

Linkage of Fisheries Sectors to Hawaii's Economy and Economic Impacts of Longline Fishing Regulations

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ABSTRACT

The survival of Hawaii's longline fisheries has recently been brought into question by environmental issues. This paper examines the linkages between Hawaii's fisheries sectors and the rest of the economy and evaluates the potential economic impacts of regulations on Hawaii's longline fisheries. Using standard linkage indicators suggested in Cai and Leung (2004), we analyzed the linkages of Hawaii's fishing industry in 1992 and 1997. We found no significant change in linkage patterns for Hawaii's fisheries sectors between the two years. We also found that Hawaii's fisheries sectors have strong linkages to the rest of the economy and any regulations imposed on fisheries will have profound economic impacts.

1. INTRODUCTION

Since longline fishing (longlining) was first introduced to Hawaii in 1917,¹ Hawaii's longline fisheries have developed into a multimillion-dollar sector, harvesting mainly swordfish (*Xiphius gladius*) and tuna (*Thunnus albacares* and *Thunnus obesus*) for local, mainland U.S., and foreign markets. However, its continuing existence has recently been brought into question by recent regulatory changes in response to environmental concerns. Because longlining poses the potential danger of accidentally catching protected species, such as marine turtles and seabirds, a series of environmental lawsuits (beginning in February 1999) sought substantial restrictions on longlining in Hawaii (e.g., *Center of Marine Conservation v. NMFS* [D. Haw.] Civ. No. 99-00152 DAE [*CMC v. NMFS*]). As a result, the Hawaii longline fishery for swordfish (called swordfishing hereafter) was closed in 2001, however, tuna longlining was kept alive. This resulted in approximately one third of swordfish-targeting vessels shifting their base from Hawaii to California. Fishers who chose to stay in Hawaii switched their focus to tuna longlining.

Recently, under a reconsideration of the issue, the swordfishing ban was replaced by a restriction on the level of swordfishing (days) and an upper annual limit on turtle by-catch. Under this new regulation the Hawaii swordfishery is halted for the rest of the year once the annual predetermined caps for turtle interactions are met. This new regulation is expected to revive Hawaii's swordfishery sector; yet the sustainability of the sector depends on how well swordfishers can coordinate to internalize the externalities of their individual swordfishing operations to the entire swordfishery sector (i.e., to adjust to the recent regulation). If an effective coordination mechanism cannot be established, uncertainties involved in swordfishing under the current regulatory framework may make swordfishing prohibitive. The situation could become more complicated as an upcoming swordfishing ban in California may lead to the return of the swordfish-targeting vessels that left Hawaii after the 2000/2001 swordfishing ban.² Designed for environmental benefit, the recent regulations imposed on Hawaii's longline fisheries had negative economic impacts. Because the sectors are interrelated, the impacts will go beyond the longline fishery and influence the entire economy through inter-sectoral economic linkages.

The purpose of this paper is to analyze the linkages between Hawaii's fisheries sectors and the rest of the state's economy, and based on that, evaluate the potential economic impacts of recent changes in Hawaii's longline fisheries regulations. Our analysis should provide useful information for regulatory decision-making on Hawaii's longline fishery. Methodologically, our analysis is an example of using the supply-driven approach in linkage analysis and impact evaluations (Leung and Pooley, 2002). The remainder of the paper is organized as follows. In section two we apply the linkage measures suggested by Cai and Leung (2004) to calculate the backward and forward linkage indicators for each of the sub-sectors of Hawaii's fishing industry and discuss their implications. In section

¹ Hereafter we refer to longline fishing as "longlining."

² See the newspaper article "Longliners set to resume fishing: New rules may test fleet's ability to prosper" (by Will Hoover) in The Honolulu Advertiser, March 13, 2004.

three we evaluate the potential direct and indirect economic impacts of longlining regulations in four different scenarios. We conclude the paper in section four.

2. LINKAGE ANALYSIS OF HAWAII'S FISHING INDUSTRY

In a 26-sector input-output table for Hawaii's economy in 1997 (SMS, 2004), the fishing industry is composed of six sub-sectors: tuna longline, swordfish longline, small commercial boats, charter boats, expense boats, and recreational boats (Table 1). Tuna and swordfish longline, small commercial boats, and expense boats belong to the commercial fishing sector whereas charter boats and recreational boats are for recreational purposes. The output value of the charter fishing boats includes both the fees paid by the patrons as well as the sale of fish while the output value of the recreation boats represents expenditures by recreational fishers. In this section we examine the linkages of these six fisheries sectors to the rest of the economy.

Table 1. A Profile of Hawaii's Fishing Industry (1997)

Sectors	Output (\$ million)	Value-Added (\$ million)	Wage Income (\$ million)	Wage Jobs	Proprietor's Income (\$ million)	Proprietor's Jobs
Swordfish longline	22.67	11.24	4.15	116	1.45	102
Tuna longline	27.37	16.46	7.30	215	2.49	191
Small Commercial Boats	11.70	6.55	0.29	10	5.40	507
Expense boats	3.94	-0.32	0.00	0	-0.78	1008
Recreation boats	10.30	0.00	0.00	0	0.00	0
Charter boats	14.17	8.39	4.67	175	1.42	67
Total Fishing Industry	90.15	42.33	16.42	516	9.99	1875
Total Hawaii's Economy	58660.04	38536.98	21626.23	615545	2087.96	126686

2.1 Methodology

Beyond direct economic impacts through its own production, a sector can also have backward-linkage impacts on its upstream suppliers, and forward-linkage impacts on its downstream demanders (Chenery and Watanabe, 1958; Hirschman, 1958). For example, the out-migration of some swordfish-targeting vessels after the 2000 swordfishing ban reduced not only longlining capacity, but also business from firms that had been servicing the longline fishing fleet. The reduction in swordfish supply may have affected the food service industry by increasing the price of swordfish, if not removing it completely from the menu.

Although the concept of linkage is straightforward, its measure is less so and controversy prone. Based on a review of major linkage measures in the literature and controversies around them, Cai and Leung (2004) suggest a supply-driven approach to calculate standard linkage measures that provide general information about inter-sectoral relationships. We will follow this suggestion in the linkage analysis of Hawaii's fishing industry.

One key feature of the supply-driven approach is to examine the impacts of changes in sectors' production. This differs from the demand-driven approach, which examines the impacts of changes in sector's final demands, or the primary-input-driven approach,

which examines changes in sectors' primary inputs (Leung and Pooley, 2002; Papadas and Dahl, 1999). Because the Leontief model describes inter-sectoral relations from an input-purchasing perspective, Cai and Leung (2004) suggest using the Leontief supply-driven multiplier as a standard backward-linkage measure. The Ghosh (1958) model captures inter-sectoral relations from an output-selling perspective, therefore, the Ghosh supply-driven multiplier is accordingly suggested as a standard forward-linkage measure.

These two standard linkage measures provide general and complementary information about inter-sectoral relationships. Sectors with large Leontief supply-driven multipliers have strong backward linkages, which implies that changes in these sectors' productions could have large impacts on their upstream input suppliers. Symmetrically, sectors with large Ghosh supply-driven multipliers have strong forward linkages and their production changes could have large impacts on their downstream demanders.

Based on the Leontief and Ghosh supply-driven multipliers, backward and forward linkage indices can be constructed to reveal sectors' relative linkage strength. A sector's backward linkage index is calculated by dividing its Leontief supply-driven multiplier by the average Leontief supply-driven multipliers for all the sectors. Thus, a backward linkage index >1 implies that the sector has a strong backward linkage relative to other sectors in the economy. Forward linkage indices can be calculated similarly by using the Ghosh supply-driven multipliers. A brief discussion on the derivations of the supply-driven multipliers and the construction of linkage indices is provided in the Appendix. A more detailed discussion can be found in Cai and Leung (2004).

2.2 Results

All six fisheries sectors had backward linkage indices >1 in 1997 (Table 2), which implies relatively strong (above-average) backward linkages. Three commercial fisheries sectors (tuna longline, small commercial boats, and expense boats) had forward linkage indices >1 , implying relatively strong forward linkages. With both relatively strong backward and forward linkages, these latter three sectors are "key" sectors in terms of inter-sectoral linkages. Swordfish longline, recreational boats, and charter boats all have forward linkage indexes <1 , implying relatively weak forward linkages.

Table 2. Linkages of Hawaii's Fishing Sectors (1997)

Sectors	Backward Linkage		Forward Linkage	
	Measures	Indices	Measures	Indices
Swordfish longline	1.44	1.02	1.04	0.81
Tuna longline	1.42	1.01	1.33	1.03
Small commercial boats	1.49	1.06	1.33	1.03
Charter boats	1.52	1.07	1.01	0.79
Recreation boats	2.15	1.52	1.00	0.78
Expense boats	2.26	1.60	1.33	1.03

By plotting the linkage indices for the 26 sectors in the 1997 model in a coordinate plane with horizontal and vertical axes gauging forward and backward linkage indices respectively, Figure 1 provides an easy visualization of fishing sector linkages compared to those of other sectors. For comparison, Figure 2 shows the linkage indices of the 72

sectors for Hawaii's economy in 1992.³ Two conclusions can be drawn from a comparison between Figure 1 and 2. First, there is no significant change in the linkage pattern for Hawaii's fishing sectors between 1992 and 1997. Second, different levels of aggregation for the rest of the economy do not give inconsistent linkage indices for fisheries sectors.⁴ The following linkage analysis will therefore be based on the 1997 input-output table, which is the most recent for Hawaii.

2.3 Longline Fisheries: Tuna Longlining and Swordfishing

Longline fisheries use 30+ miles of surface-suspended mainline to catch pelagic species (primarily tunas and swordfish) and represent around 80% of Hawaii's commercial fisheries in terms of output. Longline fishermen set their mainline differently based on species targeted. The gear is set shallow when targeting swordfish and deep for tuna.⁵ Because recent regulations treat these two fishing techniques differently, the longline fisheries are disaggregated into tuna longline and swordfish longline as two sub-sectors in the 1997 Hawaii fishery input-output model (SMS, 2004).

2.4 Backward Linkage: Tuna Longline and Swordfish Longline

Tuna longline's backward linkage is via its intermediate inputs from other sectors such as food processing, manufacturing, services, etc. Around 40% of tuna longline's inputs are intermediate inputs, including 31% of domestic intermediate inputs and 9% of imported intermediate inputs. This implies that a one-dollar change in tuna longline production will directly affect the production of its direct suppliers by 40 cents, including 31 cents for domestic suppliers and 9 cents for foreign suppliers. Because the foreign suppliers do not belong to the local economy, only the 31 cents of domestic impact is used to measure tuna longline's direct backward linkage. Because a sector's input suppliers have their own input suppliers who will also have their own input suppliers, and so on, direct backward-linkage impacts will produce a ripple effect, the total of which is usually called as indirect backward linkage.

³ The 72-sector input-output table (1992) is generally more disaggregated than the 26-sector table (1997). As far as the fisheries sectors are concerned, however, the 1997 table (with 6 fisheries sectors) is more detailed than the 1992 table (with 4 fisheries sectors).

⁴ As supply-driven linkage measures gauge only inter-sectoral but not intra-sectoral linkages (Cai and Leung [2004]), the aggregation levels of input-output tables could affect linkage indices that measure sectors' relative linkage magnitudes. The comparison between Figure 1 and 2 shows that fisheries sectors' linkage indices based on the 1997 table are not qualitatively different for those based on the less aggregate 1992 table. In a 118-sector table (1992), with the fishing industry appearing as a single sector and other sectors being more disaggregate, the fishery sector is one of the key sectors with both relatively strong backward and forward linkages (Cai and Leung [2004]; Table 3).

⁵ See Pradhan et al. (2003) and references therein for more detailed information about Hawaii's longline fisheries.

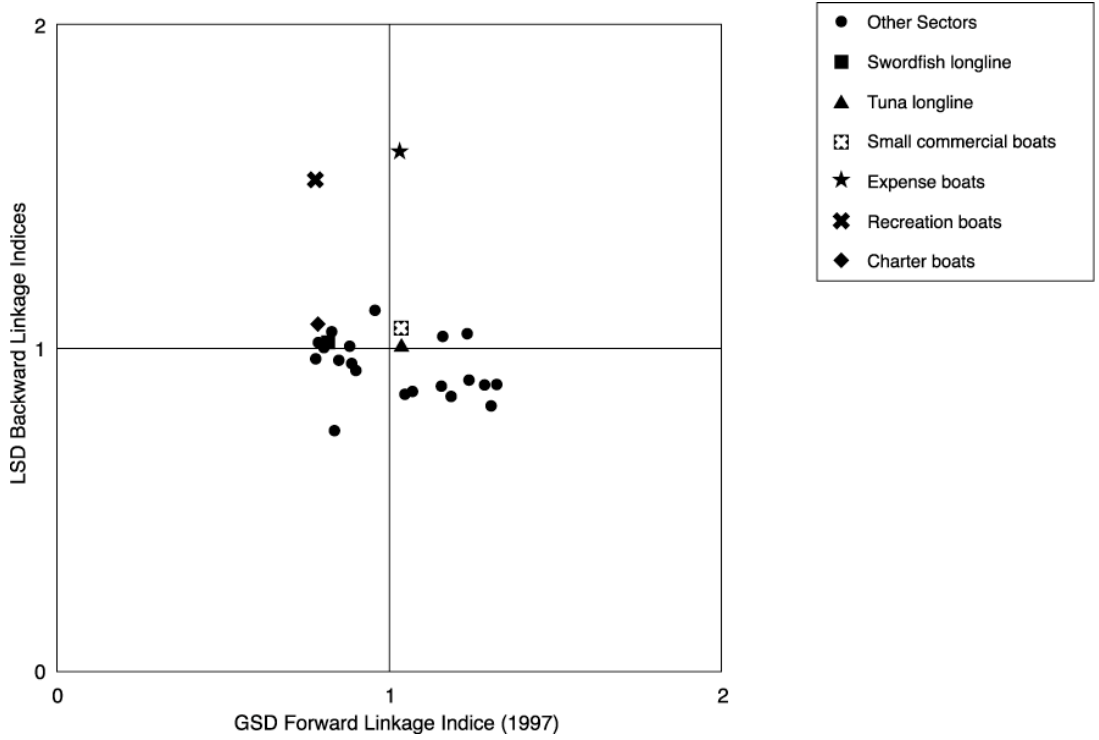


Figure 1

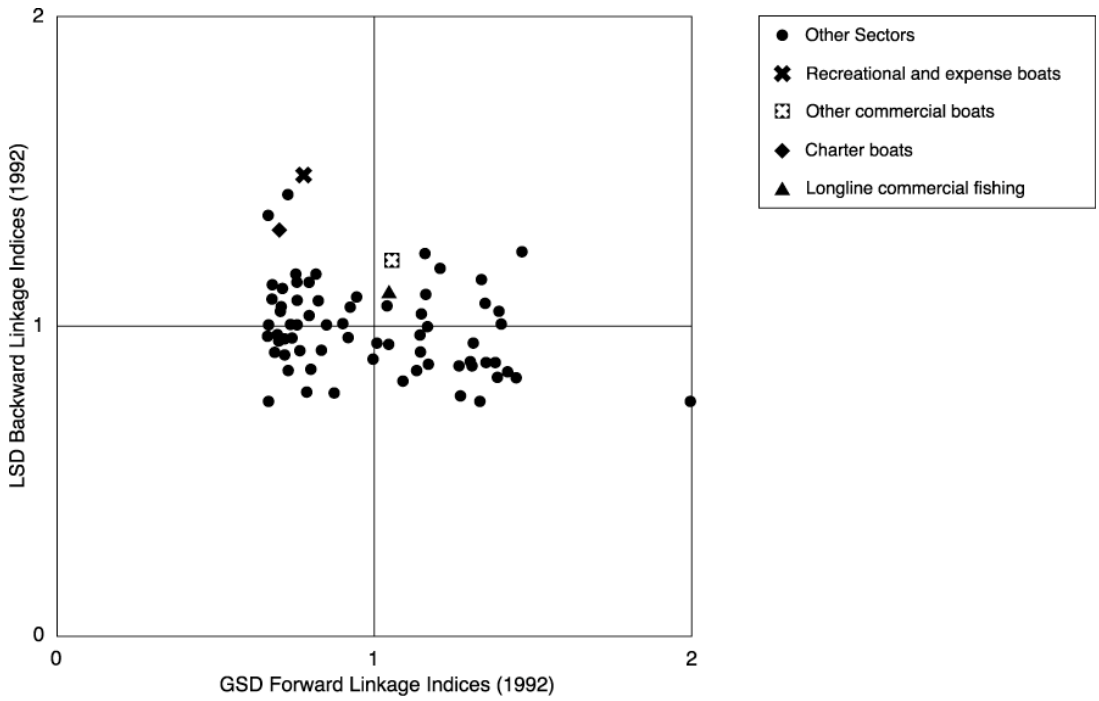


Figure 2

The Leontief supply-driven multiplier (used as the backward linkage measure here) captures both the direct and indirect backward linkages. For tuna longlining the multiplier is 1.42, which implies a \$1.00 change in tuna longline production (ex-vessel value of landings) will change production in the rest of Hawaii's economy by \$0.42. Because the direct backward-linkage impact (on tuna longline input suppliers) of the one-dollar change is \$0.31, its indirect backward-linkage impact (through a ripple effect) will be \$0.11 (i.e., \$0.42–\$0.31).

Although 50% of swordfish longline's inputs are intermediate inputs (as opposed to 40% for tuna longline), its backward linkage (1.44) is only slightly higher than that of tuna longline (1.42). This is because swordfish longline imports a higher percentage of its inputs (17%) as opposed to tuna longline (9%). With 17% out of the 50% of intermediate inputs being imported inputs, swordfish longline's direct backward linkage is 0.33. Therefore a \$1.00 change in the production of swordfishing requires \$0.33 of production change in its input suppliers. The ripple effect through indirect backward linkage will cause an additional \$0.11 of change in the rest of the economy. Thus, the total backward-linkage impacts will be \$0.44 (\$0.33 + \$0.11).

2.5 Forward Linkage: Tuna Longline and Swordfish Longline

Around 70% of tuna longline catch is sold directly for final consumption, with 55% going to local consumption and 15% for exports. The rest, 30%, is sold for intermediate uses by other sectors such as hotels, eating and drinking establishments, food processing, etc. Thus, tuna longline's direct forward linkage is 0.3. Tuna longline's total (direct and indirect) forward linkage is 1.33, which implies that its indirect forward linkage is 0.03. The majority of swordfishing products (96.5%) are directly sold for final consumption. Only 6.5% is sold for local consumption while 90% is exported. Thus, swordfishing's direct forward linkage is only 0.035. With a total forward linkage of 1.038, its indirect forward linkage is merely 0.003.

2.6 Small Commercial Boats

As opposed to large longline vessels (greater than 35 feet in length) that use mainline as fishing gear, small commercial vessels (16-33 feet in length) mainly use handlining or trolling gears to fish for tuna.⁶ In 1997 small commercial boats represented around 20% of Hawaii's commercial fisheries in terms of output or value-added. Approximately 44% of small commercial boats' inputs are intermediate inputs, including 37% domestic intermediate inputs and 7% imported inputs. Thus, the sector's direct backward linkage is 0.37, higher than the two longline sectors (0.31 for tuna and 0.33 for swordfish). The total backward linkage of small commercial boats is 1.49, higher than the two longline sectors (1.42 for tuna and 1.44 for swordfish). The sector's indirect backward linkage is 0.12, also higher than those of longline sectors (0.11 for both tuna and swordfish). The higher backward linkage for the small commercial boats sector is mainly due to the lower import content (7%) in its inputs relative to longline sectors (9% for tuna and 17% for

⁶ See Sharma et al. (2003) and references therein for more detailed information about the small commercial boats sector.

swordfish). With tuna as its major catch, the small commercial boats sector and the tuna longline sector both have total forward linkages of 1.33, with 0.3 and 0.03 as direct and indirect forward linkages respectively.

2.7 Charter Boats

Charter boats are used mainly by tourists for recreational fishing activities. Around 41% of its inputs are intermediate inputs, including 38% of domestic intermediate inputs and 3% of imported inputs. Charter boats' total backward linkage is 1.51, including 0.38 and 0.13 direct and indirect backward linkages respectively. Both charter boats' direct and indirect backward linkages are greater than the longline and small commercial boat sectors. This is because aside from the backward linkages due to vessel operation and maintenance that are common for the entire fishing industry, the charter boats sector also has special backward linkages from servicing tourists. Around 5% of charter boats' inputs are from hotels, foodservices, and arts and entertainment whereas other fisheries sectors have no inputs from these sectors. Because its "products" are mainly recreational services that are directly sold to tourists (as final demand),⁷ the charter boats sector has little forward linkage. Its only direct forward linkage is its services to hotels that amount to 1% of its total revenues. With a small direct forward linkage, the charter boats sector's indirect forward linkage is trivial.

2.8 Recreational and Expense Boats

The recreational and expense boats sectors are comprised of local residents who use private boats for recreational or semi-commercial fishing. Because expense boat owners sell only part of their products (59% or so in 1997) to the market, 59% of their fishing activities are recorded in the 1997 input-output table as commercial operations under the expense boats sector (SMS, 2004). The other 41%, together with the fishing activities of recreational boats, are accounted as recreational activities under the recreational boats sector. Both the recreational and expense boats sector have very large backward linkages (2.15 and 2.26 respectively). This reflects that the intermediate inputs of these two sectors are 100% (or more) of its total inputs. This does not mean that these boats do not need people to operate or money to finance. Rather, this is because recreational and expense boat owners usually do not profit from their fishing "businesses"—the focus is on having fun and not making money. Because all of its products are sold directly for final consumption, the recreational boats sector has no forward linkage. The commercial component of expense boat activities has a relatively large forward linkage (1.33), identical to those of the tuna longline and small commercial boats sectors.

2.9 Summary

In general, the results of our linkage analysis indicate relatively strong backward linkages for all the fisheries sectors. Most commercial fisheries sectors, except swordfish longline, have relatively strong forward linkages. Recreational fisheries sectors have relatively

⁷ Charter boats have a small amount of fish sales, equal to 3% of its total output.

weak forward linkages and relatively stronger backward linkages than commercial ones. For the commercial fisheries sectors, the small commercial boats sector has a relatively stronger backward linkage than the longline sectors. Tuna-targeting commercial operations (including tuna longline, small commercial boats, and expense boats sectors) have relatively strong forward linkages via selling their products locally, whereas the swordfish longline sector has a relatively weak forward linkage because most of its swordfish catch is exported.

3. ECONOMIC IMPACTS OF LONGLINING REGULATIONS ON HAWAII'S ECONOMY

Leung and Pooley (2002) examined longline regulations and estimated their impact on Hawaii's economy. Because the 1992 input-output table used in their study does not contain disaggregate information about swordfish and tuna longlining, they were unable to distinguish the differential impact of the potential economic impacts of shutting down the Hawaii's longline fisheries. Because of the importance of distinguishing the two longline sub-sectors, the National Marine Fisheries Service's Honolulu Laboratory disaggregated the longline fisheries sector to capture the differences in these two sub-sectors in the 1997 input-output table (SMS, 2004). This disaggregation not only allows us to distinguish the economic impacts of swordfishing from those of the longline fishery as a whole, but it also enables us to take into account interactions between swordfish longline and tuna longline as two sub-sectors. The 1997 table enables us to conduct a more refined evaluation of the potential economic impacts of recent changes in Hawaii's longlining regulations.

3.1 Methodology

Longlining regulations directly affect longline sectors. We call such impacts "self impacts." Because the sectors are interrelated, the self impacts further affect other sectors in the rest of the economy, which we will call "linkage" impacts. Based on the 1997 input-output table, we conducted a counterfactual evaluation on how longlining regulations could have affected Hawaii's economy. The evaluation was conducted in two steps. First we considered how longlining regulations could directly affect longline sectors (i.e., self impacts). We then used input-output techniques to estimate how the changes in the longline sectors could have affected the rest of the economy through their linkages (i.e., linkage impacts).

For the first step, we considered four scenarios. Motivated by the 2000/2001 swordfishing ban, the first scenario considers a situation where regulations cause a complete shutdown of the swordfish longline sector and production becomes zero. Following the 2000/2001 swordfishing ban, one third of the swordfish-targeting vessels shifted their base from Hawaii to California and those that stayed in Hawaii converted to tuna longlining. To take this situation into account, in the second scenario we estimate the economic impacts of a swordfishing shutdown together with partial capacity shift from swordfishing to tuna longlining. Because the total tuna catch by the longline fisheries increased by about 15% after the swordfishing ban, we assume that the capacity shift

increased the tuna longline sector's production by 15%. In summary, this scenario is a situation where the production of swordfishing becomes zero and that of tuna longlining is increases by 15%.

The third scenario is motivated by recent 2004 longlining regulations that replaced the 2000 swordfishing ban with a restriction on swordfishing effort. Under the new regulations, Hawaii's swordfish-targeting efforts will be limited to 2,120 "sets" per year,⁸ which amounts to about half of the swordfishing capacity prior to the swordfishing ban. Because a swordfishing ban is being implemented in California, those swordfish-targeting vessels that left Hawaii after the 2000/2001 swordfishing ban are expected to return home. Taking these elements into consideration, we consider a situation where swordfishing production is reduced by 50% and tuna longlining production increases by 10%. The 50% reduction in swordfishing production captures the self impact of the new longlining regulations that restrict swordfishing effort by half. If the other half of swordfishing capacity is converted to tuna longlining, we assume that it would increase tuna longlining production by 10%. This assumption is based on the fact that with two thirds of swordfish-targeting vessels being converted into tuna fishing after the 2000 swordfishing ban, the longlining tuna catch has increased by around 15%. Finally, the fourth scenario considers a complete shutdown of the entire longline fishery. This scenario provides information about the maximum potential economic costs of longlining restrictions.

With the self impacts of longlining regulations specified in the first step, the second step is to estimate their linkage impacts from both backward and forward-linkage perspectives. Under the backward-linkage perspective, we use the Leontief supply-driven model to estimate how changes in the longline sectors will affect the rest of the economy. An implicit assumption behind such estimations is that longlining products can be perfectly substituted by imports. Therefore, changes in the longline sectors will not affect businesses that use longlining products as inputs (e.g., restaurants). Thus, while the estimations based on the Leontief (supply-driven) model capture the longline sectors' potential backward-linkage impacts on their upstream suppliers, they nevertheless overlook the sectors' potential forward-linkage impacts on their downstream demanders.

The Ghosh supply-driven model can be used to estimate the longline sectors' potential forward-linkage impacts. However, caution needs to be taken in interpreting the results. Because a stable output coefficient matrix (implicitly assumed by the Ghosh model) is hardly consistent with production reality, the interpretation of the Ghosh model as a quantity model was viewed as "implausible" (Oosterhaven, 1988; 1989). To interpret the Ghosh model as a price model is theoretically more justifiable (Dietzenbacher, 1997); however, the underlying assumption of fixed production makes the price-model interpretation less useful in impact evaluations for most situations including the present analysis.

⁸ One set equals one day's fishing per boat.

In light of these problems, we take the estimations based on the Ghosh supply-driven model as informative yet indefinite measures of the longline sectors' forward linkage impacts. The measures are informative in that they indicate how much of each sectors' productions depend directly or indirectly on longlining products as inputs. On the other hand, the measures are indefinite in that they do not reveal exactly how changes in the availability of longlining products will affect these products. These products could be kept intact by perfect import substitutions, completely lost because of a lack of substitutions, or somewhere in between. The impacts could also in turn affect other businesses. For example, the lack of affordable and fresh tuna sashimi could have a negative impact on the expansion of seafood restaurants in Hawaii. To take these complications into account requires more data than input-output tables can provide and such data are not available to us. Rather than ignoring the potential forward-linkage impacts of longlining regulations, we choose to use the Ghosh supply-driven model to estimate how much production in what sectors could potentially be affected by longlining regulations through forward linkages. The technical details of using the Leontief and Ghosh models to estimate the backward and forward-linkage impacts are provided in the Appendix.

3.2 Results

The aggregate economic impacts of longline fishing regulations in the four scenarios are summarized in Table 3. Tables A.1-A.8 in the Appendix contain information about detailed impacts on individual sectors.

Table 3. Economic Impacts of Longlining Regulations

Scenario	Impacts	Output	Value-Added (\$ million)	Wage Income (\$ million)	Proprietor Income (\$ million)	Total Income (\$ million)	Wage Jobs	Proprietor's Jobs	Total Jobs	State Taxes (\$ million)
Swordfishing shutdown	Self Impact	-22.67	-11.24	-4.15	-1.45	-5.60	-116	-102	-218	-0.67
	Backward-Linkage Impact	-9.93	-5.68	-3.03	-0.29	-3.33	-89	-25	-114	-0.67
	Forward-Linkage Impact	-0.86	-0.45	-0.29	-0.01	-0.30	-14	0	-15	-0.05
Swordfishing Shutdown with Partial capacity shift	Self Impact	-18.56	-8.77	-3.05	-1.08	-4.13	-83	-74	-157	-0.53
	Backward-Linkage Impact	-8.20	-4.69	-2.49	-0.24	-2.73	-72	-20	-92	-0.56
	Forward-Linkage Impact	0.49	0.24	0.16	0.01	0.16	9	0	9	0.02
Swordfishing Shutdown with capacity shift	Self Impact	-8.60	-3.98	-1.34	-0.48	-1.82	-36	-32	-68	-0.24
	Backward-Linkage Impact	-3.81	-2.18	-1.16	-0.11	-1.26	-33	-9	-42	-0.26
	Forward-Linkage Impact	0.47	0.23	0.15	0.01	0.16	8	0	9	0.02
Longline fishery shutdown	Self Impact	-50.04	-27.71	-11.45	-3.94	-15.39	-331	-293	-624	-1.64
	Backward-Linkage Impact	-21.44	-12.30	-6.64	-0.67	-7.32	-200	-58	-258	-1.41
	Forward-Linkage Impact	-9.85	-5.05	-3.25	-0.15	-3.40	-167	-6	-173	-0.54

3.2.1 Scenario One: Swordfishing Shutdown

The closure of the swordfishery would mean that the sector's \$23 million output (0.085% of the total output for Hawaii's economy)⁹, \$11 million value-added (0.072%), \$5.6 million income (0.065%), 218 jobs (0.232%), and \$0.67 million state taxes (0.022%) would be lost (in 1997 terms, Table 3). The shutdown would also cause losses in the rest of the economy through backward linkages. These include a loss of \$10 million output (0.017%), \$5.7 million value-added (0.015%), \$3.3 million income (0.014%), 114 jobs

⁹ In the remainder of the paper, unless specified otherwise, percentage numbers in parentheses are in terms of Hawaii's total.

(0.015%), and \$0.67 million state taxes (0.022%). The most backward-linkage affected sectors in the rest of the economy include wholesale trade, manufacturing, and services (Table A.1). It is worth mentioning that, despite the fact that swordfish longline has no direct purchases from the real estate and rentals sector, its shutdown (through indirect backward linkages) could lead to a loss of \$0.54 million worth of business in 1997. The potential forward-linkage impacts of the swordfishing shutdown are relatively small. Through forward linkages, the shutdown could potentially affect \$0.86 million output (0.002%), \$0.45 million value-added (0.001%), \$0.30 million income (0.001%), 15 jobs (0.002%), and \$0.05 million state taxes (0.002%) in the rest of the economy. The most forward-linkage affected sectors include foodservices, food processing, and hotels.

3.2.2 Scenario Two: Swordfishing Shutdown with Partial Capacity Shift

The economic costs of a swordfishing shutdown with a partial capacity shift to tuna longlining, an increase of 15% in production, will be smaller than the first scenario. As shown in Table 3, with the production increase in the tuna longlining sector, the self impacts of the swordfishing shutdown will be smaller. The production increase in tuna longlining will have positive linkage impacts that compensate for the negative linkage impacts of the swordfishing shutdown and the economic losses for the rest of the economy will be smaller. Indeed, as the tuna longline sector has a much stronger forward linkage than the swordfish longline sector, the forward linkage impacts in this scenario could be positive. Because most of Hawaii's swordfish is exported, the swordfishing shutdown will not have much impact on local restaurants, retail groceries, or other businesses. On the other hand, these businesses might benefit from the larger tuna supply caused by the capacity shift. Table A.4 shows that the capacity shift could almost neutralize the negative forward-linkage impact of the swordfishing shutdown on hotels. The production of the eating and drinking sector and the food processing sector could actually increase because of the swordfishing shutdown if it is also accompanied by a capacity shift.

3.2.3 Scenario Three: Swordfishing Restriction with Capacity Shift

If swordfishing restrictions reduced the swordfishing production by half yet increased the tuna longlining production by 10%, then its impact on Hawaii's economy would have been such as shown in Table 3 and Table A.5 and A.6. Not surprisingly, the self-impact of economic losses in this situation are smaller than in the case of a complete swordfishing shutdown; so are the backward-linkage impacts. The forward-linkage impacts in this situation are similar to those in the case of swordfishing shutdown with capacity shift. This is because, while preserving half of swordfishing output reduces the negative forward-linkage impacts of longlining regulations, it also reduces the positive forward-linkage impacts due to the capacity shift from swordfishing to tuna longlining.

3.2.4 Scenario Four: Shutdown of the Entire Longline Fisheries

Tables 3, A.7, and A.8 show the effect on Hawaii's economy if the longline fisheries were completely shut down. The self-impact losses would be the longline fishery's direct economic contributions such as output, value-added, jobs, etc. Because the tuna longline sector has a relatively strong forward linkage, the shutdown of the entire longline fisheries will potentially have significant backward and forward linkage impacts. The

most affected sectors through backward linkages are wholesale trade, manufacturing, and services. The most affected sectors through forward linkages are eating and drinking, hotels, and food processing.

4. CONCLUSION

This paper uses a supply-driven approach to analyze the linkages of Hawaii's fisheries sectors and estimate the potential economic impacts of longlining regulations. The results show that Hawaii's longline and other fisheries sectors have significant economic linkages to the rest of the economy; and hence the economic impacts of longlining regulations go beyond the fisheries sectors being restricted. Therefore, decision making on longlining regulations should take such linkage impacts into account. Based on Hawaii's 1997 input-output table, we estimate the economic impacts of longlining regulations in four (counterfactual) scenarios. If the structure of Hawaii's economy has not changed much since 1997 (the updated model base year), these estimates (including the magnitudes and percentages) can provide approximate measures of the economic impacts of the 2000/2001 swordfishing ban, the current swordfishing restrictions, and the effect of a complete shutdown of the entire longline fishery (as a strictly hypothetical case). Because our focus here is on linkage impacts, we have only considered some simple interactions (i.e., the capacity shift) among fisheries sectors under longlining regulations, which could actually be more complicated (Pradhan et al., 2003; Sharma et al, 2003). For example, increases in tuna longlining due to a swordfishing ban or restriction may reduce the production or the value of production for the small commercial boats sector through competitive pressures with similar negative impacts also affecting the charter boats sector. To provide more accurate impact evaluations, future research needs to take these complications into account.

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APPENDIX

Leontief Supply-Driven Multiplier as a Backward-Linkage Measure

Partition the Leontief input-output model $\mathbf{x} = \mathbf{A}\mathbf{x} + \mathbf{f}$ (\mathbf{x} and \mathbf{f} are the vectors of output and final demand respectively; and \mathbf{A} is the direct input coefficient matrix) into

$$\begin{pmatrix} x_i \\ \mathbf{x}_j \end{pmatrix} = \begin{pmatrix} \mathbf{A}_{ii} & \mathbf{A}_{ij} \\ \mathbf{A}_{ji} & \mathbf{A}_{jj} \end{pmatrix} \begin{pmatrix} x_i \\ \mathbf{x}_j \end{pmatrix} + \begin{pmatrix} f_i \\ \mathbf{f}_j \end{pmatrix},$$

where i denotes sector i and j represents the rest of the economy. According to the partitioned model, the backward-linkage impacts of sector i 's one-unit output change (i.e., $\Delta x_i = 1$) on other sectors can be calculated by $\Delta \mathbf{x}_j = (\mathbf{I} - \mathbf{A}_{jj})^{-1} \mathbf{A}_{ji}$. Then, sector i 's Leontief supply-driven multiplier (denoted as LSD_i) is given by

$$LSD_i = 1 + \mathbf{e}'(\mathbf{I} - \mathbf{A}_{jj})^{-1} \mathbf{A}_{ji},$$

where \mathbf{e} is the summation vector. LSD_i provides a standard backward-linkage measure for sector i . For the purpose of inter-sectoral comparison, sector i 's backward linkage index can be calculated by

$$\frac{LSD_i}{LSD_i + \sum_j LSD_j}.$$

Ghosh Supply-Driven Multiplier as a Forward-Linkage Measure

Partition the Ghosh input-output model $\mathbf{x}' = \mathbf{x}'\mathbf{B} + \mathbf{w}'$ (\mathbf{x} and \mathbf{w} are the vectors of output and primary input respectively; and \mathbf{B} is the direct output coefficient matrix) into

$$\begin{pmatrix} x'_i & \mathbf{x}'_j \end{pmatrix} = \begin{pmatrix} x'_i & \mathbf{x}'_j \end{pmatrix} \begin{pmatrix} \mathbf{B}_{ii} & \mathbf{B}_{ij} \\ \mathbf{B}_{ji} & \mathbf{B}_{jj} \end{pmatrix} + \begin{pmatrix} w'_i & \mathbf{w}'_j \end{pmatrix};$$

according to which the forward-linkage impacts of sector i 's one-unit output change (i.e., $\Delta x_i = 1$) on other sectors can be calculated by $\Delta \mathbf{x}_j = \mathbf{B}_{ij}(\mathbf{I} - \mathbf{B}_{jj})^{-1}$. Then, sector i 's Ghosh supply-driven multiplier (denoted as GSD_i) is given by

$$GSD_i = 1 + \mathbf{B}_{ij}(\mathbf{I} - \mathbf{B}_{jj})^{-1} \mathbf{e},$$

which provides a standard forward-linkage measure for sector i . For the purpose of inter-sectoral comparison, sector i 's forward linkage index can be calculated by

$$\frac{GSD_i}{GSD_i + \sum_j GSD_j}.$$

Backward and Forward Linkage Impacts of Longlining Regulations

Partition the Leontief input-output model into

$$\begin{pmatrix} \mathbf{x}_i \\ \mathbf{x}_j \end{pmatrix} = \begin{pmatrix} \mathbf{A}_{ii} & \mathbf{A}_{ij} \\ \mathbf{A}_{ji} & \mathbf{A}_{jj} \end{pmatrix} \begin{pmatrix} \mathbf{x}_i \\ \mathbf{x}_j \end{pmatrix} + \begin{pmatrix} \mathbf{f}_i \\ \mathbf{f}_j \end{pmatrix},$$

where \mathbf{x}_i is a 2×1 vector with the two elements being the outputs of swordfishing and tuna longlining. \mathbf{x}_j is a 24×1 vector with the elements being other sectors' outputs. Based on this partitioned model, the backward-linkage impacts of changes in the longlining sectors on other sectors can be calculated by the following formula:

$$\Delta \mathbf{x}_j = (\mathbf{I} - \mathbf{A}_{jj})^{-1} \mathbf{A}_{ji} \Delta \mathbf{x}_i,$$

where $\Delta \mathbf{x}_i' = (-22.67, 0)$ for the case of swordfishing shutdown; $\Delta \mathbf{x}_i' = (-22.67, 4.11)$ for the case of swordfishing shutdown with capacity shift; $\Delta \mathbf{x}_i' = (-11.34, 2.74)$ for the case of swordfishing shutdown; and $\Delta \mathbf{x}_i' = (-22.67, -27.37)$ for the case of the shutdown of the entire longline fishery.

Similarly, based on a partitioned Ghosh model, the forward-linkage impacts of changes in the longlining sectors on other sectors can be calculated by the following formula

$$\Delta \mathbf{x}_j' = \Delta \mathbf{x}_i' \mathbf{B}_{ij} (\mathbf{I} - \mathbf{B}_{jj})^{-1}.$$

Table A.1: Backward-linkage Impacts of Swordfishing Shutdown

Affected Sectors	Output (Million \$)	Value-added (Million \$)	Wage income (Million \$)	Proprietor's income (Million \$)	Total income (Million \$)	Wage jobs	Proprietor's jobs	Total jobs	State taxes (Million \$)
Small commercial boats	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Expense boats	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Recreation boats	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Charter boats	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Agriculture	-0.06	-0.04	-0.02	0.00	-0.02	-1	-1	-2	0.00
Mining and construction	-0.06	-0.03	-0.02	0.00	-0.02	0	0	-1	0.00
Food processing	-0.23	-0.08	-0.04	0.00	-0.04	-1	0	-2	0.00
Other manufacturing	-2.00	-0.48	-0.27	-0.04	-0.31	-7	-2	-9	-0.02
Transportation	-0.44	-0.22	-0.13	0.00	-0.13	-3	0	-3	-0.01
Information	-0.18	-0.11	-0.05	0.00	-0.05	-1	0	-1	-0.01
Utilities	-0.10	-0.05	-0.02	0.00	-0.02	0	0	0	-0.01
Wholesale trade	-3.77	-2.70	-1.46	-0.05	-1.51	-38	-7	-45	-0.46
Retail trade	-0.20	-0.13	-0.08	-0.01	-0.09	-3	-1	-4	-0.03
Finance and insurance	-0.50	-0.30	-0.14	-0.01	-0.15	-3	-1	-4	-0.02
Real estate and rentals	-0.54	-0.41	-0.03	-0.02	-0.05	-1	-1	-2	-0.02
Professional services	-0.20	-0.13	-0.08	-0.04	-0.12	-2	-2	-3	-0.01
Business services	-0.33	-0.24	-0.15	-0.03	-0.18	-7	-2	-8	-0.02
Educational services	-0.01	0.00	0.00	0.00	0.00	0	0	0	0.00
Health services	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Arts and entertainment	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Hotels	-0.01	0.00	0.00	0.00	0.00	0	0	0	0.00
Eating and drinking	-0.02	-0.01	-0.01	0.00	-0.01	0	0	0	0.00
Other services	-1.14	-0.61	-0.43	-0.08	-0.52	-18	-8	-26	-0.05
Government	-0.14	-0.13	-0.11	0.00	-0.11	-3	0	-3	-0.01
Total backward linkage impacts	-9.93	-5.68	-3.03	-0.29	-3.33	-89	-25	-114	-0.67

Table A.2: Forward-linkage Impacts of Swordfishing Shutdown

Affected Sectors	Output (Million \$)	Value-added (Million \$)	Wage income (Million \$)	Proprietor's income (Million \$)	Total income (Million \$)	Wage jobs	Proprietor's jobs	Total jobs	State taxes (Million \$)
Small commercial boats	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Expense boats	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Recreation boats	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Charter boats	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Agriculture	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Mining and construction	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Food processing	-0.12	-0.04	-0.02	0.00	-0.02	-1	0	-1	0.00
Other manufacturing	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Transportation	-0.01	0.00	0.00	0.00	0.00	0	0	0	0.00
Information	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Utilities	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Wholesale trade	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Retail trade	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Finance and insurance	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Real estate and rentals	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Professional services	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Business services	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Educational services	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Health services	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Arts and entertainment	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Hotels	-0.23	-0.15	-0.09	0.00	-0.09	-3	0	-3	-0.02
Eating and drinking	-0.47	-0.25	-0.17	-0.01	-0.18	-10	0	-11	-0.03
Other services	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Government	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Total Forward linkage impacts	-0.86	-0.45	-0.29	-0.01	-0.30	-14	0	-15	-0.05

Table A.3: Backward-linkage Impacts of Swordfishing Shutdown with Partial Capacity Shift

Affected Sectors	Output (Million \$)	Value-added (Million \$)	Wage income (Million \$)	Proprietor's income (Million \$)	Total income (Million \$)	Wage jobs	Proprietor's jobs	Total jobs	State taxes (Million \$)
Small commercial boats	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Expense boats	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Recreation boats	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Charter boats	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Agriculture	-0.04	-0.02	-0.01	0.00	-0.01	-1	0	-1	0.00
Mining and construction	-0.05	-0.02	-0.02	0.00	-0.02	0	0	0	0.00
Food processing	-0.12	-0.04	-0.02	0.00	-0.02	-1	0	-1	0.00
Other manufacturing	-1.75	-0.43	-0.24	-0.03	-0.27	-6	-2	-8	-0.02
Transportation	-0.39	-0.20	-0.11	0.00	-0.11	-3	0	-3	-0.01
Information	-0.15	-0.09	-0.04	0.00	-0.04	-1	0	-1	-0.01
Utilities	-0.08	-0.04	-0.01	0.00	-0.01	0	0	0	-0.01
Wholesale trade	-3.24	-2.32	-1.25	-0.04	-1.30	-33	-6	-39	-0.39
Retail trade	-0.15	-0.10	-0.06	-0.01	-0.07	-2	-1	-3	-0.02
Finance and insurance	-0.40	-0.24	-0.11	-0.01	-0.12	-2	-1	-3	-0.02
Real estate and rentals	-0.44	-0.33	-0.02	-0.02	-0.04	-1	-1	-1	-0.01
Professional services	-0.16	-0.11	-0.06	-0.03	-0.10	-1	-1	-3	-0.01
Business services	-0.28	-0.20	-0.13	-0.02	-0.15	-6	-1	-7	-0.02
Educational services	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Health services	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Arts and entertainment	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Hotels	-0.01	0.00	0.00	0.00	0.00	0	0	0	0.00
Eating and drinking	-0.02	-0.01	-0.01	0.00	-0.01	0	0	0	0.00
Other services	-0.83	-0.44	-0.31	-0.06	-0.38	-13	-6	-19	-0.04
Government	-0.10	-0.09	-0.08	0.00	-0.08	-2	0	-2	0.00
Total backward linkage impacts	-8.20	-4.69	-2.49	-0.24	-2.73	-72	-20	-92	-0.56

Table A.4: Forward-linkage Impacts of Swordfishing Shutdown with Partial Capacity Shift

Affected Sectors	Output (Million \$)	Value-added (Million \$)	Wage income (Million \$)	Proprietor's income (Million \$)	Total income (Million \$)	Wage jobs	Proprietor's jobs	Total jobs	State taxes (Million \$)
Small commercial boats	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Expense boats	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Recreation boats	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Charter boats	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Agriculture	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Mining and construction	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Food processing	0.10	0.03	0.02	0.00	0.02	1	0	1	0.00
Other manufacturing	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Transportation	0.01	0.00	0.00	0.00	0.00	0	0	0	0.00
Information	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Utilities	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Wholesale trade	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Retail trade	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Finance and insurance	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Real estate and rentals	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Professional services	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Business services	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Educational services	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Health services	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Arts and entertainment	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Hotels	-0.02	-0.01	-0.01	0.00	-0.01	0	0	0	0.00
Eating and drinking	0.38	0.20	0.14	0.01	0.14	8	0	9	0.02
Other services	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Government	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Total Forward linkage impacts	0.49	0.24	0.16	0.01	0.16	9	0	9	0.02

Table A.5: Backward-linkage Impacts of Swordfishing Restriction with Capacity Shift

Affected Sectors	Output (Million \$)	Value-added (Million \$)	Wage income (Million \$)	Proprietor's income (Million \$)	Total income (Million \$)	Wage jobs	Proprietor's jobs	Total jobs	State taxes (Million \$)
Small commercial boats	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Expense boats	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Recreation boats	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Charter boats	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Agriculture	-0.01	-0.01	0.00	0.00	-0.01	0	0	0	0.00
Mining and construction	-0.02	-0.01	-0.01	0.00	-0.01	0	0	0	0.00
Food processing	-0.04	-0.01	-0.01	0.00	-0.01	0	0	0	0.00
Other manufacturing	-0.84	-0.20	-0.11	-0.02	-0.13	-3	-1	-4	-0.01
Transportation	-0.18	-0.09	-0.05	0.00	-0.05	-1	0	-1	-0.01
Information	-0.07	-0.04	-0.02	0.00	-0.02	0	0	0	0.00
Utilities	-0.04	-0.02	-0.01	0.00	-0.01	0	0	0	0.00
Wholesale trade	-1.53	-1.10	-0.59	-0.02	-0.61	-16	-3	-18	-0.19
Retail trade	-0.07	-0.05	-0.03	0.00	-0.03	-1	0	-1	-0.01
Finance and insurance	-0.19	-0.11	-0.05	0.00	-0.05	-1	0	-2	-0.01
Real estate and rentals	-0.20	-0.15	-0.01	-0.01	-0.02	0	0	-1	-0.01
Professional services	-0.08	-0.05	-0.03	-0.01	-0.04	-1	-1	-1	-0.01
Business services	-0.13	-0.09	-0.06	-0.01	-0.07	-3	-1	-3	-0.01
Educational services	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Health services	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Arts and entertainment	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Hotels	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Eating and drinking	-0.01	0.00	0.00	0.00	0.00	0	0	0	0.00
Other services	-0.37	-0.19	-0.14	-0.03	-0.17	-6	-3	-8	-0.02
Government	-0.04	-0.04	-0.03	0.00	-0.03	-1	0	-1	0.00
Total backward linkage impacts	-3.81	-2.18	-1.16	-0.11	-1.26	-33	-9	-42	-0.26

Table A.6: Forward-linkage Impacts of Swordfishing Restriction with Capacity Shift

Affected Sectors	Output (Million \$)	Value-added (Million \$)	Wage income (Million \$)	Proprietor's income (Million \$)	Total income (Million \$)	Wage jobs	Proprietor's jobs	Total jobs	State taxes (Million \$)
Small commercial boats	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Expense boats	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Recreation boats	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Charter boats	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Agriculture	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Mining and construction	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Food processing	0.08	0.03	0.02	0.00	0.02	1	0	1	0.00
Other manufacturing	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Transportation	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Information	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Utilities	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Wholesale trade	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Retail trade	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Finance and insurance	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Real estate and rentals	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Professional services	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Business services	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Educational services	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Health services	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Arts and entertainment	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Hotels	0.03	0.02	0.01	0.00	0.01	0	0	0	0.00
Eating and drinking	0.33	0.17	0.12	0.01	0.13	7	0	7	0.02
Other services	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Government	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Total Forward linkage impacts	0.47	0.23	0.15	0.01	0.16	8	0	9	0.02

Table A.7: Backward-linkage Impacts of Longline Fishery Shutdown

Affected Sectors	Output (Million \$)	Value-added (Million \$)	Wage income (Million \$)	Proprietor's income (Million \$)	Total income (Million \$)	Wage jobs	Proprietor's jobs	Total jobs	State taxes (Million \$)
Small commercial boats	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Expense boats	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Recreation boats	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Charter boats	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Agriculture	-0.24	-0.14	-0.09	-0.01	-0.09	-3	-2	-6	-0.01
Mining and construction	-0.12	-0.06	-0.04	-0.01	-0.05	-1	0	-1	-0.01
Food processing	-0.97	-0.32	-0.18	0.00	-0.18	-6	0	-6	-0.01
Other manufacturing	-3.63	-0.88	-0.49	-0.07	-0.56	-13	-4	-17	-0.04
Transportation	-0.82	-0.42	-0.23	-0.01	-0.24	-6	-1	-6	-0.02
Information	-0.40	-0.24	-0.10	-0.01	-0.11	-2	0	-3	-0.02
Utilities	-0.23	-0.12	-0.04	0.00	-0.04	-1	0	-1	-0.02
Wholesale trade	-7.30	-5.22	-2.82	-0.10	-2.92	-74	-13	-87	-0.89
Retail trade	-0.51	-0.35	-0.20	-0.02	-0.22	-8	-2	-11	-0.07
Finance and insurance	-1.16	-0.69	-0.31	-0.02	-0.34	-7	-3	-10	-0.04
Real estate and rentals	-1.26	-0.95	-0.06	-0.05	-0.11	-2	-2	-4	-0.04
Professional services	-0.44	-0.29	-0.17	-0.09	-0.26	-4	-3	-7	-0.03
Business services	-0.70	-0.50	-0.32	-0.06	-0.38	-14	-4	-17	-0.05
Educational services	-0.01	-0.01	-0.01	0.00	-0.01	0	0	0	0.00
Health services	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Arts and entertainment	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Hotels	-0.02	-0.01	-0.01	0.00	-0.01	0	0	0	0.00
Eating and drinking	-0.04	-0.02	-0.02	0.00	-0.02	-1	0	-1	0.00
Other services	-3.19	-1.69	-1.20	-0.24	-1.44	-50	-22	-72	-0.15
Government	-0.41	-0.39	-0.34	0.00	-0.34	-8	0	-8	-0.02
Total backward linkage impacts	-21.44	-12.30	-6.64	-0.67	-7.32	-200	-58	-258	-1.41

Table A.8: Forward-linkage Impacts of Longline Fishery Shutdown

Affected Sectors	Output (Million \$)	Value-added (Million \$)	Wage income (Million \$)	Proprietor's income (Million \$)	Total income (Million \$)	Wage jobs	Proprietor's jobs	Total jobs	State taxes (Million \$)
Small commercial boats	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Expense boats	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Recreation boats	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Charter boats	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Agriculture	0.00	0.00	0.00	0.00	0.00	0	0	0	0.00
Mining and construction	-0.02	-0.01	-0.01	0.00	-0.01	0	0	0	0.00
Food processing	-1.54	-0.50	-0.29	0.00	-0.29	-10	0	-10	-0.02
Other manufacturing	-0.02	0.00	0.00	0.00	0.00	0	0	0	0.00
Transportation	-0.09	-0.04	-0.02	0.00	-0.03	-1	0	-1	0.00
Information	-0.02	-0.01	0.00	0.00	-0.01	0	0	0	0.00
Utilities	-0.02	-0.01	0.00	0.00	0.00	0	0	0	0.00
Wholesale trade	-0.02	-0.01	-0.01	0.00	-0.01	0	0	0	0.00
Retail trade	-0.02	-0.02	-0.01	0.00	-0.01	0	0	0	0.00
Finance and insurance	-0.03	-0.02	-0.01	0.00	-0.01	0	0	0	0.00
Real estate and rentals	-0.05	-0.04	0.00	0.00	0.00	0	0	0	0.00
Professional services	-0.02	-0.01	-0.01	0.00	-0.01	0	0	0	0.00
Business services	-0.01	-0.01	0.00	0.00	-0.01	0	0	0	0.00
Educational services	-0.02	-0.01	-0.01	0.00	-0.01	0	0	0	0.00
Health services	-0.04	-0.03	-0.02	0.00	-0.02	-1	0	-1	0.00
Arts and entertainment	-0.02	-0.01	-0.01	0.00	-0.01	0	0	0	0.00
Hotels	-1.69	-1.06	-0.63	-0.02	-0.64	-20	0	-20	-0.15
Eating and drinking	-6.19	-3.23	-2.20	-0.12	-2.31	-133	-4	-137	-0.34
Other services	-0.02	-0.01	-0.01	0.00	-0.01	0	0	0	0.00
Government	-0.01	-0.01	-0.01	0.00	-0.01	0	0	0	0.00
Total Forward linkage impacts	-9.85	-5.05	-3.25	-0.15	-3.40	-167	-6	-173	-0.54