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Economic Contributions of U.S. Commercial Fisheries in American Samoa

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Executive Summary

U.S. commercial fisheries provide significant contributions to American Samoa island communities from economic, social, and cultural perspectives. U.S. fisheries—primarily the purse seine fishery, longline fishery, and small boat fishery—land their fish in American Samoa for commercial purposes. This study aims to evaluate the economic contributions of these three U.S. commercial fisheries in American Samoa.

Three distinct economic effects of the fisheries are evaluated in this study: direct, indirect, and induced effects. The direct effects include the ex-vessel values of the fish landed in American Samoa, the crew and captain employment, and their income. The indirect effects of the fisheries include the upstream effects from the fishing operations, such as the costs associated with fishing vessel operations like fuel, food, gear. These vessel expenditures generate cascading economic effects through supporting industries that create business-to-business purchases in the region. Additional output/sales, value-added, income, and employment are generated through the interdependence of industries catalyzed from their joint spending to support fishing activities. Besides the spending by fishing vessels in American Samoa, which supports the local economy, the flow of fish from harvesters to the sole processor (cannery) generates downstream effects by employing cannery workers, generating output, and revenue for local businesses that support cannery operation.

Due to the sole cannery in American Samoa, the cannery's effects are evaluated and combined with the effects from the fishing vessels' spending for data confidentiality considerations. We define the indirect effects stemming from U.S. commercial fisheries landing in American Samoa as the combined upstream and downstream effects from the fisheries. Induced effects are generated by spending of labor income associated with the industries impacted in the direct and indirect effects. Direct, indirect, and induced effects are measured in four metrics: output/sales, value-added, employment, and income.

The indirect and induced effects from U.S. commercial fisheries landing in American Samoa are estimated using IMPLAN. IMPLAN is a commercially available software that uses input-output analysis to track the interrelationships among industries and consumers. By tracking these interrelationships, IMPLAN measures the regional contribution of an event, change in industry's production, or change in household income, on all other industries, households, and governments. This study uses the 2019 American Samoa IMPLAN model (the most recent model available at time of publication) to examine the regional contributions of fisheries in American Samoa, based on the estimated trip costs in the three fisheries, and the regional contributions of the cannery in American Samoa due to fish supplied by these fisheries. It also evaluates the economic impacts of hypothetical decreased fish landing scenarios in American Samoa considering recent declines in fishing capacity and potential future climate change scenarios.

The IMPLAN model results show that the indirect and induced output effects in American Samoa from the three fisheries in 2019 are between \$291.5 million to \$292.5 million, which

are equivalent to more than a quarter (28%–29%) of the total output in American Samoa in 2019. Value-added effects range from \$142.1 million to \$143.0 million, representing more than one-fifth (22%) of 2019 GDP in American Samoa. Total employment effects range from 3,480 to 3,500 jobs, which represent 20% of total employment within American Samoa in 2019. The labor income effects range from \$74.3 million to \$74.9 million, representing 18% of total labor income in American Samoa in 2019.

The relative importance of fishing to total economic contributions in American Samoa is computed by the ratio of total output effects relative to ex-vessel value. The ratio is 4.3, representing that for every \$1 of ex-vessel value in American Samoa, an additional \$3.3 of output/sales is generated in the economy. In terms of value-added/GDP effect, for every \$1 of ex-vessel value, it supports \$1.6 of GDP. In terms of the employment effects, for every \$1 million of ex-vessel value, commercial fisheries support 39–40 jobs. For the labor income effects, for every \$1 of ex-vessel value, commercial fisheries support \$0.8 of labor income. These ratios align with studies in other regions that also used IMPLAN to analyze the economic contributions of commercial fisheries.

For a hypothetical scenario of a 10% reduction in fish landings, total employment, labor income, and value-added/GDP, each would decrease by 2% of 2019 American Samoa total employment, labor income, and value-added/GDP. Additionally, output (indirect and induced effects) would decrease by 3% of total output. If fish landings decreased by 30%, associated decreases by 6% of total employment, 5% of labor income, 7% of value-added/GDP, and 8% of output would occur. If the fish landings decreased by 50%, associated decreases by 10% of total employment, 9% of labor income, 11% of value-added/GDP, and 14% of output would occur. This scenario analysis demonstrates how decreased fish landings by U.S. commercial fisheries could have substantial economic impacts on the island economy.

The study results provide initial estimates of the economic significance of U.S. commercial fisheries to the American Samoa economy, and offers an evaluation into the potential economic impacts of potential reduced U.S. commercial fishery landings. This information is critical for fisheries managers to consider and reference when assessing fisheries policies or evaluating ecosystem factors that could potentially affect U.S. commercial fishing activities in American Samoa.

Introduction

U.S. commercial fisheries provide significant contributions to the island economy in American Samoa, although to date these contributions have not been quantified. Three fisheries that have a long history in American Samoa include the purse seine, longline, and small boat fisheries. Each fishery contributes different levels of economic, social, and cultural significance in the region. This study evaluates the economic contributions of these three commercial fisheries to the economy of American Samoa. This study provides the first economic contribution analysis of U.S. commercial fisheries in American Samoa, using information available from different sources.

Three distinct economic effects from the fisheries are evaluated: direct effects, indirect effects, and induced effects. Extraction of fish from the ocean requires labor, and the sale of fish generates revenue; these are the direct economic contributions from the fisheries. Therefore, the direct effects of the fisheries include the ex-vessel values of fish landed in American Samoa, such as the dollar value of fish landings received by fishers, employment of crew and captains, and income earned by the crew, captains, and vessel owners. The indirect effects of the fisheries include upstream effects from fishing including spending by fishing vessels required to support fishing activities, such as fuel, bait, food, gear. These sales generate further rounds of indirect economic effects through supporting industries that create business-to-business purchases in the region. Additional output/sales, value-added, income, and employment are generated through the interdependence of industries catalyzed from their joint spending to support fishing activities. In addition, the downstream effects from fish landed in American Samoa include fish that are processed locally by the sole cannery, generating employment, salary, value-added impacts, and output sales. Cannery activities generate further rounds of indirect economic effects, as local goods and services (e.g., truck transportation, wholesale services, electricity, etc.) are required to support the cannery production. Induced effects are generated from households spending on goods and services locally with income earned by employees supporting the direct and indirect effects. Figure 1 shows the types of economic contributions generated by fishing activities in American Samoa.

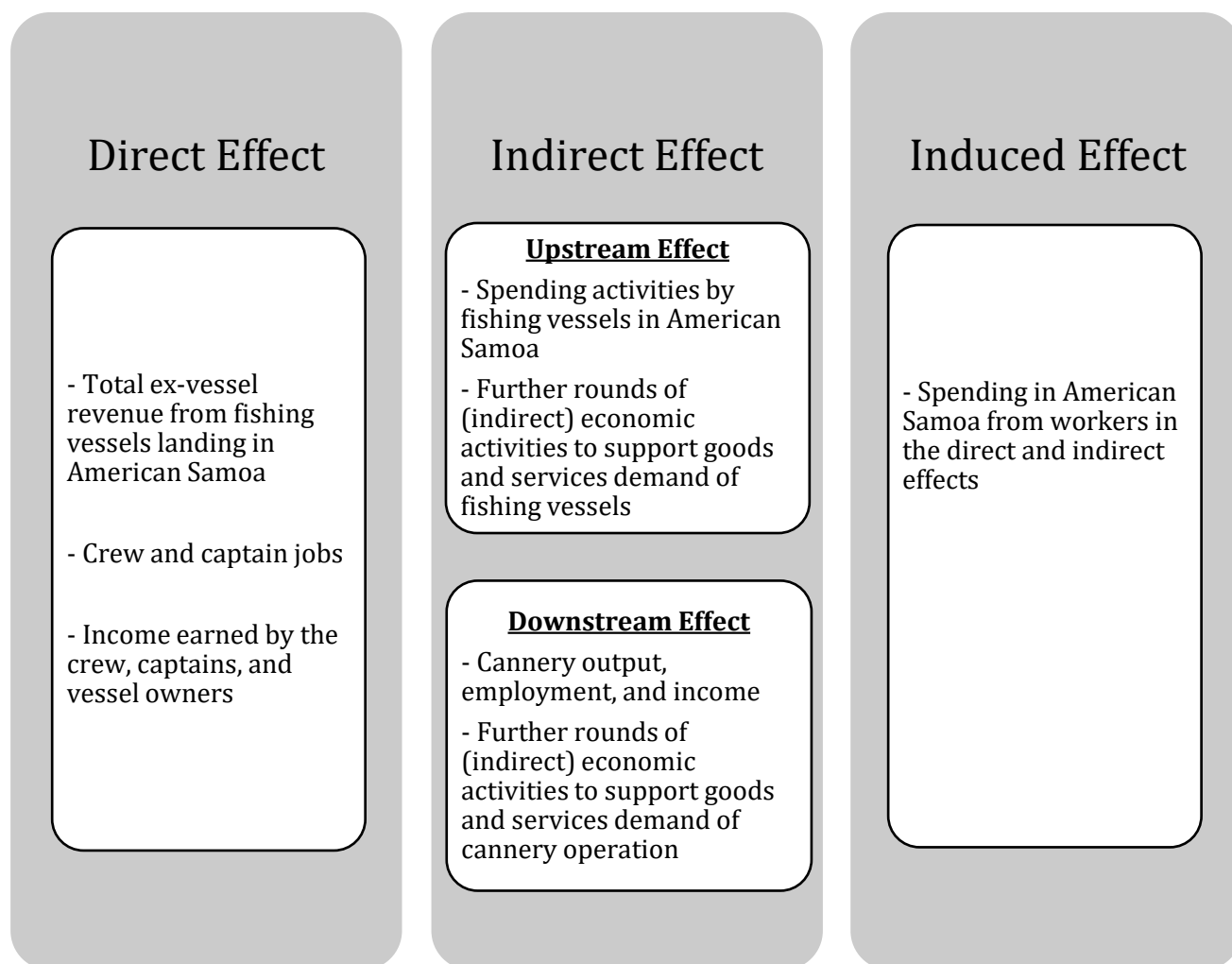


Figure 1. Types of economic contributions generated by U.S. commercial fisheries in American Samoa.

The data sources for the ex-vessel values of the fisheries include the U.S. western Pacific purse seine unloading logbook data (PIFSC 2022a), American Samoa longline logbook data (PIFSC 2022b), and Western Pacific Fisheries Information Network (WPacFIN) commercial receipt books. The data sources for the upstream effects of the purse seine fishery include a literature review of fuel use intensity for purse seine vessels targeting tuna in the Pacific, and information from industry experts regarding the per-trip fishing costs for purse seiners operating in American Samoa. The trip costs for the longline fishery were collected from the Pacific Islands Fisheries Science Center (PIFSC) Continuous Economic Data Collection Program (Pan 2018). The trip costs for the small boat fishery were the economic trip cost data collected from the boat-based creel survey. Details of the small boat economic data collection program can be found in Chan and Pan (2019).

Indirect and induced effects from the fisheries are estimated using the commercial software IMPLAN which uses input-output analysis to track the interrelationships among industries and consumers. Other information such as income earned by crew and captains

are imputed using the crew and captain employment estimation, and industry specific information for American Samoa in IMPLAN for commercial fishing.

The fishing capacity of U.S. commercial fisheries has shown a decreasing trend in recent years. In addition, climate-driven redistribution of tuna biomass could drive tuna catch rates lower in the fishing grounds where the U.S. commercial fisheries currently operate. Variation of fish landings could affect the economy of American Samoa, in particular, to the cannery which depends on the fish landings from U.S. commercial fisheries. To evaluate the potential economic impacts due to lower fish landings in American Samoa, this study evaluates hypothetical scenarios of reductions in U.S. commercial fish landings by 10%, 30%, and 50%.

Methods

IMPLAN Modeling

The indirect and induced effects from U.S. commercial fisheries landing in American Samoa are estimated using IMPLAN. IMPLAN is a commercially available software that uses input-output analysis to track the interrelationships among industries and consumers in a region. By tracking these interrelationships, IMPLAN measures the regional contribution of an event, change in industry's production, or change in household income, on all other industries, households, and governments. The ripple effects due to a change of an event (direct effect) are represented by the indirect and induced contributions to a region's economy. Indirect effects are the business-to-business purchases in the regional supply chain resulting from the event change that caused initial industry input purchases. Induced effects are generated by spending of labor income associated with the industries specified in the direct effects, and those impacted through the supply chain in the indirect effects.

Direct, indirect, and induced effects are measured in four metrics: output/sales, value-added, employment, and labor income. Output/sales represents the aggregated total dollar value of regional production across all industries. Value-added represents the difference between the total output and the cost of the intermediate inputs used in the production. In other words, it is the additional value generated by all producers, which is comprised of labor income, other property income, and taxes on production and imports. In IMPLAN, value-added is equivalent to gross domestic product (GDP). Employment is measured as the total number of full-time and part-time wage and salary positions as well as self-employed workers in a region. Income is expressed as all forms of full-time and part-time employee compensation as well as self-employed compensation (i.e., proprietor's income). Note that in IMPLAN employment is based on place of work. However, if some laborers are not residents, IMPLAN has a mechanism to estimate the portion of labor income that is earned by non-residents based on the region's in-commuting rate. IMPLAN also has a mechanism to estimate the portion of industry's input purchases that are made outside the region based on the local purchase percentage (LPP) for each input. This study uses the 2019 American Samoa IMPLAN model to examine the regional contributions of U.S. commercial fisheries in American Samoa (IMPLAN 2019 Data). This is the latest available model for American Samoa.¹ An IMPLAN model could have up to 546 industries in a region. The 2019 American Samoa IMPLAN model has 125 industries. For more information on applying the IMPLAN model to fisheries economic impacts, see Leonard and Watson (2011), Mulkey et al. (2005), and Steinback (2004).

¹ At the time of publication, IMPLAN is not intending to produce a more updated version of the American Samoa model, so this can be considered the latest version.

Direct Effects of Fisheries in American Samoa

Ex-vessel Revenue

Purse seine fishery

The U.S. purse seine fishery targets skipjack tuna for commercial purposes. The majority of landings are skipjack tuna, followed by yellowfin and bigeye tuna. In 2019, the fishery landed 73,328 mt of tunas in American Samoa; 91% were skipjack tuna and 7% were yellowfin tuna (PIFSC 2022a). Tunas are unloaded to the sole cannery in American Samoa as input for canning. Ex-vessel revenue for the purse seine fishery is estimated based on U.S. Western Pacific purse seine unloading logbook data (PIFSC 2022a) and the average Bangkok price for tunas² minus \$150 per ton. Bangkok price is taken as the standard wholesale tuna price as Bangkok is the world's largest tuna canner and Bangkok is the price leader in skipjack tuna (Squires et al. 2006). The benchmark tuna price for American Samoa is Bangkok price less \$150 per ton. Landing estimates are derived from the U.S. purse seine unloading data, based on the amount of tuna landed in Pago Pago port by species and by month, and excludes any amount rejected by the cannery. For the ex-vessel revenue of skipjack and bigeye tunas, the monthly Bangkok price for skipjack was used. For the ex-vessel revenue of yellowfin tuna, the annual Bangkok price for yellowfin was used (only annual price was available).

Longline fishery

The American Samoa longline fishery targets albacore tuna for commercial purposes. In 2019, the fishery landed 3.1 million pounds of fish; albacore made up 75% by weight, and yellowfin, skipjack, and bigeye represented 14%, 5%, and 2%, respectively. The rest of the landings include non-tuna pelagic species such as mahimahi, wahoo, and swordfish. Most of the landings were sold to the cannery and some were sold to the local markets if a better price was available or rejected by the cannery due to low quality (Pan et al. 2017). The ex-vessel value for longline fishery is from the Pacific Islands Fisheries Science Center: Fishery Economic Performance Measures (WPRFMC 2022a).

Small boat fishery

The American Samoa small boat fishery is classified in terms of target species and gear usage, including the pelagic fishery that uses trolling gear to target pelagic fish, the bottomfish fishery that uses bottomfish gear to target bottomfish, and the nearshore coral reef fishery that uses spear, rod and reel, and gillnet to target reef fish. Multiple gear usage during a single trip is common. Bottomfish fishing sometimes is combined with spearfishing and trolling (WPRFMC 2022b). Almost all of the catch (97% for 2009–2017) in the small boat fishery were intended for sale commercially (Chan and Pan 2019). The ex-

² https://investor.thaiunion.com/raw_material.html

vessel revenue is from the commercial receipt books for the top 10 ecosystem component species (ECS) commercial landings caught by small boats or shoreline fishing in the bottomfish and coral reef fisheries for 2018 and 2019 (WPRFMC 2021, 2020), and commercial landings revenue from bottomfish and coral reef fisheries for 2017 (WPRFMC 2019), and commercial revenue for Pacific Pelagic Management Unit Species (PMUS) caught by trolling in the pelagic fishery for 2017–2019 (WPRFMC 2022a). Table 1 shows the 2017–2019 total ex-vessel revenue (in 2019 dollars) from the three fisheries in American Samoa.

Table 1. Combined ex-vessel revenues from the purse seine, longline, and small boat fisheries in American Samoa, 2017–2019 (in 2019 millions \$).

Year	Ex-vessel value (millions \$)
2017	113.396
2018	124.022
2019	88.524

Crew and Captain Jobs

No data exist on the number of crew and captains active in the U.S. purse seine fishery. From personal communication with an industry expert from Western Pacific Fishery, Inc. on July 26, 2023, it was estimated that crew size varies between 20–25 crew members, and that 22 crew members is a good representation of the average crew size for a U.S. purse seine vessel. The mix of crew includes American Samoa residents and people from various areas across the South Pacific, the Republic of the Philippines, South America, New Zealand, and the United States. Applying an average crew size of 22 to the 15 unique U.S. purse seine vessels that landed in American Samoa in 2019 (PIFSC 2022b), the total number of crew is estimated to be 330. Assuming each vessel has a unique captain, there would be 15 captains and the total number of crew and captains is estimated at 345.

For the longline fishery, Pan (2019) documented the average number of crew per vessel was 5.4 in 2016 with 3.5 individuals being foreign crew. Based on the American Samoa longline logbook data (PIFSC 2022b), 18 unique longline vessels landed in American Samoa in 2019. Using an average of 5.4 individuals for crew and 18 vessels, the estimated number of total crew was 97. Assuming a different captain for each different vessel, the total number of crew and captains was estimated at 115.

For the small boat fishery, most fishers are not full-time commercial fishers (Dombrow and Hospital 2023). As small boat fishers are likely to have other jobs, they are not included in the direct effect in terms of employment and income analysis in this study.

Income Earned by Crew, Captain, and Vessel Owners

No information is available on crew and captain payment for the U.S. purse seine fishery.

For the longline fishery, payment to crew and captains vary by vessel. Hired captains were paid by a share of trip net revenue (trip revenue net of trip operating costs). Crew members were paid by share or flat rate, depending on the vessel (Pan 2019).

From the most recent cost-earnings survey on the American Samoa small boat fishery (Dombrow and Hospital 2023), most of the small boat fishers in American Samoa were not full-time commercial fishers. On average, about 20% fishers identified their primary fishing motivation to be full-time commercial, and about 25% identified as part-time commercial. Other motivations include cultural, subsistence, purely recreational, and recreational expense. Some small boat fishers identified themselves as crew members. It is evident that captains shared the catch with their crew members, and most of the crew sold either most to almost all their catch in 2020. Crew also shared a fraction of trip costs, but did not pay for any fixed expenditures. Being a crew member is not a full-time job. Most crew members noted 40%, or more, of their personal income came from fish sales.

Although information on income earned by crew and captains are not available for the purse seine fishery, and crew payments vary by vessels in the longline fishery, IMPLAN can estimate income using Census County Business Patterns (CBP) employment and wages data for commercial fishing in American Samoa. Utilizing the number of crew and captains for both purse seine and longline fisheries estimated in the previous section ($460=345+115$) for IMPLAN industry #17 Commercial Fishing, IMPLAN estimates the direct labor income effects and the associated indirect and induced employment and income effects. Information on income earned by vessel owners is lacking, and, therefore, not estimated in this study.

Indirect Effects of Fisheries in American Samoa

Upstream effects of fisheries are derived from (1) spending activities by vessels in American Samoa, and (2) the subsequent effects on local economy via the supporting industries that are impacted by the vessels' spending activities. Downstream effects of fisheries are derived from (3) fish supplied to the cannery that support production and employment in the cannery, and (4) industries that provide goods and services to the cannery to support its production. Due to the sole cannery in American Samoa, upstream and downstream effects are combined due to confidentiality considerations, and we called these combined effects indirect effects from the U.S. commercial fisheries. This section describes the estimation of spending activities by vessels in American Samoa using different data sources and assumptions, and the estimation of subsequent influencing factors (2–4) using IMPLAN.

Spending Activities by Vessels

Spending activities by vessels are defined as the fishing trip costs incurred to support fishing activities. Data are available from surveys, or can be estimated from information

available from the literature and industry experts. Across the three fisheries, fuel expenditure is a major trip cost item, comprising more than half of total trip costs.

Purse seine fishery

No cost-earnings survey has been conducted on the U.S. purse seine fishery landing in American Samoa. Therefore, fishing trip cost information is estimated using data from other purse seine fisheries based on literature review and industry experts.

Parker et al. (2015) provides a relevant source of reference for fuel use by purse seine vessels. The average length of U.S. purse seine vessels operating in the western and central Pacific Ocean (WCPO) was 68 m (Department of Commerce 2011). This is similar to the purse seiners sampled in Parker et al. (2015), which included 75 vessels with an average vessel length of 68.9 m. Parker et al. (2015) estimated that 349 liters of fuel were used per tonne of wet weight (L/t) landings by purse seine vessels that targeted skipjack tuna in the Pacific. Using the amount of tuna captured by the U.S. purse seine vessels (including landed, rejected by cannery, and transshipped) for trips that landed in American Samoa in 2019, and the ratio of 349 liters per tonne of wet weight, the amount of fuel used by U.S. purse seine vessels is estimated. As pointed out in Ruaia et al. (2021), the Singapore marine diesel oil price is a good indicator of fuel price paid by purse seine vessels operating in the western and central Pacific Ocean. In 2019, the Singapore marine diesel oil was \$597 per mt (= \$2.26 per gallon) (Ruaia et al. 2021). Using this fuel price and the estimated amount of fuel used, the total fuel costs used by U.S. purse seine vessels in 2019 is estimated. The second source of fuel use information is in Wilson and McCoy (2009), which provided another estimate of fuel use intensity for purse seine fishery targeting tuna in the Pacific Ocean (in graphical form), and the numeric value was documented in Tydemers and Parker (2012). The fuel intensity was 412 (L/t). Using the same procedure as above, the second fuel cost is estimated.

The third source of trip cost information is from two local industry experts (personal communications, February 23, 2022, and July 26, 2023) regarding the trip-level fishing costs for purse seiners landed in American Samoa. One expert is a longline vessel owner and is a former General Manager of StarKist Cannery's fleet of purse seiners that supplied the factory with tuna. Another expert is a purse seine vessel owner with the Western Pacific Fisheries, Inc. The first column in Table 2 shows the composite of approximated purse seine trip cost information provided by the two experts (per trip spending). Table 2 also shows the estimated fleetwide trip costs in 2019 based on 53 purse seine trips that landed in American Samoa in 2019.

Table 2. Estimated per trip and fleetwide fishing trip costs for purse seine vessels landed in American Samoa in 2019 based on industry experts (in millions \$).

Spending category	Per trip spending (millions \$)	Estimated fleetwide trip costs (millions \$)
Fuel	0.408	21.624
Fishing gear	0.050	2.650
Food	0.032	1.696
Supplies/parts	0.030	1.590
Repairs/maintenance	0.030	1.590
Salt	0.028	1.463
Lube	0.026	1.378
Travel	0.008	0.398
Agency/government fees	0.006	0.318
Ammonia/Freon	0.006	0.292
Storage	0.006	0.292
Freight	0.004	0.185
Total trip costs	0.632	33.475

The estimated fleetwide fuel costs from three different sources ranged from \$17.2 million to \$21.6 million. The estimated fuel cost in Table 2 is 65% of total trip costs. If replacing the \$21.6 million of fuel cost with the lower fuel cost estimate (\$17.2 million) in Table 2, fuel cost represents 59% of total trip costs. A study by Sun et al. (2016) suggested that fuel cost was about 50% of operating costs for purse seine fleet operating in the eastern Pacific Ocean (EPO) with trip length between two weeks to five months. Ruaia et al. (2021) suggested that fuel cost ranged between 15% and 52% of total trip costs for purse seine fishery (Ruaia et al. 2021). Thus, an estimated fuel cost representing 59%–65% of total trip costs appears comparable with other studies.

Longline fishery

While trip-level cost data are collected by PIFSC (Pan 2018), the average trip length for the longline fishery has varied considerably over the years across operations so cost per set is presented here to provide a more standard cost metric. Fishing trip costs per set of the American Samoa longline fleet was \$936 in 2019 (WPRFMC 2022a). The total number of fishing sets employed by the American Samoa longline fleet was 1,882 in 2019 (PIFSC 2022b). Using these two pieces of information, the estimated fleetwide fishing costs was \$1,761,552. Using the American Samoa longline trip cost structure in 2019 collected from the PIFSC Continuous Economic Data Collection Program (WPRFMC 2022a), the estimated fleetwide trip costs in 2019 by trip cost item are shown in Table 3.

Table 3. Estimated fleetwide fishing trip costs for American Samoa longline fishery in 2019 (in millions \$).

Spending category	Percent of trip costs (%)	Estimated fleetwide trip costs (millions \$)
Fuel	50	0.881
Bait	24	0.423
Gear	10	0.176
Provision	10	0.176
Communication	5	0.088
Freon	1	0.018
Total trip costs	100	1.762

Small boat fishery

The small boat fishery in American Samoa includes fishers using small boats to target pelagic fish, bottomfish, and coral reef fish using gears including troll, bottomfish, spear, and mixed bottomfish-troll. The number of trips by different gear types are available or estimated using different data sources (Table 4).

Table 4. Estimated number of small boat fishing trips by gear type in 2019.

Gear Type	Effective troll hours^a	Average hours per trolling trip^b	Estimated number of trips
Trolling	839	5.49	153
Bottomfish ^c	-	-	58
Bottom-troll mixed ^c	-	-	16
Spearfishing ^c	-	-	46

Sources: ^a Table A-18 in Western Pacific Regional Fishery Management Council. 2022a. Annual stock assessment and fishery evaluation report for the Pacific pelagic fisheries fishery ecosystem plan 2021. Remington T., Fitchett M., Ishizaki A., DeMello J. Eds. Honolulu, Hawaii, USA.

^b Boat-based creel surveys in 2019.

^c Table 10 in Western Pacific Regional Fishery Management Council. 2022b. Annual stock assessment and fishery evaluation report for the American Samoa archipelago fishery ecosystem plan 2021. Remington T., Sabater M., Seeley M., Ishizaki A. Eds. Honolulu, Hawaii, USA.

Small boat fishing trip costs were collected in American Samoa through PIFSC's economic data collection programs' add-on to the boat-based creel survey. The survey is implemented through collaborative efforts of the PIFSC Social-Ecological and Economic Systems (SEES) Program, WPacFIN, and the American Samoa Department of Marine and Wildlife Resources (DMWR) that regularly collect fishing catch and effort data through creel survey. Details of the programs and economic data are summarized in Chan and Pan (2019). Table 5 provides the fishing trip costs by gear type in 2019.

Table 5. Estimated per trip fishing trip costs for American Samoa small boat fishery by gear type in 2019 (\$).

Gear Type	Fuel cost	Ice cost	Bait cost	Lost Gear cost	Total trip costs
Trolling	85.45	22.06	0.88	11.47	119.86
Bottomfish	99.96	25.21	3.72	22.21	151.10
Bottom-troll mixed	135.97	24.44	1.33	20.00	181.74
Spearfishing	37.31	17.87	0.00	5.92	61.10

From the estimated number of trips (Table 4) and fishing trip costs by gear type (Table 5), Table 6 shows the estimated fleetwide trip costs for small boat fishery in American Samoa.

Table 6. Estimated fleetwide fishing trip costs for American Samoa small boat fishery in 2019 (\$).

Fuel cost	Ice cost	Bait cost	Gear lost cost	Estimated fleetwide trip costs
22,048	5,916	386	3,581	31,931

Two scenarios of economic contributions are examined, which are based on two fuel cost scenarios for the purse seine fleet including a lower bound (\$17.2 million, estimated based on literature review) and an upper bound (\$21.6 million, estimated by industry experts). Since fuel cost is the largest cost item, the two scenarios can take into account the uncertainty in fuel costs and provide a perspective on how economic contributions vary with different assumptions of fuel cost. The difference between upper bound and lower bound of fuel cost for the three fisheries is 25% (\$4.4 million). Table 7 summarizes the spending activities by category for the three fisheries.

Table 7. Fleetwide spending activities by fishery and category in 2019 (in millions \$).

Spending category	Purse seine fishery	Longline fishery	Small boat fishery	Estimated trip costs for three fisheries
Fuel	17.187–21.624	0.881	0.022	18.089–22.527
Bait	-	0.423	0.0004	0.423
Fishing gear	2.650	0.176	0.004	2.830
Food	1.696	0.176	-	1.872
Communication	-	0.088	-	0.088
Ammonia/Freon	0.292	0.018	-	0.309
Ice	-	-	0.006	0.006
Supplies/parts	1.590	-	-	1.590
Repairs/maintenance	1.590	-	-	1.590
Salt	1.463	-	-	1.463
Lube	1.378	-	-	1.378
Travel	0.398	-	-	0.398
Agency/government fees	0.318	-	-	0.318
Storage	0.292	-	-	0.292
Freight	0.186	-	-	0.186
Estimated total fishery trip costs	29.037–33.475	1.762	0.032	30.831–35.268

To estimate the indirect and induced effects of the fisheries due to vessels' spending and the subsequent effects through the industries that support the industries that are impacted by the vessels' spending, the spending activities listed in Table 7 are assigned to the appropriate industry or commodity related to the spending, and entered in IMPLAN to run the associated contribution effects. The assigned industry/commodity are shown in Table 8.

Table 8. Spending by category and IMPLAN sector assignment.

Spending category	IMPLAN sector
Fuel/lube	Commodity output: 3154 refined petroleum products (note: commodity 3157 petroleum lubricating oil and grease does not exist in American Samoa IMPLAN model)
Fishing gear	Industry output: 410 retail-sporting goods, hobby, musical instrument and book stores (note: commodity 3312 search, detection, and navigation instruments and commodity 3382 sporting and athletic goods do not exist in American Samoa IMPLAN model)
Supplies/parts	Industry output: 402 retail-motor vehicle and parts dealers
Repairs/maintenance	Industry output: 512 automotive repair and maintenance
Food	Commodity output: NIPA 27 food and nonalcoholic beverages
Salt	Commodity output: 3102 spices and extracts
Bait	Commodity output: 3017 fish
Ammonia/Freon	Commodity output: 3160 industrial gases (note: commodity 3167 nitrogenous fertilizer does not exist in American Samoa IMPLAN model)
Agency/government fees	Institution spending: 12001 state/local govt other services
Communication	Industry output: 434 wireless telecommunications
Ice	Industry output: 406 retail food and beverage stores (note: commodity 3105 manufactured ice does not exist in American Samoa IMPLAN model)
Travel	Industry output: 414 air transportation
Storage	Industry output: 422 warehousing and storage services
Freight	50% for industry output: 414 air transportation, 50% for industry output: 416 water transportation

Note that expenditures on food were allocated across commodity output sectors based on the National Income and Product Accounts (NIPA) food and nonalcoholic beverages purchased for off-premises consumption from Bureau of Economic Analysis (BEA) consumer expenditures survey in 2018. It represents the national average personal consumption expenditure patterns on food and nonalcoholic beverages.

Cannery Production

To estimate the downstream effects of the U.S. commercial fishing landings to the cannery, first, we need to determine the proportion of fish used in the cannery from domestic fishing landings. In the IMPLAN system, the percentage of output that is spent on intermediate inputs for an industry is represented by “gross absorption”. The spending of fish relative to total output for industry #92 seafood product preparation and packaging is 38.19%, which means 38.19% of output for cannery is spent on fish as intermediate inputs. Using this percentage and multiplied by the total output for this industry, the dollar amount of the

fish used as input by the cannery can be found. When comparing this value of fish used as input with the ex-vessel value of U.S. commercial landings in American Samoa (Table 1), the 2019 total ex-vessel revenue represents approximately 70% of the value of fish used in the cannery as input. In other words, 70% of fish input used by the cannery were from the U.S. commercial landings in American Samoa, and we assume 70% of cannery output is due to the U.S. commercial landings in American Samoa.

For this analysis, the value of fish used as input by the cannery is excluded from the economic contribution analysis for the cannery to avoid double counting the value of fish and economic contributions from the harvesting sector. This can be done by setting the LPP of fish (commodity=3017 fish) to zero in IMPLAN when running the cannery contributions. The direct contributions of the cannery due to fish landing in American Samoa include (1) the final cannery output/sales, (2) value-added to the local economy, (3) the employment of cannery workers, and (4) their income.

The indirect effect of the cannery includes the effect from the cannery production through intermediate inputs demand when assuming local fish supply is zero (i.e., setting LPP of fish=0% in the IMPLAN spending pattern events, which tells the software the local purchases of goods and services that support the production), but excludes the effect to the cannery (i.e., setting LPP of seafood product=0% in IMPLAN spending pattern events), because the cannery is the only company in this industry. Excluding the effect to the cannery would avoid buybacks to the cannery as the total output for the cannery already includes all revenue earned from other industries in American Samoa as intermediate input demand. For example, there are no more buybacks to the cannery from truck transportation and wholesalers as intermediate input, as the current production level in INPLAN industry #92 already includes all the demand from these industries that use the cannery output as intermediate input.

The induced effect of the cannery includes (1) the induced effect stemming from households spending of labor income earned from industries that support the intermediate demand of goods and services from the cannery production when assuming local fish supply is zero, and (2) the induced effect stemming from direct effect (i.e., households spending of labor income from cannery workers). Similar to the indirect effect, the induced effect excludes the effect to the cannery, since the total output for the cannery already includes the revenue earned in the form of final demand from households in American Samoa working in the industries supporting the cannery's intermediate input demand, and households that work in the cannery.

Scenario Analysis: Impact Analysis Due to Lower Fish Landings

There is always a concern with declines in fishing capacity in American Samoa as the cannery largely depends on the fish landings by the U.S. commercial fisheries, and the significance of the cannery in supporting the livelihood of people in American Samoa. In 2019, the cannery supported 15% of employment within American Samoa (Department of Commerce 2020). In recent years, U.S. commercial fisheries have shown a decreasing trend in fishing capacity. The number of U.S.-flagged purse seine vessels operating in the Pacific Ocean has decreased from 40 vessels in 2014 to 32 vessels in 2019 (U.S. Coast Guard and

NOAA Fisheries 2020). During the same period, vessels landing in American Samoa decreased further by 42%, from 26 vessels to 15 vessels (PIFSC 2022b). Eight U.S. purse seine vessels were sold in 2019, partly due to domestic operational constraints relative to fleets operating under foreign flags (Havice et al. 2019). Moreover, the American Samoa longline fleet is experiencing decreasing capacity with 23 American Samoa longline vessels active in 2014 declining by 22% to 18 active vessels in 2019 (PIFSC 2022b). The COVID-19 pandemic added additional challenges for U.S. fisheries (NMFS 2021). In 2021, the number of U.S. purse seine vessels landing in American Samoa dropped to 13 vessels (13% drop compared with 2019) (PIFSC 2022b) and active American Samoa longline vessels has dropped to 11 (39% drop compared with 2019) (PIFSC 2022b). Likewise, landings in American Samoa have fluctuated year by year. For example, purse seine landings in 2015 and 2017 were 8% and 15% below the 2019 level, respectively (PIFSC 2022a). Longline landings have dropped 55% between 2014 and 2021 (PIFSC 2022b).

To demonstrate the potential economic effects of changes in fishing capacity and landings, this exercise assumes three scenarios: a decrease in landings of 10 percent, 30 percent, and 50 percent in American Samoa. Ten percent was chosen because it is within the reasonable range of changes in landings and number of vessels in recent years. Thirty percent was chosen based on some possible scenarios in the future. For example, a drop of 15 purse seine vessels to 10 represents a 33% reduction of the fleet. This is not unreasonable given economic considerations as a purse seiner operating under the U.S. flag is subject to higher operating standards and higher vessel insurance costs relative to other flags (Havice et al. 2019). High fuel prices in recent years and into the future could further deteriorate the economic viability of operations as fuel expenditure is the highest cost item in a fishing trip.

Climate change is another possible scenario that could drive lower tuna catch in the western and central Pacific Ocean, where the U.S. purse seine fleet operates. Bell et al. (2021) estimated that under a high greenhouse gas emission scenario (RCP 8.5), tuna catch by Pacific Small Island Developing States purse seiners in the WCPO could decrease between 10% and 30% by 2050, whereas in the EPO tuna catch could increase between 15% and 37% due to climate-driven redistribution of tuna biomass from WCPO to EPO. A combination of these possible operational and climate scenarios could result in an approximate 50% drop in landings. For example, a lower tuna catch rate in the WCPO due to climate change, reflagging from U.S. to foreign flags due to higher operating costs under U.S. flag, and climate-driven higher catch rate in the EPO could make it more economical to land at processing plants in the EPO.

Fisheries' employment and trip spending are assumed to be reduced by the same percentages in the three scenarios (i.e., dropped by 10%, 30%, and 50%). To determine the impacts on the cannery due to changes in fish landings, the changes in fish landings that are purchased by the cannery are converted into changes in the cannery output by applying the gross absorption of fish by the cannery (i.e., proportion of output that goes toward purchase of fish as input), assuming no change in fish price. The output change for cannery due to a change of fish landing value is given by:

Change in output for cannery = Change in ex-vessel values ÷ gross absorption of fish by cannery

It is important to note that this analysis assumes the cannery cannot find fish from other countries as replacement for decreased domestic fish supply in American Samoa. It is likely that significant reductions in landings would require the cannery to pursue outside sources for tuna to maintain production levels, which would likely result in added costs to operations. In fact, the fluctuations of the U.S. commercial landings in American Samoa in recent years has led the cannery to import some pre-cut, frozen loins of tunas to supplement the fish input.

Results

Direct, Indirect, and Induced Effects of Fisheries

Commercial fishing economic contributions to American Samoa are summarized in Table 9 and Table 10, applying both a lower bound (\$18.089 million) and upper bound (\$22.527 million) estimate of fleetwide fuel costs. To demonstrate the output effects on the local economy stemming from the ex-vessel revenue generated by the three fisheries, we look at the indirect and induced output effects (i.e., excluding ex-vessel revenue). The indirect and induced output effects range from \$291.5 million to \$292.5 million, representing 28%–29% of total output in American Samoa in 2019. The total value-added effects (including the direct effect) range from \$142.1 million to \$143.0 million, which are equivalent to 22% of the 2019 GDP in American Samoa. The total employment effects in terms of jobs (including the direct effect) range from 3,480 to 3,500, representing 20% of total American Samoa employment in 2019. The total labor income effects (including the direct effect) range from \$74.3 million to \$74.9 million, representing 18% of total labor income in American Samoa in 2019. The results display little variance under different assumptions of fuel costs.

Table 9. Summary of fisheries contributions to American Samoa using lower bound of fuel costs.

Impact Type	Employment (number of jobs)	Labor Income (millions \$)	Value-Added (millions \$)	Output (millions \$)
Direct effect	460	3.316	20.517	88.524
Indirect effect	2,669	62.382	101.118	266.478
Induced effect	351	8.599	20.465	25.002
Total effect	3,480	74.296	142.100	380.005

Table 10. Summary of fisheries contributions to American Samoa using upper bound of fuel costs.

Impact Type	Employment (number of jobs)	Labor Income (millions \$)	Value-Added (millions \$)	Output (millions \$)
Direct effect	460	3.316	20.517	88.524
Indirect effect	2,685	62.898	101.801	267.323
Induced effect	354	8.672	20.640	25.217
Total effect	3,500	74.886	142.959	381.065

Using Tables 9 and 10, the ratio of the total output effects vs. the direct effects (ex-vessel value) represents how a \$1 ex-vessel value of fish contributes to the economy in American Samoa (Table 11). The ratio of total output vs. ex-vessel value is 4.3. This means for every \$1 of ex-vessel value in American Samoa, an additional \$3.3 of output/sales is generated in the American Samoa economy. In terms of value-added effect, for every \$1 of ex-vessel value, it supports \$1.6 of GDP. In terms of employment effects, for every \$1 million of ex-vessel value, it supports 39–40 jobs. For labor income effect, for every \$1 of ex-vessel value, it supports \$0.8 of labor income.

Table 11 also compares the current study results with other studies that evaluate the economic impacts of various commercial fisheries using IMPLAN. The results appear to

align well with other regional studies. Output effects relative to \$1 ex-vessel value is similar to Kirkley (1997) that evaluated Virginia's commercial harvesting and processing sectors (4.3 vs. 4.4). The employment effects per \$1 million of ex-vessel value is similar to Murray (2014) that evaluated wild caught finfish and shellfish fishery in Northampton County, Virginia (39.3–39.5 vs. 29.8). The labor income effect relative to \$1 ex-vessel value (0.8) is in between Murray (2014) (0.3) and Kirkley (1997) (2.9). The value-added effect relative to \$1 ex-vessel value (1.6) is similar to Kirkley et al. (2005) (1.1).

Table 11. Comparison of results for studies evaluated economic impacts of fisheries using IMPLAN.

Study	Current study (lower bound)	Current study (upper bound)	Murray (2014)	Kirkley et al. (2005)	Kirkley (1997)	Charles (2005)
Fishing sector	American Samoa commercial fisheries in 2019	American Samoa commercial fisheries in 2019	Northampton County wild caught finfish and shellfish in 2013	Virginia's commercial harvesting and processing sector in 2004	Virginia's commercial harvesting and processing sector in 1994	Texas Gulf Coast inshore landings for finfish, shrimp, and shellfish in 2003
Ex-vessel value (millions \$)	88.524	88.524	5.700	142.608	87.585	38.278
Total employment (number of jobs)	3,480	3,500	170	2,321	8,213	5,142
Total labor income (millions \$)	74.296	74.886	1.500	Not available	251.143	118.596
Total value-added (millions \$)	142.100	142.959	1.800	156.589	Not available	Not available
Total output (millions \$)	380.005	381.065	6.600	274.245	381.695	250.507
Total employment to \$1 million ex-vessel value	39.3	39.5	29.8	16.3	93.8	134.3
Total labor income to \$1 ex-vessel value	0.8	0.8	0.3	Not available	2.9	3.1
Total value-added to \$1 ex-vessel value	1.6	1.6	0.3	1.1	Not available	Not available
Total output to \$1 ex-vessel value	4.3	4.3	1.2	1.9	4.4	6.5

Scenario Analysis: Impact Analysis Due to Lower Fish Landings

This section analyzes the economic impacts to the local economy resulting from hypothetical decreases (10%, 30%, and 50%) in U.S. commercial landings in American Samoa (Table 12). For each reduction scenario, the lower bound and upper bound of trip cost spending are considered. If ex-vessel value decreased by 10% of 2019 value, employment would decrease by 338–340 jobs (2% of total employment in 2019), labor income would decrease by \$7.2–\$7.3 million (2% of total labor income in 2019), value-added would decrease by \$13.8–\$13.9 million (2% of GDP), and output (indirect and induced effects) would decrease by \$28.2–\$28.3 million (3% of total output). If the ex-vessel value decreased by 30%, associated decreases in employment by 6%, labor income by 5%, GDP by 7%, and output by 8% would occur. If the ex-vessel value decreased by 50%, employment would decrease by 10%, labor income would decrease by 9%, GDP would decrease by 11%, and output would decrease by 14%.

Table 12. Summary of economic impacts of hypothetical reductions of domestic fish landings in American Samoa.

		Change in ex-vessel revenue (millions \$)	Employment impacts (number of jobs)	Labor income impacts (millions \$)	Value-added impacts (millions \$)	Output impacts excluding ex-vessel value change (millions \$)
10% drop in ex-vessel values	Lower bound	-8.852	-338	-7.204	-13.818	-28.169
	Upper bound	-8.852	-340	-7.263	-13.904	-28.275
30% drop in ex-vessel values	Lower bound	-26.557	-1,015	-21.613	-41.455	-84.507
	Upper bound	-26.557	-1,022	-21.790	-41.713	-84.825
50% drop in ex-vessel values	Lower bound	-44.262	-1,692	-36.021	-69.092	-140.844
	Upper bound	-44.262	-1,702	-36.316	-69.521	-141.375
Impacts relative to 2019 American Samoa economy						
			Employment impacts (%)	Labor income impacts (%)	Value-added impacts (%)	Output impacts excluding ex-vessel value change (%)
10% drop in ex-vessel values	Lower bound	-	-1.93%	-1.73%	-2.17%	-2.75%
	Upper bound	-	-1.94%	-1.74%	-2.18%	-2.76%
30% drop in ex-vessel values	Lower bound	-	-5.80%	-5.18%	-6.50%	-8.24%
	Upper bound	-	-5.83%	-5.22%	-6.54%	-8.27%
50% drop in ex-vessel values	Lower bound	-	-9.66%	-8.63%	-10.83%	-13.73%
	Upper bound	-	-9.72%	-8.70%	-10.90%	-13.79%

Discussion

Understanding the economic contributions of the U.S. commercial fisheries to the island economy of American Samoa is important for fisheries managers and industry participants. This study provides the first economic contribution analysis of U.S. commercial fisheries in American Samoa. The three main U.S. commercial fisheries active in American Samoa—including purse seine fishery, longline fishery, and small boat fishery—are considered. Direct effects resulting from fisheries include ex-vessel revenue of fish landed in American Samoa, crew and captain jobs, and their income. Additionally, the upstream and downstream indirect effects stemming from the fish landed in American Samoa are considered. The upstream effects include the effects from spending for fishing operations, and the subsequent effects from the supporting industries that provide goods and services to meet the demand from these fishing operation spending. The downstream effects include the effects from the cannery production, and the supporting industries that provide goods and services to meet the demand from cannery operation. These effects are measured in terms of output production in dollar value, value-added, number of jobs, and labor income. Finally, the induced effects occur when workers involved in the direct and indirect effects spend their income, and generate sales within the local economy.

The economic contribution of fish landed in American Samoa show large ripple effects on the local economy. The total economic contributions of the three fisheries in 2019 are estimated at 3,480 to 3,500 jobs, \$74.3 to \$74.9 million of income, \$142.1 million to \$143.0 million of value-added. The indirect and induced output effects amount to \$291.5 million to \$292.5 million. These effects are significant as they are equivalent to 20% of total employment and 18% total labor income in American Samoa, are more than one-fifth (22%) of the American Samoa GDP, and are more than a quarter (28%–29%) of total American Samoa output. For a \$1 value of fish landed in American Samoa, it generated an additional \$3.3 of output in the local economy. For every \$1 value of fish, it supports \$1.6 of value-added/GDP in the economy. For every \$1 million of ex-vessel value, it generated approximately 39–40 jobs. For every \$1 of ex-vessel value, it supports \$0.8 of labor income. These results are comparable with other studies that used IMPLAN to examine the economic contributions of different fisheries. The contribution results between upper and lower bound of fuel cost display little variance despite a 25% difference in fuel cost between the two scenarios. This is not surprising given fuel is an imported good that has little multiplier effect on the local economy.

Given the decline in fishing capacity in American Samoa in recent years and potential future climate change impacts to landings, hypothetical scenarios of lower fish landings in American Samoa are presented to estimate the potential economic impacts in American Samoa if fish landings are reduced from 2019 levels. The economic impacts for reductions of 10% to 50% of landings would induce 2%–10% reduction in employment, 2%–9% reduction in labor income, 2%–11% reduction in GDP, and 3%–14% reduction in output.

It is important to note that some data are lacking, making it difficult to conduct a full contribution analysis, such as payment to owners of vessels, annual fixed costs incurred by the fleets, and a more detailed cost structure of purse seine fishing trip costs would refine our economic contribution estimates. Similarly, more detailed local economic data could help to refine IMPLAN multipliers to ensure that they are accurate representations of local industry interrelationships which could further reduce uncertainty in estimations of the economic contributions from U.S. commercial fisheries. Nevertheless, this study provides a baseline for monitoring the overall economic contributions by the U.S. commercial fisheries in American Samoa, and evaluates the potential impacts of reduced landings. Understanding the magnitude of economic contributions from domestic commercial fisheries provides valuable information for effective fisheries management and support for equity and environmental justice considerations in marine policy analysis.

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