996,159	1.20
Other local government enterprises	28,569	0.53	\$11,141,531,203	1.20
Full-service restaurants	156,498	2.92	\$10,288,043,545	1.11

(IMPLAN, 2019)

^a Owner occupied dwellings are fixed assets that provide housing services for owners. There are no employees of owner-occupied dwellings.

Table 6. Economic base of Virginia sorted by Employment.

Description / Industry	Employment (no.)	Employment (%)	Output (\$ Million)	Output (%)
Total	5,365,605	100	\$929,354,256,026	100
Other real estate	188,358	3.51	\$38,544,903,079	4.15
Employment and payroll of local govt, education	174,563	3.25	\$13,197,121,643	1.42
Employment and payroll of federal govt, non-military	171,180	3.19	\$30,932,603,926	3.33
Full-service restaurants	156,498	2.92	\$10,288,043,545	1.11
Employment and payroll of federal govt, military	149,240	2.78	\$20,575,127,673	2.21
Limited-service restaurants	147,093	2.74	\$11,210,923,990	1.21
Computer systems design services	141,269	2.63	\$21,012,780,272	2.26
Employment and payroll of local govt, other services	120,735	2.25	\$10,146,286,290	1.09
Hospitals	105,208	1.96	\$19,072,840,202	2.05
Employment services	105,044	1.96	\$11,150,996,159	1.20
Management consulting services	92,533	1.72	\$16,104,752,991	1.73
Offices of physicians	92,067	1.72	\$14,354,498,165	1.54
Management of companies and enterprises	83,763	1.56	\$21,568,375,076	2.32
Retail - General merchandise stores	79,097	1.47	\$6,015,351,583	0.65
Scientific research and development services	77,597	1.45	\$17,876,397,212	1.92
Architectural, engineering, and related services	73,476	1.37	\$14,122,826,143	1.52
Transit and ground passenger transportation	72,748	1.36	\$1,730,139,538	0.19
Retail - Food and beverage stores	70,320	1.31	\$5,161,460,986	0.56
Employment and payroll of state govt, other services	70,298	1.31	\$6,280,127,865	0.68
Custom computer programming services	69,498	1.30	\$11,166,400,367	1.20
Nursing and community care facilities	65,536	1.22	\$5,308,993,380	0.57
Construction of new single-family residential structures	65,237	1.22	\$7,444,446,842	0.80
Total	5,365,605	100	\$929,354,256,026	100

(IMPLAN, 2019)

Results

Seafood Chains

Many economic studies that investigate industries often address chains that convey outputs in forward or backward linkages. These output dynamics are also described as upstream or downstream movements from a reference level of a determined chain. Many names are used to describe these chains such as production chain, value chain, custody chain, supply chain, and others. However, a clear definition of each of these chains is not easy to find. Therefore, we attempted to propose a brief description of each of these chains used in the seafood industry in light of chain-level orientation.

Valenti & Moraes-Valenti (2010) described what is called the production chain. The chain is divided into pre-production, which considers technical support, economic support, set of regulations, public policies, and infrastructure, and post-production, including processing, distribution, marketing, and consumer. This study was focused on the elements of the post-production elements of the Virginia seafood production chain. Based on that paper, we observed that the production level (watermen and aquaculture farmers) is central and orients the production chain; it is a chain that is oriented by the producer's needs. Similarly, the value chain is oriented by the products (seafood itself), with a business management standpoint (focused on processors) that provides a series of activities that adds value to the product in order to gain competitive advantages in the market. The Virginia seafood value chain is oriented by the product's potential. The custody chain is oriented by the product's possession (focused on the distribution) at a given time. Finally, the supply chain is oriented by the consumers' satisfaction, considering integrating all the activities involved in the procurement, conversion, and logistics of the product, operations and management. It is linked to the concept of conveyance oriented by the consumer's needs.

The Virginia seafood industry commonly use the supply chain focus to describe its different levels and elements. Supply chain analyses examine entire sets of market channels for a product and typically include requirements at the production, processing, wholesaling, retail (supermarket), and food service (restaurants) levels. Supply chain analyses are descriptive in nature and describe the range of activities required for a product to be produced, cleaned, processed, and transported to appropriate market outlets. Proper marketing functions for each product form must be considered, and often include the need for consolidation and storage of product at a wholesale level and processing considerations related to adding value to raw products. Other important considerations include relative sizes and the market power of actors along the supply chain. For example, if a large company controls one or more supply chain levels, it may exert influence over prices, volumes purchased, or quality characteristics. Finally, the overall regulatory environment frequently has important implications for market development through the supply chain. In summary, any of the chains described above talk about the same thing (industry operations and dynamics), but with a slightly different approach that we identified to be the orientation by level. Therefore, we propose to present the Virginia seafood chains as a result of efforts to understand, in a simplified way, the differences between them (Figure 3).

The Seafood Chains

Same picture, different stories

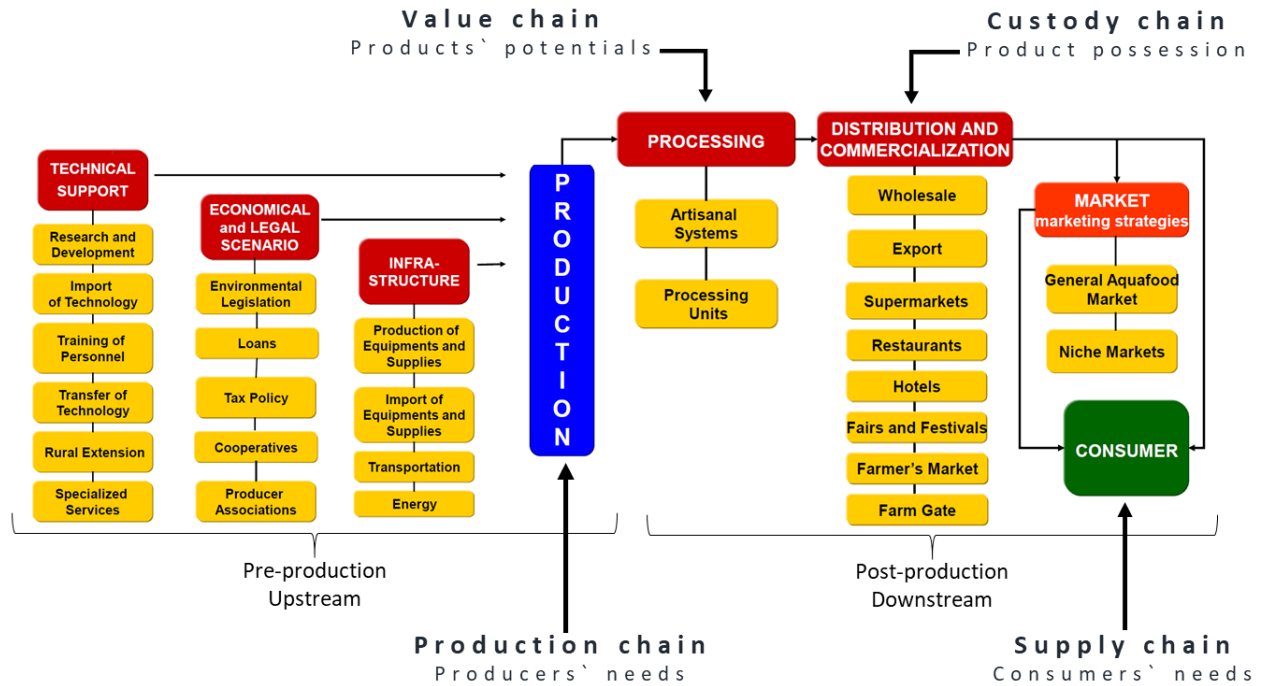


Figure 3. The seafood chains, adapted from the production chain characterization from Valenti & Moraes-Valenti (2010).

Characterization of the Virginia seafood supply chain

The information in this section is a compilation of existing data published in multiple sources such as the Virginia Marine Products Board, VDACS, VMRC, NOAA and USDA and were not obtained from the survey responses. We prepared a summary of the various elements of the Virginia seafood supply chain and a brief characterization of each level represented by production, processing, distribution, and commercialization. Figure 4 summarizes the Virginia seafood supply chain, consolidating information from multiple public agencies, followed by the description and characterization of each of these different levels below.

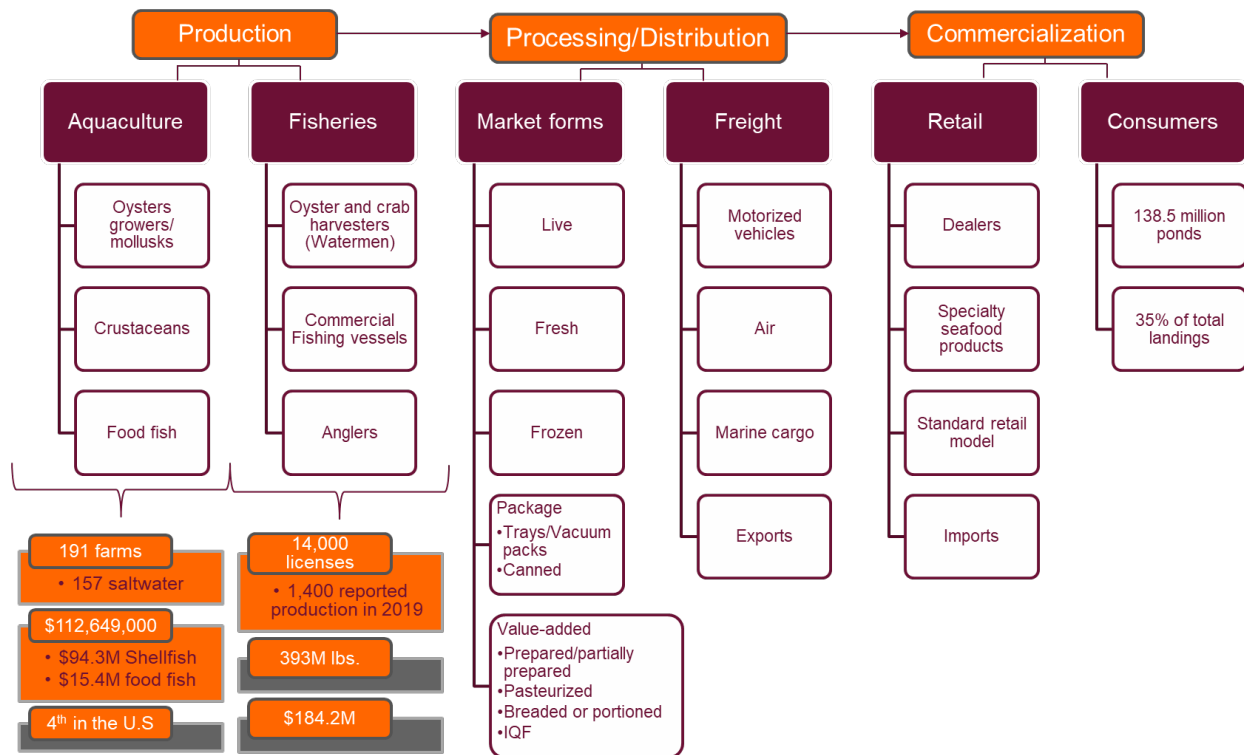


Figure 4. Virginia seafood supply chain

PRODUCTION

The production level of the seafood supply chain embeds the entities that produce seafood through harvesting fish and shellfish from their natural environment or farming using controlled aquaculture techniques in tanks, ponds, rivers, lakes, the Chesapeake Bay, and the ocean. Watermen and aquaculture farmers are included in the production level of the Virginia seafood supply chain. The production sector of the seafood industry is mainly monitored by NOAA, VMRC and USDA. The multiple sources of data are collected using different methods, such as surveying primary data, production reporting programs, or applying a growth multiplier on previous data. Due to the different methods used, production results can be presented differently between sources, causing confusion with mismatched data addressed for the same year. Production data can be found expressed in sales value and dockside value. Sales value is obtained by surveying business revenue. Dockside value is obtained by the attribution of current market prices to pounds or counts from production reports for each individual species. Understanding the differences between these terms is important to clarify interpretations of data used for watermen and aquaculture farmers' production figures.

Watermen

Watermen is a commonly used term in Virginia to address a group of men and women that are connected to aquatic environments to make a living from commercial fishing activities, including crabbing, and oyster harvesting. This report uses the term watermen to address fishermen that regularly engage in commercial wild harvesting activities that rely on natural fisheries stocks in the Chesapeake Bay waters and ocean, as defined by the Virginia Administrative Code 23VAC10-210-350.

The VMRC is responsible for commercial fishing licenses issued in Virginia and to receive production reports from watermen. There are over 11,000 commercial fishing licenses issued in Virginia. However, only 1,528 watermen reported production in excess of \$1,000 in 2019 (VMRC, 2022). The threshold of \$1,000 of reported sales in a year is a metric used by NOAA to establish active commercial watermen (NMFS-NOAA, 2015). NOAA Fisheries is an agency that also regulates fishing activities and issues permits. There are 221 fishing vessel permits along with 278 vessel operators and 68 tuna permits registered in 2019 (NOAA Fisheries, 2022). The Virginia Watermen Association provides social representation and advocates for watermen in diverse meetings in regulatory forums and boards.

Virginia is the nation’s fourth-largest producer of marine products with total landings of 393,065,090 pounds in 2019 and is only outpaced by Alaska, Louisiana and Washington (Table 7). The dockside value to watermen production was \$184,270,303 (Table 7). Virginia also ranks as the largest seafood production state on the U.S. East Coast. In 1990, Virginia registered the highest historical volume of seafood landings in excess of 786,794,000 pounds (NMFS-NOAA, 2022). Virginia also presented 13,950,632 pounds in recreational landings. Together, commercial and recreational landings accounted for over 407 million pounds which accounts for 97% and 3.43% of the total of landings (NOAA Fisheries, 2022).

Table 7. U.S. Commercial landings in poundage and dockside value, 2019

State	Thousand pounds	Thousand dollars
Alaska	5,631,389	\$1,754,111
Louisiana	898,851	\$317,319
Washington*	542,855	\$247,267
Virginia	393,065	\$184,271
Mississippi	340,716	\$58,661
Oregon	334,985	\$164,357
Massachusetts	234,230	\$681,090
Maine	181,269	\$676,639
New Jersey	175,360	\$181,789
California	112,538	\$164,066

*Washington landings include at-sea-processors
 Source: NMFS-NOAA, 2022

Virginia’s watermen harvest 50 commercially valuable species from 620,000 acres of water. Among these traditional species in order of economic value per pound are sea scallops, oysters, blue crabs, menhaden, clams, flounder, striped bass, croaker, and spot (Table 8). Watermen are also harvesting more non-traditional products for the international market, such as eel, monkfish, and illex Squid (VMPB, 2021). Virginia also presented 13,950,632 pounds in recreational landings. Together, commercial and recreational landings accounted for over 407 million pounds (407,015,724 lb.) which account for 97% and 3.43% of the total of landings (NOAA Fisheries, 2022).

Table 8. Landings and value of top 10 Virginia species, 2019

Species	Poundage	Dollar Value
Eastern Oyster	3,434,635	\$39,544,110
Blue Crab	28,729,190	\$35,057,862
Sea Scallops	3,898,803	\$34,983,183
Menhaden	332,511,812	\$26,921,609
Clams	3,773,220	\$25,583,740
Summer Flounder	1,918,045	\$5,029,834
Striped Bass	1,389,039	\$4,580,941
Spot	1,185,727	\$2,523,285
Black Sea Bass	645,817	\$2,011,166
Blue Catfish	3,020,489	\$1,498,777

Source: Virginia Marine Resources Commission, 2021

Aquaculture

The aquaculture sector in Virginia has demonstrated continued growth over the period from 1998 to 2018 (Figure 5) and its production adds significant value to the state’s seafood marketplace. Currently, Virginia ranks as the fourth largest aquaculture production state in the United States of America. From 2013 to 2018, the production of mollusks and food fish grew 44% and 35%, respectively. According to the 2018 Census of Aquaculture published by the USDA-NASS (2018), Virginia reported 191 total aquaculture farms responsible for \$112.6 million in total sales. These farms include 152 for mollusks, 25 for food fish, 6 for ornamental fish, 8 for crustaceans, and 2 for sport fish.

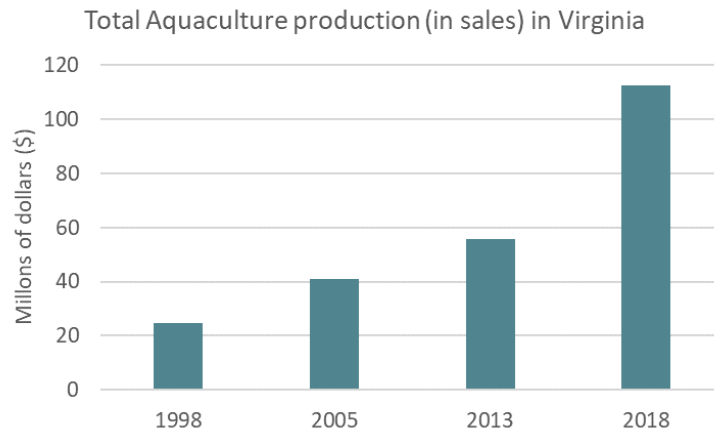


Figure 5. Total aquaculture production in Virginia. Data source: USDA Census of Aquaculture

Shellfish aquaculture (Figure 6) is the main driver of the state’s aquaculture production, providing consumers with a growing quantity of hard clams and oysters and \$94.3 million in sales in 2018 (USDA-NASS, 2018). Virginia continues to lead the nation in hard clam aquaculture production and is first on the U.S. east coast for Eastern Oyster production. 70% of the aquaculture operations in Virginia are dedicated to oyster production, which accounts for 55% of the total sales value (USDA-NASS, 2018). Oyster growers are distributed in 8 defined regions in eastern Virginia based on salinity conditions that provide a diversified tasting experience in different levels of saltiness, sweetness, and buttery/creaminess (VMPB, 2021).

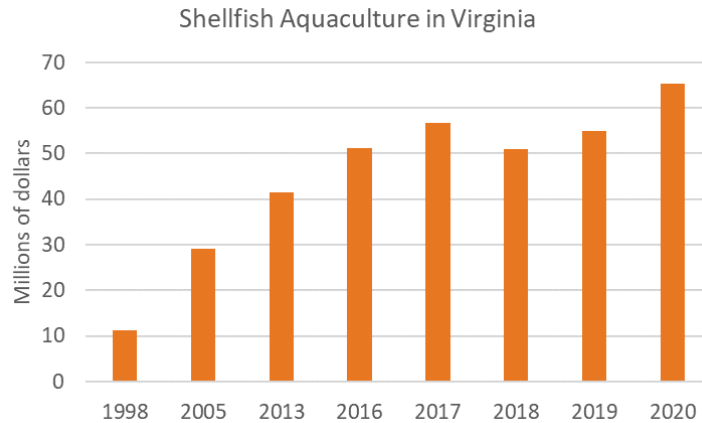


Figure 6. Shellfish Aquaculture in Virginia. Data sources: USDA Census of Aquaculture (1998, 2005, and 2013, sales value) and VMRC (2016 – 2020, dockside value).

The main aquaculture production systems and methods observed in operation in Virginia are distributed as follows: mollusks on bottom, mollusks off bottom, racks and bags, long lines, floating trays, cages or pens, ponds, raceway tanks, recirculating aquaculture system (RAS), and aquaponics. In addition, there are 25 food fish farms, mainly trout and tilapia that together account for \$15.4 million in sales in 2018 (USDA-NASS, 2018).

Processors and Distributors

Vertical integration is a strategy whereby a company owns or controls its suppliers, distributors, or retail locations to manage its value or supply chain. Vertical integration benefits companies by allowing them to control processes, reduce costs and improve efficiencies. Many seafood businesses in Virginia present some level of vertical integration, especially processors and distributors. The Virginia Marine Products Board maintains a directory of seafood suppliers, oyster growers, and retail buyers to facilitate interactions within the industry. The available information allowed us to perform some quantitative analysis of seafood distributors. While all of them distribute seafood in motorized vehicles, 30.3% via Air Freight, 13.1% via Marine Cargo, and 9.1% export seafood in different market forms.

The Virginia Department of Health certified 216 Interstate Shellfish Shippers in Virginia. According to the Virginia Department of Agriculture and Consumer Service’s statistics, Virginia seafood exports totaled \$47.3 million in 2017 to 20 countries. The top destinations where Virginia seafood is exported are France, Canada, Hong Kong, China, Japan, Netherlands, United Kingdom, India, Bangladesh, and Lithuania. Ninety percent of the seafood harvested in Virginia is harvested by day boats. Fish and shellfish are harvested, processed, and shipped within 24 hours to domestic and international markets (VMPB, 2021).

Market forms

Among the distributors identified, 82.8% transport fresh seafood, 64.6% live, and 55.6% frozen. 27.3% of those entities distribute non-Virginian species. 27.3% distributes seafood in trays or vacuum packs. Processed seafood is also found in 23.2% of the entities that distribute prepared or partially prepared products with some kind of value-added to them, 21.2% canned products, 12.1% pasteurized, 10.1% breaded or portioned, and 7.1% IQF -

individual quick freezing. Virginia seafood processors are subject stringent regulations and inspections to ensure that seafood harvested from Virginia waters is clean and safe for consumers. VDACS, VDH and VMRC are state agencies responsible for conducting continual inspections of Virginia's waters and processing plants. These stringent inspection policies ensure the safety and high-quality of the seafood for domestic and international consumers (VMPB, 2021).

Commercialization

NOAA Fisheries granted permits for 21 multispecies dealers in Virginia. The Virginia Department of Health certified 6 scallop, conch and whelk dealers and 24 crab dealers. The VMPB has a record of 130 retail buyers that provide specialties to the market place. The seafood tradition in Virginia can be observed all over the state in a large number of community events such as oyster and seafood festivals and farmer's markets. Virginia is one of the largest US suppliers of fish oil and protein products from menhaden. This herring-like fish is found in abundant quantities in coastal waters off the US mid-Atlantic. According to the federal National Marine Fisheries Service, the nation's menhaden resource is healthy and self-renewing. Menhaden oil, which is rich in long-chain Omega-3 essential fatty acids, is used as a food ingredient and is available in capsules as a nutritional supplement (VMPB, 2021).

Consumers

Virginia's commercial watermen annually harvest enough seafood to produce over 123,000,000 meals. According to the U.S. Department of Commerce's latest data, Americans consumed 16.1 pounds (edible meat) of fish and shellfish per person. Oysters, clams, blue crab, sea scallops, menhaden, conchs, striped bass, summer flounder, spot, and Atlantic croaker are the "Top Ten" most popular seafood items. Virginia has approximately 8.6 million inhabitants, considering the national annual per capita consumption of 16.1 pounds, we can estimate that Virginia consumed 138.5 million pounds or 35.24% of the total landings of the state. It is possible that the consumption per capita of seafood in Virginia is higher than the national average, considering the coastal culture and close relationship with the Chesapeake Bay.

Research and seafood jobs creation

According to McLean et al. (2006), there are over 70 job titles that can be attributed to the seafood industry (Figure 7). Investments in research and development for the fisheries and aquaculture sectors enhance and diversify job opportunities for Virginians. The seafood industry includes a variety of supporting sectors in its supply chain. The multiplicity of segments involved in the seafood industry provides a huge range of employment possibilities beyond the commonwealth (McLean et al., 2006). Through the years, the Virginia Seafood AREC has been stimulating the interest of serious entrepreneurs into expanding seafood enterprises in Virginia by assisting the creation of new business and performing industry-oriented research to support innovations and technological improvements.

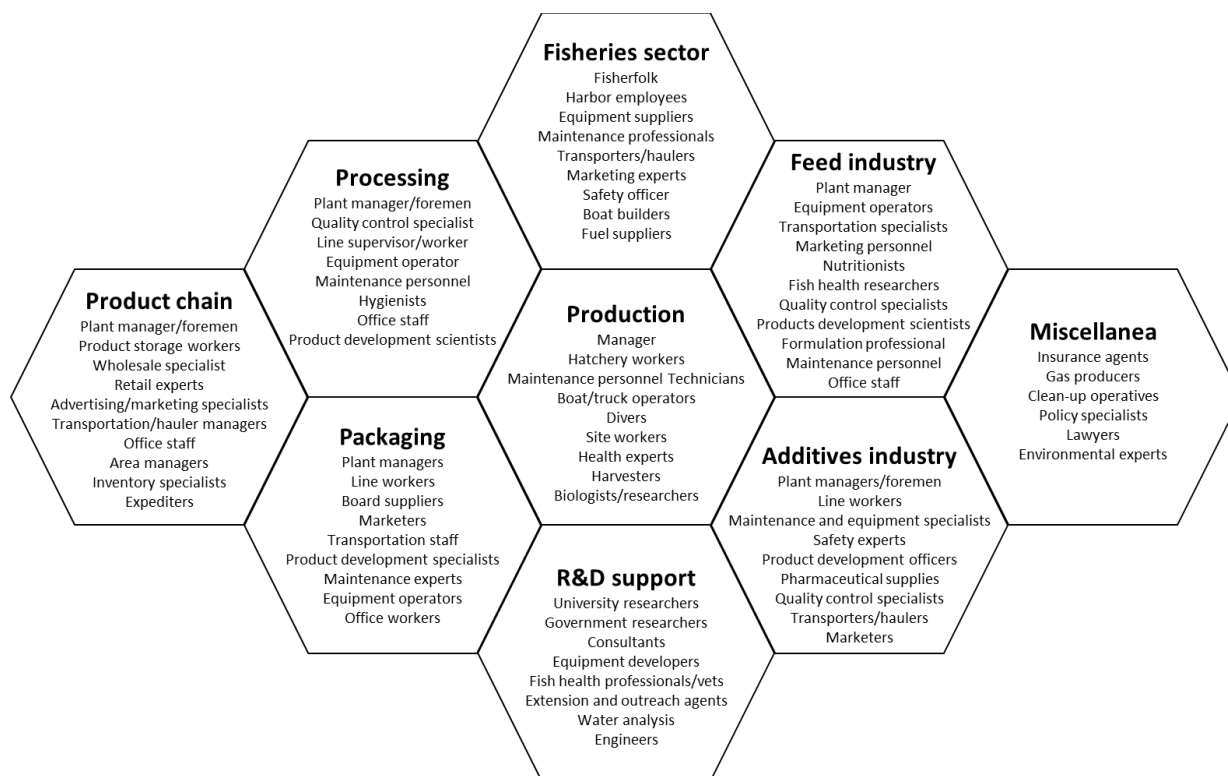


Figure 7. Employment possibilities for the seafood industry (McLean et al., 2006).

Economic contributions of the Virginia seafood industry, 2019

The economic impact model estimated a total output effect of \$1.1 billion in 2019 in Virginia, comprised of a direct effect of \$887.7 million, an indirect effect of \$117.6 million, and an induced effect of \$99.5 million. The total employment effect of the Virginia seafood industry was estimated at 7,187 people, with a direct effect of 6,050 jobs, an indirect effect of 523 jobs, and an induced effect of 614 jobs. The total labor income was estimated to be \$168.1 million and the total value added estimated to be \$428 million. Also, the model identified \$58,650,354 in direct leakages related to imports. That means that imported products purchased by the Virginia seafood industry do not generate additional direct effects in Virginia production and it is considered an economic spill-over.

Table 9 presents the summary of the direct, indirect and induced effects of the economic contributions of the Virginia seafood industry activities in 2019. All of the dollar figures on the following tables are inflation-adjusted to the 2019-dollar value and were rounded to the nearest whole number.

Table 9. Economic contributions of the Virginia seafood industry activities in 2019.

Impact Type	Employment	Labor Income	Value Added	Output
Direct Effect	6,050	\$99,711,370	\$309,253,612	\$887,750,706
Indirect Effect	523	\$38,117,158	\$59,664,979	\$117,639,920
Induced Effect	614	\$30,291,601	\$59,086,591	\$99,477,444
Total Effect	7,187	\$168,120,129	\$428,005,182	\$1,104,868,070

Seafood processors contribute to the highest effects on employment, labor income and output, followed by watermen, aquaculture, and seafood distributors. Note that this economic contribution analysis was performed to focus on the Virginia seafood industry as a whole, and the costs of seafood purchases from processors and distributors were excluded from the model to avoid double counting from the production side.

The economic multiplier effect of the Virginia seafood industry was 1.24, indicating that every \$1.00 spent in the industry generated an additional \$0.24 of output in the Virginia economy in 2019. The employment multiplier and labor income multipliers were 1.19 and 1.69, respectively. These multipliers suggest the generation of one additional job for every five direct jobs created in the Virginia seafood industry and an additional \$0.69 generated for every dollar spent with labor wage paid in the industry. Similarly, the value-added multiplier of 1.38 indicates that every dollar generated from the Virginia seafood industry reflects \$0.38 in the form of labor income, other propriety incomes, taxes on production, and imports in the state's economy. A detailed picture of the economic contributions of the Virginia seafood industry for each level of the supply chain can be observed in Table 10.

Table 10. Economic contributions of the Virginia seafood industry activities for each level of the supply chain in 2019.

Total Impact	Employment	Labor Income	Value Added	Output
Watermen	1,969	\$34,313,744	\$113,682,986	\$226,282,561
Direct	1,743	\$21,010,110	\$90,508,386	\$184,268,786
Indirect	101	\$7,124,609	\$11,120,857	\$21,720,513
Induced	125	\$6,179,025	\$12,053,743	\$20,293,262
Aquaculture	1,367	\$36,441,948	\$94,084,161	\$177,200,126
Direct	1,073	\$17,836,629	\$61,516,724	\$119,657,312
Indirect	161	\$12,029,561	\$19,743,479	\$35,951,827
Induced	133	\$6,575,758	\$12,823,958	\$21,590,987
Processors	2,570	\$74,174,637	\$177,904,164	\$592,764,852
Direct	2,089	\$45,349,506	\$127,758,567	\$497,769,653
Indirect	210	\$15,466,851	\$24,087,262	\$51,124,196
Induced	271	\$13,358,280	\$26,058,335	\$43,871,003
Distributors	1,281	\$23,189,800	\$42,333,871	\$108,620,531
Direct	1,145	\$15,515,125	\$29,469,935	\$86,054,955
Indirect	51	\$3,496,137	\$4,713,381	\$8,843,384
Induced	85	\$4,178,538	\$8,150,555	\$13,722,192
TOTAL	7,187	\$168,120,129	\$428,005,182	\$1,104,868,070

Full-time positions represented 62% of employment, and part-time employment accounting for 32%. We observed that 1% of employees live outside Virginia, which was considered as an economic spill-over in this model. In addition, unpaid labor (usually family members) accounted for 4% of labor that contributed to seafood businesses in Virginia. International workers with H2B visas are 5% of the employment in the industry. This employment category was observed in a small number of businesses but represents an important resource for those who have access to those workers, ranging from 25% to 55% of

individual businesses` labor force.

The majority of respondents (58%) work as sole proprietors of their businesses while 30% represented corporations (C-Corp, S-Corp, LLC). The most common target species are oysters (66%), crabs (42%), marine fin fish (44%), clams (23%), scallops and shrimp (11% each), freshwater fish (7%) and eels (2%). The most frequent immediate sales of seafood production go direct to consumers (24%), processors (19%), and dealers (18%) in Virginia. The most popular sales channels of the entities that sell production direct to consumers are curbside pick-up (55%) delivery (42%) farmers markets (12%), and online sales (9%). The most frequent out-of-state seafood sales reported by the respondents were directed to processors (9%), dealers (6%), and direct to consumers (5%). Air freight and marine cargo were observed as a distribution channel for 4% and 3% of respondents, respectively.

According to the survey responses, the main costs to watermen businesses are fuel (29%), long term loans (13%), motor repairs and maintenance (6%), boat depreciation (5%), vehicle (4%), traps (4%), motor depreciation (4%), warehouse/office depreciation (3%), insurance (3%), and dock fees (3%). Aquaculture farms concentrate their main costs on electricity (19%), loans and interest on invested capital (17%), feed (16%), repairs and maintenance (14%), and fuel (9%). Processors' costs are concentrated in packaging supplies (13%), leases and loans (12%), Styrofoam boxes (11%), fuel (11%), insurance (8%), freezers and cold storage (7%), plastic containers (6%), advertising and marketing (5%), and repairs and maintenance (4%). Distributor costs are concentrated in land freight (27%), trucks (23%), repairs and maintenance (15%), and leases and loans (13%).

90% of the 546 existing industries in the state are affected by the Virginia seafood industry through economic linkages. Table 11 summarizes the direct, indirect and induced effects on the top 15 industries affected by the Virginia seafood industry activities.

Table 11. Direct, indirect and induced effects on the top 15 industries affected by the Virginia seafood industry activities, 2019.

Economic sectors	Direct	Indirect	Induced	Total
Nondepository credit intermediation and related activities	\$20,203,290	\$18,750,019	\$1,646,573	\$20,396,593
Owner-occupied dwellings	\$0	\$0	\$13,794,799	\$13,794,799
Other real estate	\$4,016,698	\$6,646,758	\$4,272,132	\$10,918,890
Insurance carriers, except direct life	\$6,359,310	\$5,354,854	\$3,221,071	\$8,575,925
Commercial and industrial machinery and equipment repair and maintenance	\$10,810,924	\$7,882,297	\$120,563	\$8,002,860
Truck transportation	\$5,593,863	\$5,265,015	\$739,563	\$6,004,577
Polystyrene foam product manufacturing	\$6,418,225	\$5,026,733	\$1,223	\$5,027,957
Hospitals	\$0	\$0	\$4,830,093	\$4,830,093
Electric power generation - Nuclear	\$0	\$4,311,634	\$249,876	\$4,561,510
Insurance agencies, brokerages, and related activities	\$0	\$2,801,515	\$1,564,579	\$4,366,095
Monetary authorities and depository credit intermediation	\$0	\$1,648,789	\$2,597,732	\$4,246,522
Electric power generation - Fossil fuel	\$0	\$3,678,202	\$213,166	\$3,891,368

Air conditioning, refrigeration, and warm air heating equipment manufacturing	\$6,109,828	\$3,721,998	\$2,797	\$3,724,795
Tenant-occupied housing	\$0	\$0	\$3,449,624	\$3,449,624
Electric power transmission and distribution	\$0	\$2,028,232	\$1,357,227	\$3,385,459
All other industries (475)	\$828,238,568	\$50,523,873	\$61,416,425	\$940,178,866
Total economic impact (546)	\$887,750,706	\$117,639,920	\$99,477,444	\$1,104,868,071

The polystyrene foam product manufacturing and boat building sectors were the sectors with the highest percentage of growth from the output impact from the seafood industry activities, with 7% and 5% of the total output of each of those industries in 2019. Sporting and athletic goods manufacturing is the industry that includes fishing gear and aquaculture cages. Table 12 summarizes the top 15 economic sectors with the highest percentage of the total industry output affected by the Virginia seafood industry activities.

Table 12. Estimated growth of top 15 industries affected by the economic contributions of the Virginia seafood industry activities, 2019.

Economic sectors	Industry Total Output	Impact Output	Estimated Growth
Polystyrene foam product manufacturing	\$73,486,372	\$5,027,957	6.84%
Boat building	\$17,468,894	\$849,993	4.87%
Sporting and athletic goods manufacturing	\$196,223,690	\$1,526,460	0.78%
Commercial and industrial machinery and equipment repair and maintenance	\$1,043,937,307	\$8,002,860	0.77%
Other engine equipment manufacturing	\$88,338,541	\$464,755	0.53%
Air conditioning, refrigeration, and warm air heating equipment manufacturing	\$783,347,495	\$3,724,795	0.48%
Food product machinery manufacturing	\$113,804,051	\$515,841	0.45%
Animal production, except cattle and poultry and eggs	\$218,034,488	\$969,225	0.44%
Other animal food manufacturing	\$516,195,983	\$2,135,286	0.41%
Seafood product preparation and packaging	\$558,568,034	\$1,855,432	0.33%
Personal and household goods repair and maintenance	\$791,353,949	\$2,068,353	0.26%
Industrial gas manufacturing	\$59,828,848	\$138,352	0.23%
Electric power generation - All other	\$3,519,375	\$7,862	0.22%
Electric power generation - Wind	\$27,235,085	\$60,840	0.22%
Electric power generation - Biomass	\$95,369,645	\$213,046	0.22%

The 15 sectors most affected by the Virginia seafood industry activities varied based on employment (Table 13), labor income (Table 14), value-added (Table 15), and economic output (Table 16). The seafood industry supports 1,137 jobs in 350 different industries, which represents 64% of the 546 industries listed in Virginia in 2019. Nondepository credit intermediation and related activities and commercial and industrial machinery and equipment repair and maintenance were the most affected sector based on employment,

with an estimated 78 and 71 jobs affected, respectively. This was followed by other real estate with 53 jobs affected. Table 13 summarizes the economic contributions of the Virginia seafood Industry to the top 15 industries, ranked by supported employment.

Table 13. Economic impact of Virginia seafood industry on employment in 2019.

Industry description	Employment	Labor Income	Value Added	Output
Nondepository credit intermediation and related activities	78	\$10,751,295	\$13,753,549	\$20,396,593
Commercial and industrial machinery and equipment repair and maintenance	71	\$5,261,561	\$5,355,847	\$8,002,860
Other real estate	53	\$1,263,508	\$4,648,884	\$10,918,890
Truck transportation	40	\$2,443,874	\$2,931,615	\$6,004,577
Full-service restaurants	39	\$1,004,247	\$1,497,106	\$2,556,243
Limited-service restaurants	35	\$741,919	\$1,236,147	\$2,668,405
Hospitals	27	\$2,037,042	\$2,460,829	\$4,830,093
Employment services	24	\$1,282,829	\$1,814,520	\$2,505,428
Animal production, except cattle and poultry and eggs	22	\$23,898	\$903,917	\$969,225
Offices of physicians	21	\$2,210,782	\$2,332,563	\$3,298,281
Retail - Food and beverage	20	\$653,037	\$912,985	\$1,499,101
Retail - General merchandise	20	\$602,368	\$927,203	\$1,509,924
Automotive repair and maintenance, except car washes	18	\$1,012,212	\$1,054,847	\$1,602,691
Insurance carriers, except	18	\$1,373,565	\$2,994,558	\$8,575,925
Personal and household goods repair and maintenance	17	\$730,148	\$1,404,734	\$2,068,353
All other industries	633	\$37,016,474	\$74,522,266	\$139,710,776
Indirect and induced impact	1,137	\$68,408,759	\$118,751,570	\$217,117,365

The seafood industry supports \$68.4 million in labor income effects in 489 different industries, which represents 89.6% of the 546 industries listed in Virginia in 2019. Table 14 summarizes the economic contributions of the Virginia seafood industry on the top 15 industries, ranked by labor income supported. Nondepository credit intermediation and related activities was the most affected sector for labor income with over \$10.7 million in effect, followed by commercial and industrial machinery and equipment repair and maintenance with over \$5.2 million in labor income effects.

Table 14. Economic impact of Virginia seafood industry on labor income in 2019.

Industry description	Employment	Labor Income	Value Added	Output
Nondepository credit intermediation and related activities	78	\$10,751,295	\$13,753,549	\$20,396,593
Commercial and industrial machinery and equipment repair and maintenance	71	\$5,261,561	\$5,355,847	\$8,002,860
Truck transportation	40	\$2,443,874	\$2,931,615	\$6,004,577
Offices of physicians	21	\$2,210,782	\$2,332,563	\$3,298,281
Hospitals	27	\$2,037,042	\$2,460,829	\$4,830,093
Management of companies and enterprises	12	\$1,667,945	\$1,978,131	\$3,061,564
Insurance carriers, except direct life	18	\$1,373,565	\$2,994,558	\$8,575,925
Insurance agencies, brokerages, and related activities	16	\$1,339,564	\$1,731,007	\$4,366,095
Employment services	24	\$1,282,829	\$1,814,520	\$2,505,428
Other real estate	53	\$1,263,508	\$4,648,884	\$10,918,890
Scenic and sightseeing	15	\$1,064,248	\$1,169,294	\$2,329,705
Accounting, tax preparation, bookkeeping, and payroll services	11	\$1,044,234	\$1,608,723	\$2,103,912
Automotive repair and maintenance, except car washes	18	\$1,012,212	\$1,054,847	\$1,602,691
Full-service restaurants	39	\$1,004,247	\$1,497,106	\$2,556,243
Electric power generation - Nuclear	4	\$969,383	\$2,463,403	\$4,561,510
All other industries	690	\$33,682,471	\$70,956,695	\$132,002,998
Indirect and induced impact	1,137	\$68,408,759	\$118,751,570	\$217,117,365

The seafood industry supports \$118.7 million in value-added effects in 490 different industries, which represents 89.7% of the 546 industries listed in Virginia in 2019. Table 15 summarizes the economic contributions of the Virginia seafood industry to the top 15 industries, ranked by value-added supported. Nondepository credit intermediation and related activities were the most affected sector for value-added with an over \$10.7 million effect, followed by owner-occupied dwellings with \$10.9 million and commercial and industrial machinery and equipment repair and maintenance with over \$5.2 million in value-added effects.

Table 15. Economic impact of Virginia seafood industry on economic value-added in 2019.

Industry description	Employment	Labor Income	Value Added	Output
Nondepository credit intermediation and related activities	78	\$10,751,295	\$13,753,549	\$20,396,593
Owner-occupied dwellings	0	\$0	\$10,866,700	\$13,794,799
Commercial and industrial machinery and equipment repair and maintenance	71	\$5,261,561	\$5,355,847	\$8,002,860
Other real estate	53	\$1,263,508	\$4,648,884	\$10,918,890
Tenant-occupied housing	7	\$167,316	\$3,116,196	\$3,449,624
Insurance carriers, except direct life	18	\$1,373,565	\$2,994,558	\$8,575,925
Truck transportation	40	\$2,443,874	\$2,931,615	\$6,004,577
Monetary authorities and depository credit	10	\$899,241	\$2,550,218	\$4,246,522
Electric power generation - Nuclear	4	\$969,383	\$2,463,403	\$4,561,510
Hospitals	27	\$2,037,042	\$2,460,829	\$4,830,093
Offices of physicians	21	\$2,210,782	\$2,332,563	\$3,298,281
Management of companies and enterprises	12	\$1,667,945	\$1,978,131	\$3,061,564
Electric power generation - Fossil fuel	2	\$424,044	\$1,930,742	\$3,891,368
Employment services	24	\$1,282,829	\$1,814,520	\$2,505,428
Other local government	8	\$735,885	\$1,774,875	\$3,063,586
All other industries	762	\$36,920,490	\$57,778,941	\$116,515,745
Indirect and induced impact	1,137	\$68,408,759	\$118,751,570	\$217,117,365

The seafood industry supports \$217.1 million in indirect and induced effects in output in 490 different industries, which represents 90% of the 546 industries listed in Virginia in 2019. Table 16 summarizes the economic contributions of the Virginia seafood industry to the top 15 industries, ranked by output supported. Nondepository credit intermediation, owner-occupied dwellings, and real estate were the three sectors most affected by total economic output with 8-figure values.

Table 16. Economic impact of Virginia seafood industry on economic output in 2019.

Industry description	Employment	Labor Income	Value Added	Output
Nondepository credit intermediation and related activities	78	\$10,751,295	\$13,753,549	\$20,396,593
Owner-occupied dwellings	0	\$0	\$10,866,700	\$13,794,799

Other real estate	53	\$1,263,508	\$4,648,884	\$10,918,890
Insurance carriers, except direct life	18	\$1,373,565	\$2,994,558	\$8,575,925
Commercial and industrial machinery and equipment repair and maintenance	71	\$5,261,561	\$5,355,847	\$8,002,860
Truck transportation	40	\$2,443,874	\$2,931,615	\$6,004,577
Polystyrene foam product manufacturing	13	\$817,489	\$1,582,371	\$5,027,957
Hospitals	27	\$2,037,042	\$2,460,829	\$4,830,093
Electric power generation - Nuclear	4	\$969,383	\$2,463,403	\$4,561,510
Insurance agencies, brokerages, and related	16	\$1,339,564	\$1,731,007	\$4,366,095
Monetary authorities and depository credit	10	\$899,241	\$2,550,218	\$4,246,522
Electric power generation - Fossil fuel	2	\$424,044	\$1,930,742	\$3,891,368
Air conditioning, refrigeration, and warm air heating equipment manufacturing	9	\$720,852	\$1,172,955	\$3,724,795
Tenant-occupied housing	7	\$167,316	\$3,116,196	\$3,449,624
Electric power transmission and distribution	2	\$428,856	\$1,758,621	\$3,385,459
All other industries	787	\$39,511,169	\$59,434,075	\$111,940,298
Indirect and induced impact	1,137	\$68,408,759	\$118,751,570	\$217,117,365

Tax revenue generated by the Virginia seafood industry in 2019

The Virginia seafood industry generated \$26.4 million in federal, state, and local taxes in 2019 (Table 17). Twenty-four percent (\$6.3 million) of the total tax generated was local. Local taxes include the revenue generated in sub-county general, sub-county special districts, and county levels. The state of Virginia generated 20% (\$5.2 million) and the federal government generated 57% (\$14.9 million).

Table 17. Tax revenue generation by the Virginia seafood industry activities in 2019.

Tax category	Watermen	Aquaculture	Processors	Distributors	Total
Local tax*	\$1,223,269	\$1,976,523	\$2,391,161	\$696,679	\$6,287,632
State tax	\$1,013,845	\$1,557,919	\$2,064,370	\$579,463	\$5,215,597
Federal tax	\$2,916,320	\$4,080,025	\$6,293,750	\$1,652,066	\$14,942,160
Total tax	\$5,153,434	\$7,614,467	\$10,749,280	\$2,928,208	\$26,445,389

*includes sub-county general, sub-county special districts, and county level

Perceptions of the impacts of events on the seafood industry

The survey contained extra information regarding perceptions of how certain events may affect seafood businesses in a negative or positive way. By ranking the biggest challenges of the industry, this report can recommend topics in demand to be addressed by authorities and research groups.

Table 18. Perceptions of the effects of events on seafood businesses in Virginia (n=60)

Question	Negative impact	Neutral / No impact	Positive impact
Climate change	65.00%	30.00%	5.00%
Migration of species	49.15%	40.68%	10.16%
Weather events (hurricanes, winds, waves, hail, fog, snow)	81.04%	17.24%	1.72%
Overfishing/reduced stocks	46.55%	53.45%	0.00%
Invasive species	55.17%	43.10%	1.72%
Wetlands/marsh degradation	56.90%	41.38%	1.72%
Pandemic, like COVID-19	72.41%	13.79%	13.79%
Regulations/Permits compliance	63.16%	35.09%	1.75%
Misinformation and acceptance of seafood	52.63%	47.37%	0.00%
Labor availability	68.97%	31.03%	0.00%
Pollution/Plastic and chemicals	65.51%	32.76%	1.72%
Offshore enterprises (wind energy, aqua farms, oil platforms)	35.09%	61.40%	3.50%

The responses to what are the greatest challenges for seafood businesses are strict regulations (25%), labor availability (21%), price of supplies (21%), access to markets and distribution (13%), environmental issues (runoff and warmer waters) (16%), and effects on fishing restrictions on offshore enterprises (4%) were the most popular topics reported. The majority of respondents (66.7%) understand the benefits the results of this study can generate for the Virginia seafood industry, however, only 34% would be willing to provide expenditure data on an annual basis for annual economic impact analysis. According to 25% of respondents, the survey benefited respondents to better understand their own business' annual expenditures.

COVID-19 effects on commercial landings

The seafood industry in Virginia has faced many challenges that affect the commercial viability of businesses. Even though the scope and objectives of this study were focused on the economic contributions of the Virginia seafood industry for the year 2019, the authors cannot ignore the effects of the COVID-19 pandemic on commercial landings in 2020. Covid-19 and related policy actions affected both labor availability and markets, causing disruptions to the Virginia seafood industry.

When COVID-19 hit, the Virginia seafood industry faced a supply shock with a 17% drop in reported landings by weight. However, the dockside value of landings increased 8% comparing 2019 to 2020 data. A summary of the variation in landings by weight and value per species compared to 2019 can be observed in Table 19. Hard clams, for example, experienced a 25% drop in landings, but dockside value increased slightly during the same reporting period. Spot was the only species that reported higher landings by weight in 2020, as compared to 2019.

Table 19. Landings and value of top Virginia species 2020.

Species	Poundage	%*	Dollar Value	%*
Eastern Oyster	3,030,222	-12.8	\$37,492,314	-5.2
Blue Crab	21,215,175	-26.2	\$29,532,166	-15.8
Menhaden	4,610,321	-98.6	\$498,209	-98.2
Clams	2,847,450	-24.5	\$25,696,245	0.4
Summer Flounder	17,035	-99.1	\$54,247	-98.9
Striped Bass	682,897	-50.8	\$2,340,070	-48.9
Spot	1,231,478	3.9	\$2,661,238	5.5
Blue Catfish	1,561,588	-48.3	\$756,873	-49.5
Conch	275,716	-46.4	\$779,958	-46.4
Spiny Dogfish	2,205,420	-64.5	\$368,214	-65.4
Atlantic Croaker	144,906	-84.1	\$191,223	-77.8
Horseshoe Crab	22,286	-95.5	\$23,702	-96.2
Spanish Mackerel	64,085	-57.2	\$122,479	-70.2
Spotted Sea Trout	51,564	-62.0	\$141,805	-58.2
Bluefish	89,356	-53.6	\$97,070	-51.3

Source: Virginia Marine Resources Commission, 2021.

* % compared to the 2019 landings for both poundage and dollar value.

Commercial fisheries landings by region

VMRC keeps records of commercial landing of seafood from different aquatic systems that are part of the Chesapeake Bay. Fishing resources reported to be captured in the ocean dropped over 80% by weight and 95% in value. Some regions experienced reduced landings in pounds but increased value, showing an inflationary event in the production level of the Virginia seafood industry. The percentage variation of landings (both value and poundage) in each of the aquatic systems can be observed in Table 20.

Table 20. Commercial fisheries landings by aquatic system in coastal Virginia for 2019 and 2020 and the variation between weight and value.

VMRC System	POUNDS			VALUE		
	2019	2020	%	2019	2020	%
Ocean	15,894,901	2,951,595	-81.4	\$46,734,299	\$2,296,904	-95.1
Eastern shore	4,031,906	3,607,038	-10.5	\$19,259,850	\$19,309,950	0.3
Miscellaneous seaside	293,890	251,405	-14.5	\$410,375	\$403,334	-1.7
Chesapeake Bay	23,551,265	16,458,391	-30.1	\$43,507,882	\$33,091,733	-23.9

James river	5,645,175	4,566,453	-19.1	\$19,557,127	\$14,026,158	-28.3
York river	4,048,076	3,397,930	-16.1	\$6,646,816	\$9,227,645	38.8
Rappahannock river	4,934,680	4,532,443	-8.2	\$6,945,407	\$10,187,766	46.7
Potomac river	2,024,087	1,776,258	-12.2	\$7,010,003	\$8,949,730	27.7
Bay tributaries	3,345,095	1,993,724	-40.4	\$7,603,135	\$5,111,814	-32.8
All systems	115,427	262,240	127.2	\$208,087	\$383,721	84.4

Source: Virginia Marine Resources Commission, 2021.

Discussion

The response rate for farms in this study is comparable to that of other studies regarding seafood and aquaculture in the United States. A recent study on the economic impact of the wild-caught fishing industry in North Carolina for the same year 2019 obtained a 22.7% response rate from commercial seafood harvesters offering a \$50 Amazon gift card as a reward for each responding survey participant (Dumas, 2021). A study conducted in 2019 to assess the economic benefits of the Maryland shellfish aquaculture obtained 5% response rate for wholesale/distributors and 33% for both hatcheries and farms (van Senten et al., 2019). Massachusetts shellfish industry reported a response rate of 35% (Barnes, 2015) and Maine, 66.4% (Cole et al., 2017). Survey fatigue and refusals are a reality that researchers must contend with in every study. Therefore, it should be noted that there are some limitations to this analysis, and as a result, the estimates presented are likely underestimating the impacts of the Virginia seafood industry in 2019. The response rate is the primary limitation of this analysis, and a potential cause of under-estimated activity expenditures. An indicator that the results present conservative numbers is a comparison between values from survey results and IMPLAN averages for the industry of income per employee. Except for aquaculture figures that were 15 times smaller than those surveyed, IMPLAN database presents higher average values of income per employee for fisheries, seafood processing, and truck transportation in the order of 2, 2.3, and 4.5 times higher than the values of the present study, respectively.

Table 21. Comparison of labor income per worker from IMPLAN database for Virginia and survey responses.

Labor income per worker	Survey	IMPLAN
Watermen	\$12,050.62	\$24,276.18
Aquaculture	\$16,627.31	\$1,105.75
Processors	\$21,708.29	\$49,460.61
Distributors	\$13,545.93	\$61,047.35

Despite repeated efforts to contact entities on the list frame, it was very difficult to increase participation in the survey. Some feedback from refusals to participate include the length of the survey, the type of information requested, and fear of the study results being used to create new regulations. The latter was a very common complaint based on past experiences with research studies that led to stricter regulations on fishing activities. According to the McLaughlin-Sherouse List (2016), fishing is the seventh most regulated industry in the United States, outpacing oil and gas extraction, pharmaceutical and medicine

manufacturing and deep sea, coastal and great lakes water transportation (Figure 8). This list is ranked by Industry Regulation Index calculated based on the methodology developed by Al-Ubaydli and McLaughlin (2012).

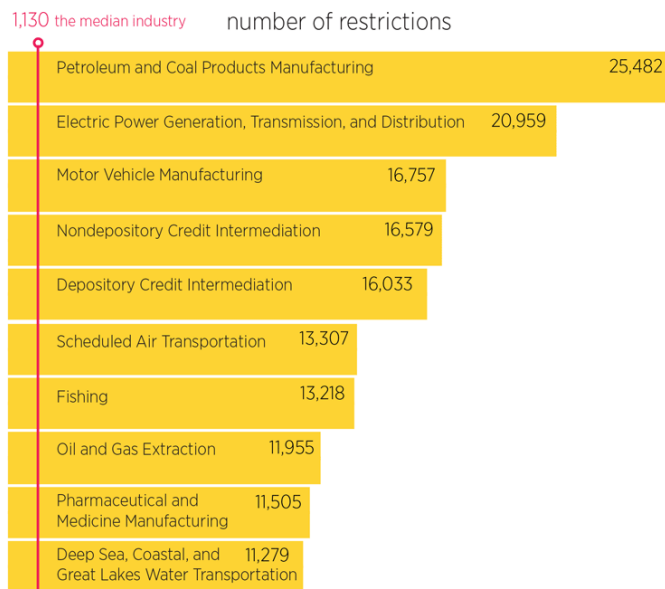


Figure 8. The McLaughlin-Sherouse List: The 10 most regulated industries in 2014 (Mercatus Center, 2016 - RegData.org).

The results presented in this report are a snapshot of the year 2019, right before the effects of the global COVID-19 pandemic affected the Virginia seafood industry. A national COVID-19 impact assessment, carried out by VSAREC and The Ohio State University, demonstrated that the U.S. mollusk aquaculture sector was strongly affected by the pandemic, with 97% of shellfish respondents indicating they were negatively impacted. The non-essential business shutdown mandates led to the loss of sales and market opportunities for seafood producers. These economic impacts created ripple effects throughout the seafood supply chain, with a variety of secondary effects and impacts on labor, operations, and future supply (van Senten, et al., 2021). The over 400 years of recorded fishing activity in the Chesapeake Bay is evidence of its historical, cultural, environmental, and socioeconomic importance to the seafood industry that makes Virginians proud to be among the top seafood producers in this nation. Even though COVID-19 is not part of the original scope of this study, the results can be used as a benchmark for policies to increase the preparedness for crises and the resilience of the industry in order to protect its important existence.

The economic impact estimated in this study was confined to activities and expenditures within the state of Virginia. That is to say, expenditures and activities that happened outside of the state are not captured in the final economic impact estimates. For example, the respective portion of the equipment that was produced or purchased outside of Virginia, would not have contributed to the economic impact in Virginia. There were also records of equipment, employment and sales that extended beyond the study area of Virginia. These activities have economic impacts outside of Virginia and are also not accounted for in the estimate of the economic impact within Virginia. In economic impact analysis, this concept is referred to as “leakage”. Leakage of impacts is always present given

that goods and services are not always fully contained within the relevant study area. Any portion of a good or service that is manufactured, purchased, or sold elsewhere contributes to the leakage of impacts from the study area.

Direct employment in the Virginia seafood industry is likely underestimated in this study. According to data from Virginia Marine Resources Commission, 11,638 individuals held commercial fishing permits and 521 people held aquaculture permits in 2019. Some oyster farmers mentioned that it's common for homeowners to obtain licenses and lease aquaculture grounds to avoid aquaculture activities occurring by their waterfront properties. Thus, direct employment was estimated from survey responses including accounting for non-response based on active licenses that reported production, in the case of watermen and the USDA census of aquaculture to establish the number of active farms. Using the data that was provided by respondents, we estimated a direct employment effect of 6,050 employees. Previously collected farm data (Engle et al., 2020) were utilized to assist in the development of relative expenditures for fresh water species such as trout and tilapia. Fresh water species represent around 15% of total sales of the aquaculture sector in Virginia (USDA-NASS, 2018) and are considered in the spending patterns dedicated to the aquaculture sector.

Furthermore, this study did not attempt to capture the impacts of seafood retail or restaurant sales in Virginia. A publication by NMFS-NOAA (2022) reported that the economic impact for the Virginia commercial fishing industry, including wild harvesting, processing, retail, wholesale and imports, accounted for 23,523 jobs, \$3.2 billion in sales, \$803 million in income, and \$1.2 billion in value-added (NMFS-NOAA, 2022). Aquaculture was not included in the data and the estimation of imports was based on a common multiplier that was applied throughout all of the levels of the supply chain. It should be noted that the methodology used in the NMFS-NOAA study was different from the analysis by parts approach utilized in this project. This present study provides numbers based on primary data collected directly from the industry and are relevant even with the assumption that the numbers are conservative and underestimated.

The survey activities were successful in capturing data to perform the economic contribution analysis for the Virginia seafood industry. In order to preserve the confidentiality of respondents, all study results were reported as aggregates of each respective supply chain level for the entire state of Virginia and not revealed by county or region.

Conclusion

The Virginia seafood industry provides valuable employment opportunities for watermen and citizens in coastal areas of the Commonwealth. The total economic output of the Virginia seafood industry was estimated at \$1.1 billion in 2019. The total employment effect of the Virginia seafood industry was estimated to benefit 7,187 people; with a direct effect of 6,050 jobs, indirect effect of 523 jobs, and induced effect of 614 jobs. Finally, the Virginia seafood industry supports a wide variety of other economic sectors, from polystyrene foam product manufacturing, boat building, sporting and athletic goods manufacturing, commercial and industrial machinery, equipment repair and maintenance through direct expenditures by seafood businesses. Nondepository credit intermediation, owner-occupied dwellings, and real estate sectors are supported as wages and salaries paid to employees throughout the seafood supply chain multiply in Virginia's economy.

Acknowledgment

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Appendix

Recruitment Materials

Flyer and video - Distributed electronically via email and physically by mailing to stakeholders, handed in conferences, and in-person encounters. The materials provide information about the study and ways access to the survey online or in-person by appointment. The recruitment video can be accessed at the link <https://bit.ly/3tTslGA>

SURVEY PARTICIPANTS NEEDED
CAPTURING THE ECONOMIC BENEFITS OF THE VIRGINIA SEAFOOD INDUSTRY

WHAT: Seafood industry stakeholders are needed for a Virginia Seafood Agricultural Research and Extension Center research study sponsored by the Virginia Marine Products Board. (IRB #21-433)

WHY: The purpose of this study is to develop an **economic impact analysis** that provides quantitative estimates of the economic **benefits of the Virginia seafood industry**.

WHO: You may qualify to participate if you are an adult fisherman, waterman, aquaculture farmer, or work with seafood processing, packaging, or distribution.

HOW: Complete it on your computer at this link: <https://bit.ly/vaseafoodsurvey>

Schedule an appointment or reach out for more information.

Contact Dr. Fernando Gonçalves
ocfernando@vt.edu
(757) 900-9914

Help provide visibility for the industry and its importance to the state's economy

VIRGINIA SEAFOOD
VIRGINIA TECH.

Figure 9. Flyer to recruit participants to access the survey online via a QR code

Survey information and consent sheet

Information Sheet for Participation in a Research Study

Principal Investigator: Jonathan van Senten

IRB# and Title of Study: IRB# 21-433 Economic benefits of the Virginia seafood industry

Sponsor: Virginia Marine Products Board

You are invited to participate in a research study. This form includes information about the study and contact information if you have any questions.

WHY ARE WE DOING THIS STUDY?

This study is performed by the Virginia Seafood AREC - Virginia Tech in partnership with VMPB (Virginia Marine Products Board) and will produce meaningful information to benefit the Virginia seafood industry. With your help, we aim to assess and summarize the Virginia seafood supply chain and perform an economic impact analysis that provides quantitative estimates of the total economic benefits of the Virginia seafood industry to the Commonwealth. This analysis will also identify the magnitude and reach of the industry, jobs sustained, and support to other sectors of the Commonwealth's economy.

WHAT SHOULD I KNOW?

If you agree to participate in this study, you will complete a survey. You will be asked to provide business expenditures from your records for 2019 (before COVID-19). You may also send a copy of your accounting records to our research team or schedule a phone call for assistance completing the survey. The survey should take approximately 60 minutes of your time. We do not anticipate any risks from completing this study. If you agree to participate in this study, you may withdraw at any time without consequences of any kind. You may also refuse to answer any questions you don't want to answer and remain in the study. The investigators may withdraw you from this research if circumstances arise which warrant doing so.

CONFIDENTIALITY

We will do our best to protect the confidentiality of the information we gather from you. Any data collected during this research study will be kept confidential by the researchers. The researchers will code the transcripts using a pseudonym to mask participant identities. Any recordings will be stored on a secure password-protected computer in the researcher's office. The survey responses, code key, and any recordings will be stored for 3 years after the study has been completed and published and then destroyed.

WHO CAN I TALK TO?

If you have any questions or concerns about the research, please feel free to contact Dr. Fernando Gonçalves ocfernando@vt.edu or (757) 900-9914. You are not waiving any legal claims, rights or remedies because of your participation in this research study. If you have questions regarding your rights as a research participant, contact the Virginia Tech HRPP Office at 540-231-3732 (irb@vt.edu).

CONSENT: By returning this survey, you are agreeing to the use of your responses for this research.

Keep this information sheet for your records.



Screening questions

Q1 At what level of the Virginia seafood supply chain does your business perform its activities? You can select more than one, if applicable.

- Waterman Processor Aquaculture farm
 Fisherman - Commercial vessel Distributor Dealer Other _____

Q2 What species do you work with? You can select more than one, if applicable.

- Oysters Crabs Shrimp Fresh water fish
 Clams Scallops Marine fin fish Other _____

Q3 What is the structure of your business?

- Sole proprietor Partnership Corporation (C-Corp, S-Corp, LLC) Other _____

Q4 Please select the area(s) in which your business operates. You can select more than one, if applicable.

- Northern neck Eastern shore Southern Virginia
 Middle peninsula Virginia Peninsula Other _____

Q5 Employment, Cost and Sales summary - 2019

Number of full-time employees _____
Number of part-time employees _____
Number of H1B/H2B visa workers _____
Number of unpaid family members _____
Total employees (full-time, part-time, seasonal) _____
Total employees that live outside VA? _____
Total payroll in 2019 (\$) _____
Total costs of the business in 2019 (\$) _____
Total sales in 2019 _____

Q6 Who are the immediate customers to whom your business sells its products? Please, indicate the percentage for each category.

	% of sales in VA	% of sales outside VA
	0 -100	0 - 100
Processor		
Broker		
Dealer		
Other watermen / fishermen / Aquaculture farm		
Specialty seafood market		
Grocery or retail		
Direct to consumers		
International exports		
Others_____		

Q7.1 In 2019, what were your "Direct to consumers" sales channel(s)?

- | | |
|---|---|
| <input type="checkbox"/> Curbside pick-up | <input type="checkbox"/> Retail outlet |
| <input type="checkbox"/> Online sales | <input type="checkbox"/> Farmers market |
| <input type="checkbox"/> Delivery | <input type="checkbox"/> Other _____ |

Q8 What are the primary product forms of processing and packaging for your business? You can select more than one, if applicable.

- | | |
|---------------------------------|--|
| <input type="checkbox"/> Live | <input type="checkbox"/> Canned |
| <input type="checkbox"/> Fresh | <input type="checkbox"/> Prepared or semi-prepared |
| <input type="checkbox"/> Frozen | <input type="checkbox"/> Pasteurized |
| <input type="checkbox"/> Tray | <input type="checkbox"/> IQF |
| <input type="checkbox"/> Vacuum | <input type="checkbox"/> Other _____ |

Q9 Distribution

- | | | |
|--|---------------------------------------|--------------------------------------|
| <input type="checkbox"/> Wholesaler | <input type="checkbox"/> Air freight | |
| <input type="checkbox"/> Freight forwarder | <input type="checkbox"/> Marine cargo | |
| <input type="checkbox"/> Trucking | <input type="checkbox"/> Exporter | <input type="checkbox"/> Other _____ |

Expenditures questionnaire

Waterman/Fisherman Investments

Please complete the equipment list below and provide the additional requested information for each item. Please include all equipment that is necessary for your seafood business.

Item	Quantity	Original price	Year purchased	Useful life (years)	Purchased in VA?		Maintained in VA?		Maintenance cost/year
					Yes	No	Yes	No	
Boat/vessel									
Motor									
Crane									
Cages									
Traps									
Nets									
Fishing gear									
Ice machine									
Styrofoam boxes									
Plastic containers									
Knives									
Miscellaneous supplies (Scale, buckets, ropes)									
Boyos									
Ropes									
Anchor									

Item	Quantity	Original price	Year purchased	Useful life (years)	Purchased in VA?		Maintained in VA?		Maintenance cost/year
					Yes	No	Yes	No	
Navigation tools									
GPS									
Water pump									
Pressure washer									
Vehicle									
Warehouse/office									
Stainless steel Table									
Sink									
Walk-in cold room									
Refrigerated truck									
Freezer									
Shelves and displays									
Other: please describe									
Other: please describe									
Other: please describe									

Additional comments, if any.

Waterman/fisherman operational costs

Fill the following operational costs matrix only if you are a waterman / fisherman

Please, complete the following table concerning the inputs of the operation used on your business for 2019. If you do not have “Quantity”, please include the total cost.

Item	Quantity	Unit (i.e. number, hours, \$/day, lb, kg, etc.)	Total cost 2019	% spent OUTSIDE VA , if applicable (0-100%)
Full-time Labor				
Part-Time labor				
H1B/H2B workers				
Labor, hourly workers				
Management, salaried employees				
Dock fees				
Permit fees				
Ground rent/oyster beds				
Insurance				
Fuel				
Oil				
Ice				
Onboard food				
Chlorine				
Cleaning supplies				

Item	Quantity	Unit (i.e. number, hours, \$/day, lb, kg, etc.)	Total cost 2019	% spent OUTSIDE VA, if applicable (0-100%)
Extra labor				
Water bill				
Electric bill				
Telephone				
Packaging				
Seafood purchases (if dealer)				
Sales fees				
Other: please describe				
Other: please describe				
Other: please describe				

Additional comments, if any.

Aquaculture investments

Fill the following investment matrix only if you are aquaculturist

Please complete the equipment list below and provide additional requested information for each item. Include all equipment necessary for your seafood business.

Item	Quantity	Original price	Year purchased	Useful life (years)	Purchased in VA?		Maintained in VA?		Maintenance cost/year
					Yes	No	Yes	No	
Ponds									
Drainage system									
Sod									
Incubators									
Production gear (lanterns, bags, cages)									
Bottom lines / rigging									
Bottom cages									
Water pump									
Power washer									
Styrofoam boxes									
Aerators									
Plastic containers									
Water quality kit									
Miscellaneous equipment (scale, buckets, tools)									
Power tools									
Nets									

Item	Quantity	Original price	Year purchased	Useful life (years)	Purchased in VA?		Maintained in VA?		Maintenance cost/year
					Yes	No	Yes	No	
Vehicle									
Refrigerated truck									
Boat + engine									
Warehouse/office									
Anti-predation (duck nets, etc.)									
Dredge									
Drag									
Tongs									
Rakes									
Winch									
Jib Hoist									
Upweller									
Floating									
Land-based									
Hopper									
Oyster washer									
Conveyer									
Shaker table									
Sorter/cleaner									

Item	Quantity	Original price	Year purchased	Useful life (years)	Purchased in VA?		Maintained in VA?		Maintenance cost/year
					Yes	No	Yes	No	
De-clumper									
De-bysser									
Walk-in cold room									
Ice machine									
Baskets / Totes									
Shelves and display									
Other: please describe									
Other: please describe									
Other: please describe									

Additional comments, if any.

Aquaculture operational costs

Fill the following operational costs only if you are aquaculturist

Please, complete the following table concerning the inputs of the operation used on your business for 2019. If you do not have “Quantity,” please just include the total cost.

Item	Quantity	Unit (i.e. number, hours, \$/day, lb, kg, etc.)	Total cost 2019	% spent OUTSIDE VA , if applicable (0-100%)
Full-time Labor				
Part-Time labor				
H1B/H2B workers				
Labor, hourly workers				
Management, salaried employees				
Seeds / Eggs				
Fry				
Juveniles				
Broodstock				
Fertilizer				
Lime				
Feed				
Ground rent / oyster beds				
Land lease				
Water lease				
Pond lease				

Item	Quantity	Unit (i.e. number, hours, \$/day, lb, kg, etc.)	Total cost 2019	% spent OUTSIDE VA , if applicable (0-100%)
Building lease				
Equipment lease				
Water supply				
Water filtration				
Water treatment				
Electricity				
Boat Fuel				
Road fuel				
Oxygen				
Predator control supplies				
Herbicides				
Telephone/Internet				
Repairs & maintenance				
Miscellaneous supplies (Waders, gloves, etc.)				
Seines, nets				
Office expenses				
Vehicle insurance				
Propriety insurance				
Crop Insurance				
Property taxes				

Item	Quantity	Unit (i.e. number, hours, \$/day. lb, kg, etc.)	Total cost 2019	% spent OUTSIDE VA , if applicable (0-100%)
Sales taxes				
Operating loans				
Equipment loans				
Real Estate loans				
Legal permits				
Trade dues				
Veterinarian/diagnostic fees				
Seafood purchases				
Other: please describe				
Other: please describe				

Additional comments, if any.

Processor investments

Fill the following investment only if you are a seafood processor

Please complete the equipment list below and provide the additional requested information for each item. Please include all equipment that is necessary for your seafood business.

Item	Quantity	Original price	Year purchased	Useful life (years)	Purchased in VA?		Maintained in VA?		Maintenance cost/year
					Yes	No	Yes	No	
Warehouse									
Office									
Conveyor belt									
Freezers									
Cutting boards									
Power washer									
Styrofoam boxes									
Cleaning equipment									
Boiler / Pasteurizer									
Label Printers									
Scale									
Buckets									
Vehicle									
Warehouse/office									
Ice machine									
Thermometers									

Item	Quantity	Original price	Year purchased	Useful life (years)	Purchased in VA?		Maintained in VA?		Maintenance cost/year
					Yes	No	Yes	No	
Special Machinery									
Cold storage									
Forklift									
Oven									
Stoves									
Pressure cooker									
Autoclave									
Other: please describe									
Other: please describe									
Other: please describe									

Additional comments, if any.

Processor operational costs

Fill the following operational costs only if you are a processor

Please, complete the following table concerning the inputs of the operation used on your business for 2019. If you do not have “Quantity”, just include the total cost.

Item	Quantity	Unit (i.e. number, hours, \$/day, lb, kg, etc.)	Total cost 2019	% spent OUTSIDE VA , if applicable (0-100%)
Full-time Labor				
Part-Time labor				
H1B/H2B workers				
Management, salaried employees				
Labor, hourly workers				
Seafood purchases				
Seasonings				
Food additives				
Chemical preservatives				
Breeding				
Ice				
Plastic containers				
Metal containers				
Styrofoam Trays				
Metal trays				
Plastic boxes				

Item	Quantity	Unit (i.e. number, hours, \$/day, lb, kg, etc.)	Total cost 2019	% spent OUTSIDE VA , if applicable (0-100%)
Plastic bags				
Cardboard boxes				
Cold packs				
Hot packs				
Styrofoam boxes				
Corrugated boxes				
Chemicals for shipping				
Labels				
Building lease				
Equipment lease				
Water supply				
Water filtration				
Water treatment				
Electricity				
Fuel				
Telephone/Internet				
Repairs & maintenance				
Gloves				
Office expenses				

Item	Quantity	Unit (i.e. number, hours, \$/day, lb, kg, etc.)	Total cost 2019	% spent OUTSIDE VA , if applicable (0-100%)
Accounting				
Advertising				
Insurance				
Property taxes				
Operating loans				
Equipment loans				
Real Estate loans				
Advertising & marketing				
Legal permits				
Sanitary inspections				
Other: please describe				
Other: please describe				
Other: please describe				

Additional comments, if any.

Distributor investments

Fill the following investment matrix only if you are a distributor

Please complete the equipment list below and provide the additional requested information for each item. Please include all equipment that is necessary for your seafood business.

Item	Quantity	Original price	Year purchased	Useful life (years)	Purchased in VA?		Maintained in VA?		Maintenance cost/year
					Yes	No	Yes	No	
Warehouse									
Office									
Conveyor belt									
Freezers									
Cold storage									
Dock									
Refrigerator unit-truck									
Refrigerated trailer									
Grain trailer									
Dump trailer									
Pickup									
Straight-line truck									
18-wheeler									
Forklift									
Ice machine									
Thermometers									

Item	Quantity	Original price	Year purchased	Useful life (years)	Purchased in VA?		Maintained in VA?		Maintenance cost/year
					Yes	No	Yes	No	
Special Machinery									
Power washer									
Cleaning equipment									
Other: please describe									
Other: please describe									
Other: please describe									

Additional comments, if any.

Distributor operational costs

Fill the following operational costs only if you are a distributor

Please, complete the following table concerning the inputs of the operation used on your business for 2019. If you do not have “Quantity”, please just include the total cost.

Item	Quantity	Unit (i.e. number, hours,\$/day. lb, kg, etc.)	Total cost 2019	% spent OUTSIDE VA , if applicable (0-100%)
Full-time Labor				
Part-Time labor				
H1B/H2B workers				
Management, salaried employees				
Labor, hourly workers				
Driver				
Fuel (gas + diesel)				
Land Freight				
Air (i.e. Fed Ex)				
Marine cargo				
Insurance for trucking and transport				
Vehicle insurance				
Trucks lease				
Vans lease				
Pickup truck lease				
Box truck lease				

Item	Quantity	Unit (i.e. number, hours, \$/day. lb, kg, etc.)	Total cost 2019	% spent OUTSIDE VA , if applicable (0-100%)
Tractor-trailer				
Compressed oxygen				
Cylinders - rented				
Containers & packaging				
Cold packs				
Hot packs				
Styrofoam boxes				
Corrugated boxes				
Chemicals for shipping				
Plastic bags				
Buildings leased; related to marketing				
Miscellaneous supplies: Specify				
Advertising & marketing				
Broker fees				
Oxygen				
Telephone/Internet				
Repairs & maintenance				
Office expenses				
Insurance				
Property taxes				

Item	Quantity	Unit (i.e. number, hours, \$/day. lb, kg, etc.)	Total cost 2019	% spent OUTSIDE VA , if applicable (0-100%)
Legal permits				
Seafood purchases				
Other: please describe				
Other: please describe				
Other: please describe				

Additional comments, if any.

Perceptions of vulnerabilities

The following events may **negatively affect your business income, causing production challenges and/or losses and/or loss of equipment or property**. Please rate how the following events affect your business.

	Major negative impact	Minor negative impact	Neutral	Minor positive impact	Major positive impact
Climate change	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Migration of species	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Weather events (hurricanes, winds, waves, hail, fog, snow)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Overfishing/reduced stocks	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Invasive species	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Wetlands/marsh degradation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Pandemic, like COVID-19	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Regulations/Permits compliance	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Misinformation and acceptance of seafood	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Labor availability	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Pollution/Plastic and chemicals	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Offshore enterprises (wind energy, shellfish farms, oil and gas platforms, etc)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Validation of the survey

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
This survey helped me to understand the annual expenditures of my business	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I understand the benefit the results of this study can generate for the Virginia seafood industry	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I would be willing to provide expenditure and sales data on an annual basis to allow for annual economic impact analysis of the seafood industry	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

What are the greatest challenges for your business? What types of assistance would be of greatest value to your business?

Voluntary identification

intended for possible follow-up and clarification of responses

- First Name -----
- Last Name -----
- Email -----
- Phone number -----
- Zip code -----

Thank you for your participation!