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Charter fishing in Hawaii: A multi-region analysis of the economic linkages and contributions within and outside Hawaii☆

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ABSTRACT

This study develops several single- and multi-region input-output models in IMPLAN using the annual expenditure data from a 2012 survey of charter fishing operations in the state of Hawaii. The survey reached out to 207 charter vessel operators, with a response rate of 36%, and collected demographic, trip, catch, and economic information across islands and vessel sizes. Four separate county models are built to observe regional effects, and one state model to observe total state effects. The state model is linked to secondary regions (the mainland west coast made up of Oregon, California, and Washington, as well as the rest of the mainland U.S.) to observe the economic effects occurring outside the state of Hawaii. This is especially relevant to Hawaii because of its dependence on the mainland to supply many of its raw materials and finished products. The multi-region approach allows us to observe spillover effects (effects occurring in the secondary regions in response to a demand in the study region) and feedback effects (further effects that occur in the study region as a result of purchasing goods and services by the secondary regions). The results from this multi-region model method are more informative and broad reaching as they capture the spillover and feedback effects that would otherwise be lost as leakages.

1. Introduction

Hawaii is well known among serious anglers for its unique recreational fishing opportunities and as a destination for big game fishing trips. Across the Hawaiian Islands, charter fishing vessels took over 8000 trips in 2015, with total landings of just over 529,000 pounds. Pelagic species were the most highly sought after, with yellowfin tuna (*Thunnus albacares)*, blue marlin (*Makaira nigricans)*, and mahi mahi (*Coryphaena hippurus*) making up nearly 80% of the total landings [1].

Hawaii's fisheries and fishery resources are an important part of the Hawaii economy, both directly and indirectly. While the commercial fishing sector in Hawaii claims a very large portion of fishery-related economic activity, less is known about the economic contributions of recreational fishing. Nationally, fishery managers and the recreational fishing community have routinely stated a need for additional socio-economic data in order to understand and predict the impacts that future policy changes may have on both recreational anglers and the businesses that support them. NOAA Fisheries' Pacific Islands Fisheries Science Center (PIFSC) conducted a cost and earnings survey of the charter fishing fleet for 2011 in order to provide updated economic data for policy analysis [2]. This is currently the latest available socio-economic data on the charter fishing fleet in Hawaii since 1997 [3].

This study conducts an economic contribution analysis of charter fishing in Hawaii in 2011, based on the data from the NOAA Fisheries survey. Economic contribution is defined as "the gross changes in economic activity associated with an industry, event, or policy in an existing regional economy".[1] In this context, "gross changes" refer to the movement of economic activity through a region's economy. Often "economic impact" and "economic contribution" are used interchangeably in the literature; however, they are different effects. Watson et al. [4] defines an "economic impact" as "the net changes in new economic activity associated with an industry, event, or policy in an existing regional economy," which includes consideration of opportunity costs associated with a change. Economic impact analysis looks at scenarios considering the introduction of new revenue, or preservation of existing revenue slated to be lost to a region, whereas an economic

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[1] We follow the definition of economic contribution as laid out by Watson et al. [4].

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contribution analysis simply tracts the movement of economic activity through a region. In the context of charter fishing in Hawaii, a contribution analysis tracks the **existing** flow of spending by charter operations or charter patrons through the regional economy and measure the economic output and jobs supported by this spending. **In contrast,** an economic impact analysis in this context would show how a change in policy or an outside event (such as a change in fishery conditions) would lead to a change in the flow of spending by charter operations or charter patrons.

1.1. Review of economic contribution analysis in the context of recreational fisheries

Studies employing economic impact models in the context of fisheries typically look at the economic impacts of policy decisions on commercial fisheries, or at the economic contributions of a fishery's operations within the region of study. A study by Arita et al. [5] considered the distributional characteristics of the economic contributions from Hawaii's commercial fishery sector through the use of a Social Accounting Matrix (SAM). They found that Hawaii's commercial fishing sector primarily impacts middle income groups, with modest linkages to lower income groups.

Several studies commissioned by the National Marine Fisheries Service (NMFS) collected detailed data on the business structure and costs of for-hire fishing fleets in different U.S. regions, and measured the economic contribution using single-region models. Steinback and Brinson [6] measured the economic contribution of the for-hire fleet to the American northeast region (Maine to North Carolina). Their study was stratified over charter and head-boats, based on data from a survey of the for-hire fleet. Holland et al. [7] measured the economic contributions of for-hire recreational fishing fleets in the American southeast (Florida, Georgia, South Carolina, and North Carolina) in 2009, and compared the results to a previous study in 1997. They found that total output impacts were 11% greater in 2009 compared to the base year, but labor income and employment impacts were 18% and 20% lower, respectively. A baseline assessment of the U.S. marine retail bait and tackle industry in 2013 was conducted from a survey by Hutt et al. [8]. The study measured the economic condition and contributions of independently owned small businesses of bait and tackle retail stores near coastal communities in 23 U.S. states, aggregated across 8 regions (New England, Mid-Atlantic, South Atlantic, Gulf of Mexico, West Coast, Alaska, Hawaii, and Nationwide) using single-region IMPLAN models. Hutt and Silva [9] conducted an economic contribution analysis from cost and earnings trip logbook data of the Atlantic Highly Migratory Species (HMS) for-hire fleet in 2013. The study was divided into three regions (Northeast, Southeast, and Gulf of Mexico), and estimated single-region input-output models in IMPLAN to generate economic contributions.

Kauppila and Karjalainen [10] emphasized the importance of recreational fishing as a tourism attraction for the development of a region, particularly rural regions. They used a process model, based on an input-output model developed specifically for the Nordic region, for the analysis of expenditures made by recreational fishers.

Very few studies analyze multi-region economic contributions related to fisheries, in large part due to the time commitment required to develop the datasets [11]. More often, multi-region models are not necessary in the regional studies conducted. The limited multi-region economic modeling studies pertaining to fisheries have been done using commercial fishing data and applied to Alaska [11–14]. Seung and Lew [11] examined the multi-region impacts associated with changes in harvest limits within recreational fisheries in Alaska to the rest of the U.S., the west coast, and Alaska using a multi-region computational general equilibrium model (CGE). To our knowledge, there have been no studies modeling the multi-region economic contribution of recreational or for-hire fisheries in Hawaii on the United States mainland. This study follows the example of Seung and Lew [11], the only other study conducting a multi-region analysis of recreational fishing in a region strongly dependent on other U.S. states.

In Section 2, a brief background is given on the charter industry in Hawaii and the differences across the islands of Oahu, Hawaii, Maui, and Kauai is described. Section 3 explains the theory behind the regional economic impact model and introduces the multi-region model. Section 4 describes the data on costs and earnings of the charter fleet in 2011, and how these were used to create the regional economic model. Section 5 discusses the results at the county level, state level, to the west coast and the rest of the U.S. The paper closes with a few concluding thoughts in Section 5.

2. Charter fishing in Hawaii

As the only state in the U.S. where marlin can be reliably caught all year long, Hawaii is a particular favorite of charter anglers. After World War II, the general increase in tourism to Hawaii helped expand the charter fishing industry in the state [15]. The promise of catching giant marlin such as “Choy's Monster[2]” lured many prospective charter patrons to Hawaii. In the past few decades the charter fishing industry has been on the decline, faced with rising fuel and trip costs, poorly maintained harbors, competing tourist attractions, and changes in tourist preferences.

2.1. Industry structure and culture

Hawaii charter vessels offer half and full day trips, as well as overnight or multiday pelagic fishing trips. Few also offer trips in nearshore waters that target bottom fish or reef fish species. Other vessels charter as a part of whale watching, sailing, and/or snorkeling trips in which fishing is not always the principle activity. Vessels are chartered either as “exclusive” trips with a flat fee that covers the cost of the full vessel's charter and carries parties ranging from one to six, or as “shared[3][4]” trips with a per person fee and often a set minimum capacity. Charter fishing vessels in the state of Hawaii must hold a valid state commercial marine license (CML). The license is issued to an individual (captain or owner) and is valid for one calendar year. License holders are required to submit monthly trip and catch reports. Unlike in some other states, however, there is no unique license for charter vessels versus commercial fishing vessels; it is the same across all types of commercial fishing. Additionally, CMLs are not strictly enforced, so compliance can be variable across the charter fishing fleet.[5] Charter vessels are also allowed to sell their catch, which results in a hybrid situation where they operate on a spectrum between pure commercial and pure recreational fishing, as some captains supplement their charter fee revenues with fish sales.

2.2. County-level differences

Across each of the islands, the survey [2] showed differences in charter operations in terms of patron type, vessel demographics, catch disposition, and overall operations.[6] The number of active vessels differs significantly by county. In 2011, Hawaii County had 106 active

[2] Choy's Monster was a giant marlin caught by renowned Hawaii captain Cornelius Choy in 1970, weighing a record-breaking 1805 lbs.

[3] The survey results from Rollins and Hospital [2] showed a prominent drop in shared trips when compared to a similar survey from 1998 [3]. This could be due to the decline in demand for charter fishing in Hawaii.

[4] For-hire shared trips are generally referred to as “headboats” elsewhere in the U.S.

[5] Approaches to enumerate charter fishing vessels are described in Rollins and Hospital [2].

[6] Results are presented at the County-level due to the concentration of charter fishing operations at ports on the islands of Kauai, Oahu, Maui, and Hawaii Island.

vessels (including CML and non-CML holders). Oahu County had 39 active vessels, Maui County had 29 active vessels, and Kauai County had 18 active vessels.[7] Fig. 1 presents the percentage of charter vessels by size by county, with the number of responses in brackets, from the survey data. The vessel sizes were determined by length in feet, with small vessels measuring less than 35 ft, medium vessels measuring 35 ft to less than 45 ft, and large vessels measuring 45 ft or greater. Table 1 and 2 describes the charter patron type, by vessel size and county. These are based on survey questions asking charter operators about their patron types. The values are presented as midpoints of percent ranges for each patron type, by vessel size and county.

Kailua-Kona, on the island of Hawaii, is one of the more popular locations for charter fishing in the state. The continental shelf drop off point is close to shore at Honokohau harbor, so vessels don't have to go too far out before they are in very deep water. As the home of many world renowned sport fishing captains, Kailua-Kona gained a reputation among anglers, and the number of charter vessels increased from under 20 boats in the 1950s to over 100 boats in 1996. The Hawaii charter fleet continued to grow until the mid-1980s but has been declining in the wake of economic downturn in the late 1990s coupled with competition from other tourism activities. The development of resorts on the Kohala coast of Hawaii island displaced the tourist base from the Kailua-Kona area [16].

As of 2012, Hawaii County had the largest fishing fleet with 106 vessels and hosts many world famous fishing tournaments. With a high percentage of return and/or regular customers (Table 1), it attracts the more serious fishing enthusiasts looking to catch a giant marlin. Medium vessels made up the highest proportion of vessel sizes in Hawaii County (55%), followed by small (33%), and then large (12%).

Oahu hosted the second largest fleet in the state in 2011, with 39 vessels. Most charter vessels in Oahu County are moored in Kewalo Harbor, situated in an urban tourist hub between the Honolulu airport and Waikiki beach. Most patrons chartering vessels in Oahu are first-time customers and inexperienced fishers. Oahu boasted the second largest number of active charter vessels in 2011, with 44% medium, 31% large, and 25% small vessels.

Maui had the second smallest fleet in Hawaii in 2011. Despite its small size, however, the Maui charter fleet has often been the most profitable thanks to low inter-harbor competition and its location in the heart of Lahaina's tourist district [15]. Maui County has some of the highest percentages of first-time customers and inexperienced fishers – suggesting that many patrons are tourists looking for an enjoyable experience. Charter fishing fee rates in Maui are the highest in the state of Hawaii, and Maui charter operations receive the highest per trip revenues. The vessel size distribution in Maui in 2011 was small at 44%, medium at 33%, and large at 22%.

Kauai had the smallest charter fleet with only 18 vessels, mostly moored in Nawiliwili small boat harbor, south of the Lihue Airport. Kauai is the least developed of the four Hawaiian counties, with many beautiful natural attractions. Nawiliwili harbor is conveniently located near hotels, shops, and restaurants. Close to eighty-five percent of charter patrons in Kauai were almost evenly split between first-time inexperienced fishers, and return and/or regular customers in 2011, suggesting that charter businesses in Kauai get a healthy mix of both tourists and avid charter fishers. Only 15% of charter patrons were first-time customers and experienced fishers.

Hawaii's unique geographical attributes and location sets it apart from charter operations on the west coast mainland. Spatially, charter vessels in Hawaii are somewhat limited in the species they can catch. As mentioned earlier, the main species targeted by Hawaii charter vessels include: blue marlin, yellowfin tuna, and mahi mahi. California's long coastline allows charter fishing boats to catch a wide variety of species. In 2012, the main species caught in Southern California were: yellowfin tuna, albacore tuna (*Thunnus alalunga)*, mahi mahi (*Coryphaena hippurus)*, and yellowtail (*Seriola lalandi dorsalis)*. In Northern California, the species of choice for charter fishing was Chinook Salmon. Also, lingcod was targeted throughout the state [17]. Similar to California, the Pacific North West (Washington and Oregon) targets a wide variety of species, depending on the location along the coast. And because of their bountiful lakes and rivers, charter trips are not confined to the ocean. A 2012 NOAA commissioned survey of charter fishing operators in Washington and Oregon found that the main targets were salmon in the Puget Sound and Columbia River, and rockfish and tuna off the coast [18].

Although Kailua-Kona draws in many return and regular patrons with its world renowned tournaments, historical harbor and promises of giant catches, for the most part, Hawaii's charter operations host first time patrons visiting the state. In the Pacific Northwest (Oregon and Washington) the charter industry had a much stronger return/regular patron base. In 2012, the largest share of personal income among charter business owners came from return/regular clientele [18].

In terms of size, the California charter fishing fleet operates on a much larger scale than that of Hawaii. In 2012, the average maximum passenger capacity for large boats (measuring 50 ft or more) was 61 [17], compared to 6 in Hawaii (with large boats measuring 45 ft of more). In terms of revenue, the average annual total revenue in Hawaii across all boat sizes was closest to that or Oregon, with $97,000 and $95,000 respectively [18]. In comparison, the average total revenues across all boat sizes in California and Washington were $337,000 and $145,000, respectively. Among charter operations in all three regions, rising fuel costs has increasingly become an economic burden.

3. Methods and data

3.1. IMPLAN modeling approach

3.1.1. Single-region economic model

Regional input-output models are often used to understand how the activities of a given industry or set of industries contribute to the economy of a specific region. The economic contributions consist of direct effects as well as indirect and induced multiplier effects on a regional economy. In this study, the direct effects include the revenue (output), income (both employee compensation and proprietor's income), and employment of the Hawaii charter industry. The indirect effects are made up of several rounds of expenditures through the economy. The first round is the initial expenditures of the charter industry itself; charter businesses purchase goods and services directly from the suppliers of their inputs to operate. In the second round, these suppliers purchase inputs from their providers to meet the demands of the charter industry. The third round of indirect effects is the tertiary industries making purchases to meet the demands from the second round. This continues until all subsequent purchases are derived from outside the region. Finally, the induced effects measure the consumption spending in the region of interest induced by all of the household incomes generated from the direct and indirect activities. In the context of charter fishing in Hawaii, individuals employed by the charter industry as captains, crew, and office workers are compensated, and the income they spend flows back into the regional economy generating induced effects. The summation of the direct, indirect, and induced multiplier effects that remain within the region of interest represent the total economic contributions.

This study uses IMPLAN[8] (Version 3.1, 2013), along with county and state data (base year 2014) to calculate the total effects and

[7] Active vessels by county were obtained from the Hawaii Department of Land and Natural Resources vessel registry, these include vessels owned by non-CML holders.

[8] IMPLAN is proprietary input-output modeling software with default county, state, and nation-wide datasets available for purchase. http://implan.com/.

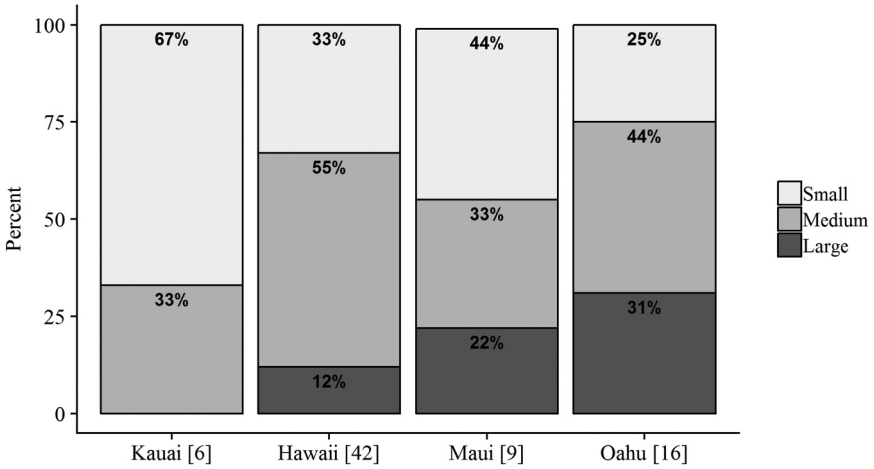

Fig. 1. Distribution of charter vessel sizes by county (number of responses in brackets), 2011.
Source: Rollins and Hospital [2].

Table 1
Percent of charter patron types, by vessel size. 2011.
Source: Rollins and Hospital [2].

		Vessel size		
	All respondents	Small	Medium[a]	Large
Number of respondents (n)	72	25	34	12
Return and/or regular (%)	39.0	39.2	37.2	43.1
First-time, experienced (%)	27.2	26.4	28.9	22.5
First-time, inexperienced (%)	33.7	34.4	33.9	34.4
Total (%)	**100**	**100**	**100**	**100**

[a] For Medium vessels, there were only 32 responses for first-time, inexperienced patrons.

Table 2
Percent of charter patron types, by county. 2011.
Source: Rollins and Hospital [2].

		County			
	All respondents	Hawaii	Oahu	Maui[a]	Kauai
Number of respondents (n)	72	42	15	9	6
Return and/or regular (%)	39.0	44.1	27.8	33.0	40.5
First-time, experienced (%)	27.2	27.7	32.4	24.7	14.8
First-time, inexperienced (%)	33.7	28.2	39.8	42.3	44.7
Total (%)	**100**	**100**	**100**	**100**	**100**

[a] There were only 8 responses from Maui for first time, inexperienced patrons.

multipliers. IMPLAN multipliers estimate the total sales, employment, and income generated within a region triggered by $1 in sales by any particular sector [6]. The IMPLAN system provides algorithms for calculating input-output models using the default data and data input to reflect economic changes or an event. IMPLAN uses the input-output models to calculate multipliers that measure the total impact of a change or event in one industry on all other industries in a local economy [19]. These input-output models represent inter-industry transactions, transactions among industries and households and governments, and final demand from households, government, and exports.

Multipliers calculate the indirect and induced effects of contributions to a region's economy for three different metrics: economic output, or "sales", income, and employment [8]. Sales represent the total dollar value of production in a region summed across all industries. Employment is measured as the total number of full- and part-time wage and salary positions, as well as self-employed workers in a region. Income is expressed as all forms of full- and part-time employee compensation, as well as self-employed compensation (i.e., proprietor's income). The sum of the direct, indirect and induced effects represents the total contributions on a region's economy.

3.1.2. Introduction of multi-region model

The limitation of a single-region model is that it ignores the interconnectivity of economies in different regions; all values transferred from the region of interest are lost and treated as leakages. In a multi-region model, those leakages are captured as spillover and feedback effects. Spillover effects occur in other regions in response to a demand in the region of interest. For example, a demand for groceries prompted by the charter industry in Hawaii County may cause grocery stores to purchase supplies from wholesalers in Oahu. Feedback effects occur in the study region as a result of secondary regions purchasing input from the study region to produce output [11]. Feedback effects are often very low relative to spillover and regional effects.

These effects are detailed in Fig. 2, where Region 1 and Region 2 represent the primary and secondary regions, respectively. The demand for goods and services in the primary region by the charter industry creates new demand on secondary industries for inputs and services, which cycles through the economy as regional contributions. Spillover arises when goods and services are imported from Region 2, triggering a flow of economic activity in that secondary region and can result in feedback effects, where Region 2 requires inputs from Region 1.

The single-region models measure the contributions of the charter industry in each county and the total contributions to the state of Hawaii. Because of its geographical features, remoteness, and scarcity of resources, Hawaii imports many of its raw materials and finished products from the mainland. Therefore, the multi-region multiplier effects of Hawaii charter expenditures to mainland suppliers are lost in the single-region county models. For these reasons, the second section of this study focuses on multi-region effects of the Hawaii charter industry on two regions: the U.S. mainland (excluding Hawaii), and the west coast (Oregon, California, and Washington).

3.2. Cost and earnings data

The Hawaii charter fishing industry is modeled using average annual expenditures in a multi-industry contribution analysis. In order to avoid double-counting, a constraint is imposed on IMPLAN sector 496[9]

[9] Along with the charter industry, IMPLAN sector 469, Other amusement and recreation industries, contains industries from amusement parts, miniature golf courses, and boating clubs to dance halls and youth sports teams.

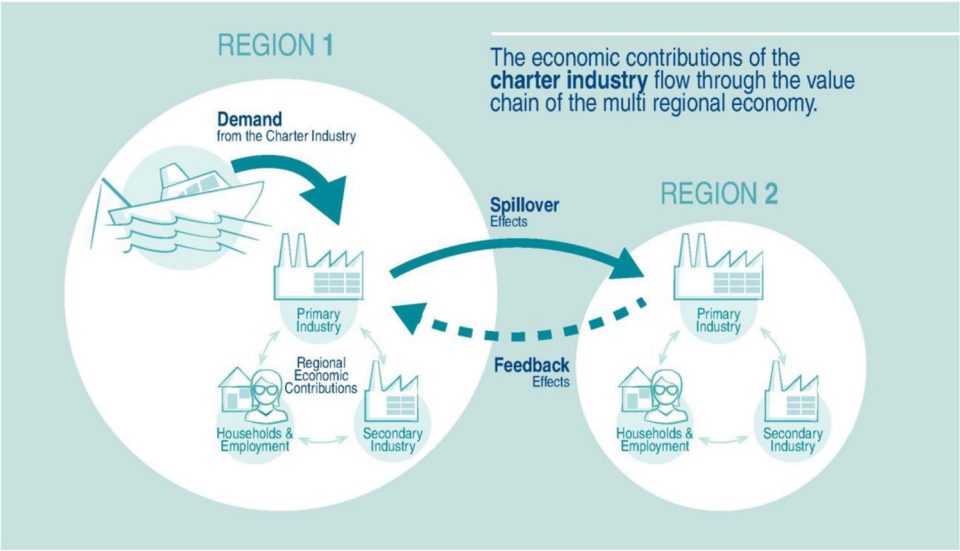

Fig. 2. Feedback and spillover effects triggered from the induced demand of the charter industry.

containing the charter industry by setting the Regional Purchase Coefficient (RPC) to zero. This effectively assumes all sectors purchasing from sector 496 will now be importing to Hawaii. This is a very conservative estimate as charter and recreational fishing only make up about 1.8% of all the sectors comprising sector 496. Despite this, the constraint has a relatively small impact on the results, with a percent change ranging from 0.0% to 0.7%.

Further, no distinction is made between the local and tourism revenue for the charter industry, as might be done in some studies performing economic base analysis [20], partly because the revenue data is such that this level of disaggregation is impossible. However, through anecdotal evidence and industry insight it is relatively safe to assume that the majority of sales by the charter industry are due to tourism.

To represent the aggregate expenditures of charter fishing in the state of Hawaii, the average charter boat expenditure per county is multiplied by the total number of active vessels for each county in 2011 as recorded by the Hawaii Department of Aquatic Resources (HDAR). A model was built for each county in the state of Hawaii, as well as a statewide model.

The expenditure data used in this study comes from the previously mentioned NOAA fisheries' PIFSC charter fishing survey [2]. The survey of the Hawaii charter fishing fleet was conducted to collect data on the owner and vessel demographics, catch disposition, trip characteristics, revenues, and expenditures. The data were collected for the year 2011, via a mixed methods approach using a mail survey and in-person interviews when necessary. The survey population was identified by the registered Commercial Marine License (CML) holders through the Hawaii Department of Aquatic Resources (HDAR) who identified their operations as charter fishing, as well as pre-survey outreach identifying non-compliant CML holders that did not appear in the CML registry, based on field observations. The final survey population size was 207, resulting in 74 completed surveys, and a response rate of 35.74%. Full metadata of the charter survey are available through the NMFS InPort enterprise management system [21].

The income and expenditure data are presented in Table 3 below. Average owner income (i.e., proprietor's income) and operating expenditures were categorized by county and multiplied by the number of active vessels in 2011 to calculate total owner income and expenditures. In this context, net revenue to owner does not mean profit, as it does not account for fixed costs and depreciation. Glaring outliers not typical for normal charter operations were removed. This process involved a systematic review of all operating expenditures and considered outliers far outside the 99% confidence interval of each expenditure. The frequency distributions were observed and professional judgement was used to either keep or remove especially high outliers on a case by case basis. Overall, 14 individual outliers were removed from 12 categories (in any given category, if an outlier was dropped, it represented only 1.3–2.7% of observations used in the analysis).

The largest expenses from charter fishing come from: the labor income to captains and crew; fuel; booking agent fees and commissions; and repair, maintenance, and improvements for vessel(s), engines, or trailer. Expenditures for booking agent fees in Maui were much higher than the other counties, which is likely due to the popularity of the Lahaina harbor and the level of tourist traffic. Hawaii County had the highest overall expenditures across counties, due to the high number of vessels (106). Hawaii County's expenses were only lower in the truck and trailer registration category, with $6212 per year versus Oahu's expenses at $7020 per year. The proprietary (owner) income is what remains after expenses are paid.

Annual expenditures in Kauai were considerably lower than the other counties, due in part to the smaller population size. The labor expenses for charter captains in Kauai were especially lower, at only $18,000. There were very few instances of captain compensation in the sample size for Kauai, with owners predominately captaining vessels. Further, the compensation for office workers in Kauai was also very low compared to the other counties, likely because of the smaller scale of charter operations.

Some of the highest annual expenditures came from the repair and maintenance category – particularly for repair, maintenance, and improvements for vessels, where expenditures ranged from $137,484 in Kauai to $527,445 in Hawaii County. Drydock costs also drive up the repair and maintenance category, although they are an episodic expenditure and may not be necessary every year. Drydock expenditures ranged from $22,680 in Kauai to $493,843 in Hawaii County.

3.2.1. IMPLAN sector categorization and model modification

Expenditures must be categorized into IMPLAN sector codes for compatibility with IMPLAN. Some expenditure variables from the original report were reincorporated into existing categories when there was no specific IMPLAN sector associated with them. These variables included responses to an "other" expenditures category. These variables were reincorporated into the interest, permit, and moorage categories.

Table 3
Total annual expenditures of charter operations in Hawaii, 2011.

	Annual expenditures per county				
Expenditure/income category	**Hawaii**	**Kauai**	**Maui**	**Oahu**	**State**
Number of active vessels	*106*	*18*	*29*	*39*	*192*
Total ($)	10,223,403	1,387,777	6,678,497	5,024,720	23,314,397
Labor					
Captain (share payments, bonuses, other compensation, and payroll taxes)	1,894,750	18,000	442,250	450,321	2,805,321
Crew (share payments, bonuses, other compensation, and payroll taxes	1,548,490	100,512	2,106,488	653,695	4,409,185
Office (wages, bonuses, other compensation, and payroll taxes)	254,962	6908	146,813	117,000	525,683
Insurance	62,159	7807	21,869	22,048	113,883
Accounting	150,170	4944	74,309	47,337	276,759
Trip-Related Expenses					
Fuel, oil, and lube (boat and vehicle)	1,925,193	173,635	632,832	738,005	3,469,665
Ice	191,669	31,568	88,262	79,907	391,406
Food and crew provisions	172,250	21,114	144,240	70,980	408,584
Bait	40,693	4896	38,901	32,733	117,223
Fishing gear, tackle, and electronics (added safety gear to this category)	337,334	61,664	148,060	199,419	746,477
Other (cleaning supplies, etc.)	79,733	6948	15,770	32,616	135,067
Fees and Permits					
State and Federal fishing permits (CML, USCG registration, etc.)	44,032	18,990	22,838	11,801	97,661
Truck and trailer registration	6212	3960	1813	7020	19,004
Slip/moorage fees	392,105	55,699	129,717	326,820	904,341
Professional certifications or training	10,123	0	3315	5655	19,093
Booking agent fees and commissions	114,067	13,320	904,762	141,921	1,174,070
Fishing association dues	3010	0	1088	1950	6048
Repair and Maintenance					
Repair, maintenance, and improvements for vessel(s), engines, or trailer	527,445	137,484	189,022	270,215	1,124,167
Repair, maintenance, and improvements for company/tow vehicle	35,425	14,962	12,688	18,108	81,182
Repair, maintenance, and improvements for booth or office space	5576	0	1813	13,650	21,038
Drydock costs	493,843	22,680	125,567	124,800	766,891
Advertising	283,497	102,001	140,911	141,851	668,259
Utilities					
Slip utilities	39,199	508	42,230	22,725	104,662
Telephone	102,693	31,784	32,263	44,019	210,759
Building lease and utilities	17,935	10,800	23,563	10,920	63,218
Office equipment and supplies	31,715	0	16,385	11,528	59,629
Net Revenues to Owner					
Owner income	1,459,122	537,592	1,170,733	1,427,677	4,595,123

The safety variable from the expenses in the survey was also re-incorporated into the gear category for this report.

Expenditures were assigned to IMPLAN industry or commodity sectors (Table 4). In cases where expenditures fall into two or more IMPLAN sectors, the average proportion of final household demand was used to split the expenditures across IMPLAN sectors. Several expense categories were split across IMPLAN sectors. These categories include: fishing gear, tackle, electronics, and safety, which were split into: sporting and athletic goods, and search, detection, and navigation instruments. The cleaning supplies category was split into: soaps and other detergents, and brooms, brushes, and mops. The telephone category was split into: wired telecommunication services and wireless telecommunication services.

In cases where the household expenditures proportions would not be appropriate for industry spending, professional judgement was used. Among these categories was the accounting variable, which included interest payments, accounting, and legal fees (industry codes 433, 447, and 448). The household proportional spending for these categories is much more heavily weighted for interest and legal fees (65% and 30%), with only 5% towards accounting, tax preparation, bookkeeping, and payroll services. Assuming that a business spends a much higher proportion on accounting than a household, and following the method of Hutt et al. [8], these three categories were split out by their respective IMPLAN codes and evenly proportioned. The survey category “fishing gear (including electronics)” was split out by sporting and athletic goods, and search, detection, and navigation instruments. Professional judgement was again used to proportion these categories to more accurately reflect the expenditures of a charter business. It was assumed that the charter fishing industry spends a much higher proportion on fishing electronics such as GPS and fish finders than a household (household spending patterns show 99.7% and 0.3% toward athletic goods and search, detection, and navigation instruments, respectively); therefore, a 60/40 split was determined for athletic goods, and search, detection, and navigation instruments.

The costs of permits, licenses, registration, and obtaining professional certificates were automatically assigned to IMPLAN sectors according to the state/local government non-education institution spending pattern included in IMPLAN. Only the state institutional spending pattern was used for permits and licenses because there are no federal fishing licenses required for charter fishing. The survey instrument did not request a breakdown of food and beverage expenditures, but rather a grouped category. Therefore, this category was assigned to IMPLAN sectors according to the Personal Consumption Expenditure (PCE) activity database for grocery store purchases created by the Bureau of Economic Analysis [6].

Insurance payments and interest payments on loans generate very little direct contribution as these sales are measured on a net basis. If these expenses were incorporated into the model in full, the impacts would be overstated. To avoid inflating the impacts, the insurance expenditure estimate was adjusted by the average net profit margin percentages for the U.S. insurance sector (10.4%) [22], and the bank interest expenditure was adjusted by the average net profit margin of the banking industry (18%) [23]. The expense category “loan payments” from the survey is excluded in the IMPLAN model as interest on loan

Table 4
Charter boat IMPLAN sectoring scheme.

Expenditure/income category	IMPLAN sector(s)	IMPLAN description
Labor		
Owner income	10,004:10,008	Households (range by county)
Captain (share payments, bonuses, other compensation, and payroll taxes)	5001	Employee compensation
Crew (share payments, bonuses, other compensation, and payroll taxes	5001	Employee compensation
Office (wages, bonuses, other compensation, and payroll taxes)	5001	Employee compensation
Insurance	437	Insurance carriers
Accounting	433, 447, 448	Monetary authorities and depository credit intermediation, legal services, Accounting, tax preparation, book-keeping, and payroll services
Trip-Related Expenses		
Fuel, oil, and lube (boat and vehicle)	3156	Refined petroleum products
Ice	107	Manufactured ice
Food and crew provisions	PCE, NIPA 1111	Retail food and beverage stores
Bait	3017	Fish
Fishing gear, tackle, and electronics (added safety gear to this category)	3385,3315	Sporting and athletic goods, search, detection, and navigation instruments
Other (cleaning supplies, etc.)	3179,3392	Soaps, brooms, brushes, mops
Fees and Permits		
State and federal fishing permits (CML, USCG registration, etc.)	State govt	Employment and payroll of state govt, non-education
Truck and trailer registration	State govt	Employment and payroll of state govt, non-education
Slip/moorage fees	496	Other amusement and recreation industries
Professional certifications or training	State govt	Employment and payroll of state govt, non-education
Booking agent fees and commissions	466	Travel arrangement and reservation services
Fishing association dues	515	Business and professional associations
Repair and Maintenance		
Repair, maintenance, and improvements for vessel(s), engines, or trailer	363	Ship building and repairing
Repair, maintenance, and improvements for company/tow vehicle	504	Automotive repair and maintenance, except car washes
Repair, maintenance, and improvements for booth or office space	62	Maintenance and repair construction of nonresidential structures
Drydock costs	363	Ship building and repairing
Advertising	457	Advertising, public relations, and related services
Utilities		
Slip utilities	496	Other amusement and recreation industries
Telephone	427,428	Wired and wireless telecommunication services
Building lease and utilities	462	Office administrative services
Office equipment and supplies	387	Office supplies (except paper) manufacturing

payments was assumed to be captured by the interest category.[10] Therefore, it is assumed that the survey responses to "loan payments" represented the principals paid on loans and excluded this expense category.

For all commodities except bait, the Local Purchase Percentage (LLP) was set to the Social Accounting Matrix (SAM) value. Since bait (fish) is very likely sourced from Hawaii, the LLP was set to 100%. This assumes that no bait purchased by charter operations is imported from outside the state.

3.2.2. Disposable income spending by owners, hired captains, crew/mates, and office staff

The contribution of income expenditures from charter fishing varies by income level and was calculated separately for crew, office workers, paid captains, and proprietors (including proprietor captains). Table 4 shows each expenditure/income category, and the associated IMPLAN sector code and description. The employee compensation sector (sector 5001) was assigned for crew, office workers, and paid captains. This sector contains the average household spending pattern across Hawaii households, representing a reasonable approximation of household spending by those employed by charter boat owners. One crew member, captain, and office worker per vessel was assumed for each county except for Maui with three crew members, and Oahu with two crew members. These numbers are based on the average responses from a survey question asking how many different paid employees worked for the charter business by boat (includes captain) and shore worker.

To get the proprietor income from charter fishing, the net revenue was used (minus the labor expenses for office workers, crew, and paid captains) for charter boat operations in each county. However, the majority of charter captains in the State of Hawaii were also the vessel owners. There was reason to believe that some owner/captains misunderstood the survey question asking for the captain's labor expenditures and included their own income. These cases were filtered out by looking for all responses with a value greater than zero for captain expenditures by owner/captains who also indicated the owner captaining the vessel. In these instances, the captain's labor expense was re-incorporated into the net revenue. The household income change option in IMPLAN was used for proprietor income to account for difference in household spending across income levels. This option estimates the household expenditures patterns by income category after removing personal taxes and savings based on regional average rates. The total household income ranges as indicated by the survey respondents were used to represent the spending patterns of proprietors. The total charter vessel proprietor income for the state of Hawaii came out to be $4,595,123. The average household income of charter vessel proprietors in the state of Hawaii was $86,934.

4. Results

4.1. Single-region models

The economic contributions of charter fishing operations in the state of Hawaii are presented in this section for the single-region models. The county-level effects of the charter industry on each county are

[10] This assumption was made while faced with the decision to include loan payment expenses and risk overstating the contributions, or make the conservative choice to exclude it. Since the survey instrument was not clear on whether to exclude the loan principal when asking about loan payments, the respondents' interpretation of the question was not certain. Further, the expense category directly below loan payments on the survey instrument was called "accounting" and explicitly included interest and financial services. Thus, it was decided to omit loan payments. This limitation in the survey instrument provides useful foresight for future survey designs.

calculated with four regional models (one for each county), and estimate the state-wide effects using a single-state base model.[11]

Table 5 shows the direct, indirect, induced, and total effects of charter fishing in the state of Hawaii on employment, labor income, and sales output. A "sum-of-parts" analysis was used to obtain the true direct and indirect effects for the single-region models, following the approach by Hutt and Silva [9]. The "direct" impacts measure the total employment, labor income, and sales output within the Hawaii charter industry. Direct employment impacts were estimated by multiplying the average number of employees per vessel (by crew, office workers, captain, and proprietor) and multiplying the product by the total number of active vessels by county in 2011.

The total effects show that charter operations in Hawaii directly and indirectly supported 861 jobs, generated $20,317,000 in labor income, and $49,184,000 in total sales output in 2011. Direct effects accounted for the largest proportion of the total effects across each measure of economic contribution (47–78%), and indirect effects accounted for the smallest portion of total effects across each measure (10–26%).

Table 6 displays the results of the county models, comparing the total effects (direct + indirect + induced) for each county. These impacts represent the effects of the charter industry in each county on the respective county. Charter fishing in Hawaii County had the highest contributions in 2011, supporting 387 jobs, generating $7,380,000 in labor income, and $17,285,000 in sales output. Maui generated the second highest contributions with 192 jobs, $5,506,000 in labor income, and $11,928,000 in sales output. Charter fishing operations in Oahu and Kauai generated the third and fourth highest contributions, respectively. One hundred and ninety-six jobs were directly and indirectly supported in Oahu, $4,387,000 was generated in labor income, and $10,603,000 was generated in sales output. In Kauai, 65 jobs were directly and indirectly supported, $1,045,000 was generated in labor income, and $2,559,000 was generated in sales output.

It is important to note that the county-level models do not include transactions between counties. They measure the localized economic contributions to each specific region, with inter-county economic activity lost as leakages. Therefore, the summation of the county-level model contributions would result in an underestimate of the total state impacts. As an example, the state model captures intra and inter-county transactions and estimates the employment supported by the Hawaii charter industry to be 861 statewide. The total jobs supported and economic output generated by charter fishing operations across individual counties was 840 and $42.4 million, respectively. This means that charter fishing operations in each county encouraged enough inter-county spending to support 21 jobs, and generate $6.8 million dollars in economic output. While it should be noted that the state values are based on state-wide averages and so may be slightly inflated, these figures are substantial – especially when compared to the economic output generated in Kauai County. This gives the impetus for the following section which links the Hawaii state model to models of the west coast mainland, and the rest of the U.S.

Table 7 shows the economic contributions of the Hawaii charter fishing fleet to the top ten industries affected. The top three industries affected in terms of economic output from the charter fishing industry in Hawaii were: petroleum refineries, ship building and repairing, and owner-occupied dwellings, which generated $1.97, $1.90, and $1.72 million in economic output, respectively. In terms of employment, the "other amusement and recreation" industries sector supports the most employment, with 15 jobs. This sector includes mooring and docking for recreational and charter fishing vessels. The second top industry in terms of employment was the travel arrangement and reservation services sector, supporting approximately 9 jobs. The affected industries in this state model are quite varied and strongly reflect the direct expenditure categories for the charter industry. Thus, in this state model, a clear link can be identified between the charter industry expenditures and the economic effects on secondary industries.

Table 5
Hawaii state contributions summary (in million $, excluding employment, and % of Total).

Impact type	Employment	% of total	Labor income	% of total	Output	% of total
Direct Effect	673	78%	12.3	61%	23.3	47%
Indirect Effect	88	10%	3.7	18%	12.6	26%
Induced Effect	100	12%	4.3	21%	13.3	27%
Total Effect	**861**		**20.3**		**49.2**	

Table 6
Total contributions by county (in millions, excluding employment).

Region	Employment	Labor income	Output
Hawaii	387	$7.4	$17.3
Maui	192	$5.5	$11.9
Oahu	196	$4.4	$10.6
Kauai	65	$1.0	$2.6
Total	840	$18.3	42.4

Table 7
Economic contribution of charter fishing on the State of Hawaii by top ten industries (in millions, excluding employment).

Industry institution description	Employment (Full- & part-time jobs)	Economic contributions	
		Output	Labor income
Petroleum refineries	0.2	$1.97	$0.05
Ship building and repairing	7.4	$1.90	$0.61
Owner-occupied dwellings	0.0	$1.72	$0.00
Real estate	6.2	$1.32	$0.23
Wholesale trade	6.9	$1.30	$0.39
Travel arrangement and reservation services	8.8	$1.23	$0.35
Other amusement and recreation industries	15.1	$1.01	$0.42
Advertising, public relations, and related services	5.1	$0.79	$0.18
Hospitals	4.6	$0.69	$0.39
Insurance carriers	1.6	$0.60	$0.13
Total	55.8	12.5	2.7

4.2. Multi-region model

The single-region county models are limited in that they focus solely on the geographic (state or county) regions of interest and ignore spillover and feedback effects between regions. This results in conservative estimates of the total economic effects of regional activity in each county. While the state-level model captures spillover and feedback effects between counties, it does not account for spillover and feedback effects with other states.

This section explores, the economic contributions of the Hawaii charter industry on the mainland's west coast (California, Oregon, and Washington), as well as the rest of the U.S. (not including Hawaii or the west coast). Like many businesses in Hawaii, the charter industry relies heavily on the U.S. mainland for numerous production inputs. Although they may not be directly purchased from the mainland, much of the

[11] Two factors inflate the results using the State of Hawaii model. The first (and more negligible) factor is that the multipliers are based on averages for the state of Hawaii, rather than individual counties. The second factor is that the state model includes the inter-county linkages that are lost in the individual county models.

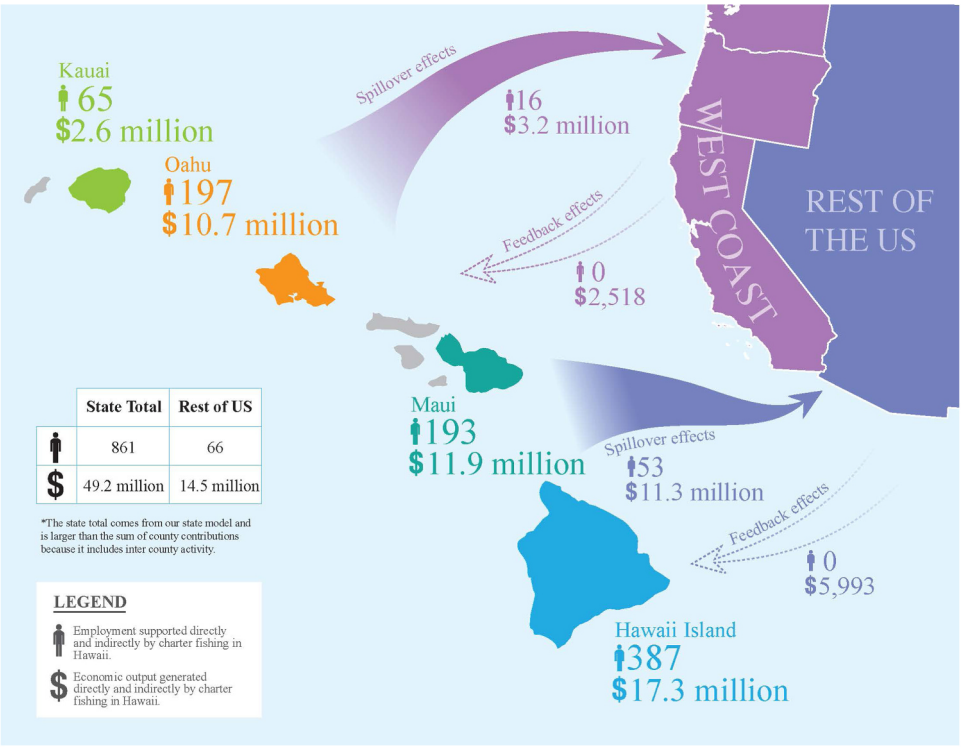

Fig. 3. Economic contributions to each Hawaiian island, the west coast, and the rest of the U.S. of the Hawaii charter industry in 2011.

Hawaii charter industry's production inputs can be sourced back to the mainland through the value chain.

Fig. 3 shows the results of the multi-region analysis, and the strong linkages between Hawaii and the mainland. The values presented in each county represent the total employment and sales output generated from charter fishing operations by county (Table 6). In 2011, 16 jobs were supported and $3.2 million in output was generated supported in the west coast due to charter fishing in Hawaii (with 89% employment and 87% of economic output generated in California alone). The economic output generated by spillover effects in the west coast alone surpasses the economic output generated in Kauai. No additional employment was supported through feedback effects; however, $2518 was generated in economic output in Hawaii from the west coast. Across the rest of the U.S. (excluding the west coast and Hawaii[12]) 53 jobs were supported and $11.3 million in output were generated indirectly by the Hawaii charter industry. For reference, the $11.3 million generated through spillover effects in the rest of the U.S. is close to that generated in Maui. Feedback effects from the rest of the U.S. generated $5993 in economic output in the State of Hawaii. In total, 69 jobs were supported and close to $14.5 million were generated in the mainland U.S. due to charter operations in the State of Hawaii. These results expose the scope and scale of the seemingly small Hawaii charter fishing fleet in the context of the mainland U.S.

Table 8 displays the top ten industries in the west coast affected by the Hawaii charter industry.[13] The top industry by economic output in the west coast impacted by the Hawaii charter industry is internet publishing and broadcasting and web search portals, in California. The second most impacted industry was wholesale trade in all three west coast states – unsurprising as the mainland supplies many of Hawaii's intermediate inputs. The third top impacted industry was insurance agencies, brokerages, and related activities. The third top impacted industry was advertising, public relations, and related services. Interestingly, cable and other subscription programming also made the top ten lists of impacted industries in the west coast. These programming industries affected were based in California, and could be a result of induced household spending.

Table 9 presents the top ten affected industries in the nation[14] (excluding Hawaii and the west coast) by the Hawaii charter industry, ordered by economic output. On a nationwide scale, the main U.S. industries affected by the Hawaii charter industry include energy production, wholesale trade, housing, financial institutions, and management. Extraction of natural gas and crude petroleum made the top of the list with approximately $1.5 million generated in economic output. The wholesale trade and petrochemical manufacturing industries came in second, with $310,000 and $270,000 generated in economic output, respectively.

5. Discussion and conclusions

This study extended the results from Rollins and Hospital [2] into a multi-region economic contribution analysis, and found the economic contributions of the Hawaii charter industry in 2011. The IMPLAN input-output modeling system is used to calculate the contributions of expenditures by the charter industry. Although it is based on the latest available data, it should be noted in the interpretation of these results that seven years have elapsed since the year of these data. However, an understanding of the operational aspects of the Hawaii charter fishing fleet based on the latest available data is important in getting a sense of the industry's health, particularly after the many macroeconomic and regulatory changes in the 15 years since the last available data in 1996.

[12] The results from the U.S. model include linkages with the west coast. The west coast was included in the linked U.S. model in order to capture the economic activity associated with the west coast. The total effects of the west coast model were then subtracted from those of the U.S. model.

[13] These values were estimated by combining the top ten industries for each state (California, Oregon, and Washington), and then sorting the combined table by the top ten industries.

[14] These results exclude linkages with the west coast.

Table 8
Economic contribution of Hawaii charter fishing fleet on the West Coast by top ten industries affected. (in millions, excluding employment).

	Employment	Economic contribution	
Industry institution description	(Full- & part-time jobs)	Output	Labor income
Internet publishing and broadcasting and web search portals	0.8	$0.21	$0.08
Wholesale trade	1.2	$0.19	$0.06
Insurance agencies, brokerages, and related activities	0.5	$0.18	$0.07
Advertising, public relations, and related services	0.5	$0.12	$0.04
Data processing, hosting, and related services	0	$0.10	$0.04
Real estate	0.3	$0.09	$0.01
Cable and other subscription programming	0.5	$0.08	$0.02
Owner-occupied dwellings	0.5	$0.08	$0.00
Semiconductor and related device manufacturing	0.4	$0.06	$0.01
Lessors of nonfinancial intangible assets	0.5	$0.06	$0.00
Total	5.22	$1.17	$0.32

Table 9
Economic contribution of Hawaii charter fishing fleet on the U.S.[a] by top ten industries affected. (in millions, excluding employment).

	Employment	Economic contribution	
Industry institution description	(Full- & part-time jobs)	Output	Labor income
Extraction of natural gas and crude petroleum	3.14	$1.47	$0.39
Wholesale trade	1.32	$0.31	$0.11
Petrochemical manufacturing	0.02	$0.27	$0.00
Extraction of natural gas liquids	0.11	$0.26	$0.01
Monetary authorities and depository credit intermediation	0.99	$0.26	$0.07
Other financial investment activities	1.43	$0.24	$0.07
Owner-occupied dwellings	0.00	$0.22	$0.00
Real estate	1.15	$0.21	$0.02
Petroleum refineries	0.02	$0.17	$0.00
Management of companies and enterprises	0.76	$0.17	$0.09
Total	8.94	$3.60	$0.78

[a] Excluding Hawaii.

We present the total effects of the charter industry on the State of Hawaii with a single-region IMPLAN model, as well as the regional effects of each of Hawaii's four counties, using individual county IMPLAN models. The findings show that the Hawaii charter industry supported 861 jobs across the state and generated $49.2 million in sales output.[15] In terms of individual counties, Hawaii County supported the highest number of jobs (387) and generated $17.3 million in sales output.

Single-region models cannot capture the whole story when conducting impact analysis – especially when dealing with an isolated and highly import-dependent region like Hawaii. An additional 21 jobs and $6.8 million in sales output is estimated to be generated through inter-county activity alone in Hawaii – the majority likely generated from Oahu. This forms the basis of the subsequent step in examining the spillover and feedback effects between Hawaii and the west coast, and the rest of the U.S. The multi-region IMPLAN model gives us insight into the interaction between the Hawaii and secondary region economies brought on by the Hawaii charter industry. The results show that the internet publishing and broadcasting and web search portals industry was the highest affected industry in the west coast by charter fishing in Hawaii, followed by wholesale trade. Additionally, 16 full-time equivalent jobs were dependent upon Hawaii charter fishing in the west coast. On a national scale (excluding Hawaii and the west coast), natural gas production and wholesale trade industries were the highest impacted industries, with 53 full-time equivalent jobs dependent upon Hawaii charter fishing.

This study takes a fairly novel approach in its methods of modeling a multi-region component in an economic contribution analysis using IMPLAN. Future research implications for this model might examine the impacts of a change in the charter industry, such as a reduced number of trips as a result of changes in regulation, or include a behavioral model. These impacts could be traced from Hawaii to the west coast or the mainland U.S. for a complete picture of the effects of that industry change. This approach, though not relevant in all situations, can be a powerful tool in capturing the full contributions of an industry in regions similar to Hawaii, such as Puerto Rico or the U.S. Virgin Islands. Further, distinguishing a region of interest as import-dependent and modeling it accordingly could have real implications on the findings and subsequent management decisions.

Understanding the economic contributions of the Hawaii charter fishing fleet is of interest to policy makers and industry participants alike. Particularly for a seemingly small charter fishing fleet such as Hawaii, information on the geographical range and magnitude of impact by the charter industry can be highly useful in gaining perspective and insight, and is an important consideration for management and policy decisions. It is therefore also important to understand the economic health of the industry.

Based on the survey results from Rollins and Hospital [2], the number of Hawaii charter fishing vessels has continued to decline from 1997 to 2011. Furthermore, pressure by increasing fuel and trip costs and a decline in demand for charter fishing has threatened the viability

[15] Comparing these numbers to the 2011 Fisheries Economics of the U.S. (FEUS) study by NMFS [24] on the Hawaiian recreational fishing contributions, 570 jobs were supported, and $54.6 million dollars were generated. These discrepancies are likely due to a number of factors: a different version of IMPLAN was used, expenditures were collected directly from anglers as compared to charter operators, and the FEUS study collected expenditures by trip, while this study looked at annual expenditures. It is thus unsurprising that our study, which looks at expenditures by the charter industry and includes labor, would result in a higher number for employment. The economic output generated is relatively similar across both studies.

of Hawaii charter fishing fleet. And although 2011 was the depth of the recession, it is unclear whether or to what extent it affected the Hawaii charter industry. Rollins and Hospital [2] found that average net revenues for charter operations in 2011 were in general very low and at times negative. However, the motivations for working on and operating a for-hire fishing business, as expressed by charter operators and crew, were not entirely profit-driven. Many respondents expressed motivation for working in the charter fishing industry to be driven in part as a means to be on the ocean or have access to a slip for their vessel. Likewise, for many owners (especially those residing on the mainland and hiring captains or with multiple streams of income), making a profit from charter operations does not appear to be the primary focus in this industry. For those reliant on charters as a primary source of income, however, it may not be an easy task to change careers. One survey respondent explained that it was the only way they knew how to make money.

Charter fishing in Hawaii falls in the grey area between commercial and recreational fishing. Although charter operations are commercial in terms of licensing, there is a prevalent catch and release culture, as well as subsistence quality to chartering. Only a small portion of catch is sold by charter captains and owners, and often only done to recover trip costs. Furthermore, most Hawaii charter patrons are not experienced or serious fishers [25,26]. They are more concerned about the overall experience of taking a fishing trip than landing fish. Therefore, they are unlikely to take longer and more expensive trips. The combined climate of tighter competition, declining demand, fuel prices, and patron attitudes may contribute to tighter margins and uncertainties about the future feasibility of the charter industry. This inspires questions of the possible directions of the charter industry, and its place among Hawaii's fishing culture and tourism industry.

Declarations of interest

None.

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