The Economic Impact of Rhode Island's Fisheries and Seafood Sector:

Technical Appendix

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December 13, 2018

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Data Collection

Data were collected from a variety of sources with the goal of generating a list of fisheries-related businesses to determine the size of the sector. Business listings were obtained from a survey, from the Commercial Fisheries Research Foundation (CFRF), and also from directory listings maintained by RI Department of Environmental Management (DEM). Further potential businesses were then pulled from a variety of sources including the RI Secretary of State (RISOS) business database and the marketing/business information database of AtoZ Databases (AZ) and Manta. These businesses were eliminated or added to our final list in consultation with CFRF, in an attempt to ensure that we only included businesses active in 2016, the year of our study (businesses closing before 2016 or opening after 2016 were explicitly excluded). In total, we identified 428 firms engaged with the fisheries and seafood sector within Rhode Island. Of note, these 428 firms include a count of 150 commercial fishing operations, a number that is much smaller than the count of 1,229 registered license holders. This discrepancy is treated in more detail below.

CFRF also assisted with categorizing the businesses into eight subsectors. The subsectors are: Commercial Fishing, Charters, Processors, Professional Services, Retail Dealers, Service and Supply, Tackle Shops and Wholesalers. The divisions between subsectors are fairly straightforward, with a few points bearing discussion:

1. *Commercial Fishing vs. Processors.* Because some commercial fishing operations are also engaged in processing and vice versa, we distinguish them according to their primary business. Namely, if the firm has both fishing and processing operations, but they primarily process fish that they caught themselves, then they are designated as commercial fishing. If instead they primarily process fish caught by others then they are designated as processors.
2. *Processors vs. Wholesalers.* Since processing operations can overlap with wholesalers, we use similar logic as above to differentiate them. Namely, if their wholesale sales are primarily composed of fish that they have processed, then the firm is designated as a processor. If instead they primarily sell fish processed by others, then they are a wholesaler.
3. *Charters.* We recognize that charters occupy a unique space in Rhode Island since they are regulated in many ways as if they are commercial fishing operations, but the standard for economic impact analysis is to treat them as part of the recreational fishing sector since they are not engaged in food production. We make a similar distinction between the Service and Supply vs. Tackle Shops below, with the former group primarily supplying commercial fishing operations and the latter group primarily supplying recreational (not food production) fishing activities.

4. *Tackle Shops vs. Service and Supply.* Tackle shops include primarily bait and tackle sellers, rod and reel dealers and producers of lures, all specializing in retail sales for recreational fishing. Service & supply, on the other hand, includes providers of bait and tackle for commercial fishing operations, as well as fishing boat maintenance, service, and fuel, and other supplies such as traps and rigging. The distinction here coincides almost perfectly with our distinction (for economic analysis) between commercial fishing and charters, as discussed above. While a number of tackle shops do supply commercial rod and reel operations, the *primary* business of these firms is to supply recreational fishers.

Economic data (revenues *aka 'gross sales"*, employees) were collected via an online survey distributed by CFRF and URI, and these survey data (9 observations outside of commercial fisheries, which had to be treated separately; 1 response did not contain revenue information) were supplemented by economic data available through atozdatabases.com and manta.com. In the aggregate we have revenue observations for 140 firms and employment observations for 143 firms.

Subsector Data Summary

Our dataset for the fisheries and seafood subsectors are described in Table 1 below. For each subsector we note the total number of firms, the number for which we have economic data, and the remaining number for which economic data need to be imputed. For commercial fishing, total landings data are pulled from the National Oceanic and Atmospheric Administration (NOAA), so no firms are imputed.

Table 1A. Raw Data for Fisheries Subsectors (Revenues)

Subsector	Firms w/ Economic Data	Firms w/out Economic Data	Total Firms
Commercial Fishing	150	0	150
Charters	15	60	75
Processors	8	3	11
Professional Services	11	7	18
Retail Dealers	14	12	26
Service & Supply	20	7	27
Tackle Shops	15	10	25
Wholesalers	57	39	96
Total	**290**	**138**	**428**

Table 1B. Raw Data for Fisheries Subsectors (Jobs)

Subsector	Firms w/ Economic Data	Firms w/out Economic Data	Total Firms
Commercial Fishing	150	0	150
Charters	14	61	75
Processors	9	2	11
Professional Services	11	7	18
Retail Dealers	14	12	26
Service & Supply	20	7	27
Tackle Shops	15	10	25
Wholesalers	60	36	96
Total	**293**	**135**	**428**

Estimation Procedure

To establish our final estimates, we imputed economic data for the firms without data available. We used log-linear regression models by subsector, following Sproul and Michaud (2018), who selected the log-linear model according to well-established information criteria (AIC, BIC) and other goodness of fit measures (R^2). Regression tables are shown below.

Table 2A. Ordinary Least Squares Regression – Log-Linear Model (Revenues)

```
                            OLS Regression Results
==============================================================================
Dep. Variable:          np.log(REVS)   R-squared:                       0.210
Model:                           OLS   Adj. R-squared:                  0.175
Method:                Least Squares   F-statistic:                     5.908
Date:               Wed, 12 Dec 2018   Prob (F-statistic):           1.72e-05
Time:                       08:21:12   Log-Likelihood:                -252.62
No. Observations:                140   AIC:                             519.2
Df Residuals:                    133   BIC:                             539.8
Df Model:                          6
Covariance Type:           nonrobust
============================================================================================
                              coef    std err          t      P>|t|      [0.025      0.975]
--------------------------------------------------------------------------------------------
Category1[CHARTER]         11.9012      0.389     30.556      0.000      11.131      12.672
Category1[PROC]            14.5123      0.533     27.210      0.000      13.457      15.567
Category1[PROF SERVICES]   12.3130      0.455     27.072      0.000      11.413      13.213
Category1[RETAIL]          12.7690      0.403     31.672      0.000      11.972      13.566
Category1[SVC & SUPPLY]    13.7925      0.337     40.890      0.000      13.125      14.460
Category1[TACKLE SHOPS]    12.7222      0.389     32.663      0.000      11.952      13.493
Category1[WHSL]            13.8137      0.200     69.136      0.000      13.418      14.209
==============================================================================
Omnibus:                       5.986   Durbin-Watson:                   2.082
Prob(Omnibus):                 0.050   Jarque-Bera (JB):                6.170
Skew:                          0.504   Prob(JB):                       0.0457
Kurtosis:                      2.792   Cond. No.                         2.67
==============================================================================
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The regression results show we have a reasonably accurate estimate of the conditional mean (of log revenues, log jobs) for each subsector. Of note, raising the log-linear regression prediction to a power of *e* results in an estimated median if business revenues (and jobs) are assumed to follow a lognormal distribution. In this manner, we introduced conservatism into our imputations, attempting to model all missing businesses as being from the peak of the distribution and thus reducing the influence of larger observations in the tail.

Table 2B. Ordinary Least Squares Regression – Log Linear Model (Jobs)

OLS Regression Results

Dep. Variable:	np.log(JOBS)	R-squared:	0.192
Model:	OLS	Adj. R-squared:	0.156
Method:	Least Squares	F-statistic:	5.390
Date:	Wed, 12 Dec 2018	Prob (F-statistic):	5.04e-05
Time:	08:21:12	Log-Likelihood:	-189.26
No. Observations:	143	AIC:	392.5
Df Residuals:	136	BIC:	413.3
Df Model:	6		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
Category1[CHARTER]	0.7014	0.249	2.816	0.006	0.209	1.194
Category1[PROC]	2.5333	0.311	8.154	0.000	1.919	3.148
Category1[PROF SERVICES]	0.9703	0.281	3.453	0.001	0.415	1.526
Category1[RETAIL]	1.4796	0.249	5.939	0.000	0.987	1.972
Category1[SVC & SUPPLY]	1.4898	0.208	7.148	0.000	1.078	1.902
Category1[TACKLE SHOPS]	0.6760	0.241	2.809	0.006	0.200	1.152
Category1[WHSL]	1.4509	0.120	12.058	0.000	1.213	1.689

Omnibus:	17.176	Durbin-Watson:	1.939
Prob(Omnibus):	0.000	Jarque-Bera (JB):	19.383
Skew:	0.853	Prob(JB):	6.18e-05
Kurtosis:	3.583	Cond. No.	2.58

It is important to note that we could not include estimates using regression analysis for commercial fishing because we were unable to avoid double counting of businesses due to substantial and unobservable overlap between the data available and the official license counts we obtained. Thus, for revenues we used the Value of X-Vessel Landings for 2016 from NOAA

/SAFIS (Standard Atlantic Fisheries Information System) of $88.39 million. Since jobs data were not available, we estimated jobs for commercial fishing using the IMPLAN jobs multiplier applied to the X-Vessel revenues estimates. Estimation details for all sectors are shown below.

Table 3A. Revenue Estimates for Marine Subsectors

Subsector	**Firms**	**Observed Revenues, $M**	**Imputed Revenues, $M**	**Total Revenues, $M**
Commercial Fishing	150	88.39	0.00	88.39
Charters	75	11.14	8.85	19.99
Processors	11	61.02	6.02	67.05
Professional Services	18	4.20	1.56	5.76
Retail Dealers	26	7.36	4.21	11.57
Service & Supply	27	77.77	6.84	84.61
Tackle Shops	25	11.36	3.35	14.71
Wholesalers	96	207.33	38.93	246.26
Total	**428**	**468.57**	**69.76**	**538.33**

Table 3B. Jobs Estimates for Marine Subsectors

Subsector	**Firms**	**Observed Jobs**	**Imputed Jobs**	**Total Jobs**
Commercial Fishing	150	1,711	0	1,711
Charters	75	59	123	182
Processors	11	190	25	215
Professional Services	18	55	18	73
Retail Dealers	26	84	53	136
Service & Supply	27	121	31	152
Tackle Shops	25	42	20	62
Wholesalers	96	463	154	617
Total	**428**	**2,724**	**424**	**3,147**

Confidence Intervals

In addition to estimating the revenues in the overall fisheries sector, it is also important to address the degree of certainty in our estimates. Namely, we estimate a 95% confidence interval, assuming that the total estimate comes from a normal distribution. There are two sources of uncertainty in our estimates, which we assume to be independent of one another (and therefore additive, in terms of variance). First, sampling uncertainty relates to the potential variation over which businesses appear in our data set, and thus which businesses are used to impute the remaining businesses for which economic data are unobserved. To address sampling uncertainty, we estimated the variance of our imputation procedure over 1,000 bootstrapped replications of our data (sampled with replacement). Imputed revenues across all subsectors were $73.94 million with a bootstrapped standard deviation of $14.65 million. Imputed jobs across all subsectors were 438 with a bootstrapped standard deviation of 59.

A second source of uncertainty in our estimates was measurement error. Since we received only limited surveys with revenue data, this discussion applies primarily to the data obtained from public sources. While we used multiple public sources, only 19 observations contained data from multiple sources, making it difficult to precisely estimate measurement error from the current data set. We therefore rely on the measurement errors calculated during our previous study for the Rhode Island composites sector.

Namely, the standard deviation of measurement errors on revenue is 27% of the true value, and 22% for jobs. These errors correspond to a standard deviation of $22.27 million for our measured total revenues of $380.2 million (excluding commercial fisheries), and a standard deviation of 35 jobs for our measured total jobs of 1,013 (also excluding commercial fisheries).

A confidence interval was calculated only for total revenues of the overall fisheries and seafood sector. As stated above, we assume measurement error to be an independent source of variation from sampling error, and therefore the variances add. We also assume that the effect of measurement error on our imputation process is sufficiently well captured by the bootstrapping procedure as to not require a further adjustment. Finally, for the commercial fishing data, we applied a proportional adjustment to scale the estimated standard deviation. Specifically, we estimated total revenues of $538.33 million including $88.39 million from commercial fishing, but our standard deviation of estimation error was only calculated on the underlying amount of $449.94 million (83.6% of the total). We thus divided our estimated standard deviations of estimation error by 83.6% for revenues. For jobs, since commercial fishing jobs were estimated at 1,711 using the IMPLAN jobs multiplier applied to NOAA X-Vessel landings value, the adjustment was larger: our underlying estimate was calculated on 1,436 jobs (only 45.6% of the total estimate). Thus, the jobs standard deviation was divided by 45.6%. As is well known, the 95% confidence interval of a normal distribution corresponds to 1.96 standard deviations on either side of the mean. Thus, we estimate total revenues for the fisheries and seafood sector of $538.33 million, +/- $62.50 million (11.6%), and 3,147 jobs, +/- 296 (9.4%).

Economic Impact Estimates

Economic impact estimates were generated using the industry-standard IMPLAN software. All effects are estimated for the 2016 calendar year. The IMPLAN codes used for each subsector category and economic impact estimates are listed below.

Table 4A. IMPLAN Codes by Subsector Category

Category	IMPLAN Code	IMPLAN Description
Commercial Fishing	17	Commercial fishing
Charters	496	Other amusement and recreation industries
Processors	93	Seafood product preparation and packaging
Professional Services	460	Marketing research and all other miscellaneous professional, scientific, and technical services
Retail Dealers	400	Retail - Food and beverage stores
Service & Supply	395	Wholesale trade
Tackle Shops	404	Retail - Sporting goods, hobby, musical instrument and book stores
Wholesalers	395	Wholesale trade

The only judgment call used here was to count the Service & Supply category as IMPLAN 395 Wholesale Trade. The category includes both wholesale suppliers, as well as various types of technical and maintenance services, so 395 Wholesale Trade was chosen for conservatism. The impact of this choice is to bias the estimates downward for Service & Supply, given the application of margin discounting to all output estimates (and corresponding jobs and value added estimates) in IMPLAN.

Table 4B. Economic Impact Estimates

Impact Type	Employment	Value Added, $M	Output, $M
Direct Effect	3,147	164.58	251.09
Indirect Effect	414	34.55	54.99
Induced Effect	819	69.45	113.24
Total Effect	**4,381**	**268.59**	**419.33**
(+/-)	**(508)**	**(31.16)**	**(48.64)**

Direct effect impacts are calculated net of interactions between firms in the subsectors in question. Indirect effects are downstream demand effects on suppliers to the firms in our study, and induced effects are further downstream effects in the economy arising from increased wages, proprietor income, etc. The top-line value of interest is the Output, with a $419.33 million total effect. The Output value represents the hypothetical economic cost to the state if all of these businesses were to disappear. The Value-Added column is also useful, as this number is most directly comparable to GSP (Gross State Product, the state-level version of GDP). The total jobs impact includes a direct effect of 3,147 jobs in the fisheries and seafood sector and 4,381 total jobs across the state arising from the economic activity in fisheries and seafood.

We generate confidence intervals for our IMPLAN results by adjusting them according to the largest (percentage-wise) confidence interval among revenues and jobs in our study. In this case the revenues estimate has the largest uncertainty (+/- 11.6%). Our IMPLAN confidence intervals of +/- $48.64 million of output, $31.16 million of value added and 508 jobs thus err on the side of conservatism, since they are the worst-case 95% intervals that would arise under perfect rank-correlation of estimation errors, and under an assumption of uncertainty in the revenues estimates carrying through fully into the employment impacts (as would have been the case if we estimated all jobs via multipliers on revenues).

Analysis of Multipliers

A careful reader of this report will note that we have estimated the effect of the entire fisheries and seafood sector on the Rhode Island economy, but we have not yet undertaken to isolate the effect of the commercial fishing subsector explicitly. Since effects (multipliers) arising from direct changes to commercial fishing may be of substantial policy importance, we undertake to estimate them here.

Prior to the present study, the most recent study evaluating the industry profile and economic impact of RI commercial fishing was conducted by Cornell University (Hasbrouck et al., 2011). The results are below.

Table 5: Table 3.1 of Hasbrouck et al. (2011, p.60):
Multiplier Effects Per Dollar of Ex-Vessel Revenue Landed in Rhode Island

Sector Impacted	Sales Multiplier	Jobs per $million	Jobs [corrected]
Harvesting	1.170	25.4	25.4
Primary Dealers/Processors	0.267	3.54	3.54
Secondary Wholesalers/Distributors	0.329	4.47	4.47
Restaurants	0.579	46.5	4.65
Grocers	0.145	2.29	2.29
Total	2.490	82.2	40.35

First, note the last column of the table showing that the reported jobs value for restaurants is apparently incorrect. It should be 4.65 jobs instead of 46.5,[1] changing the employment multiplier total to 40.35 jobs across Rhode Island per million dollars of X-Vessel commercial fishing revenues.

Second, there are two contravening effects that may cause these estimates to be inaccurate: these figures understate multiplier effects for the RI economy because they consider only impacts on specific sectors and not the rest of the RI economy. At the same time, the figures *overstate* multiplier effects for sales because they use *sales multipliers* instead of the more conservative *output multipliers*, which have more recently become standard practice (Jeong and Crompton, 2015). The effect of sales multipliers is to

[1] Note that this figure is intended to represent the amount of restaurant jobs generated by $1 million of X- Vessel revenues in RI commercial fishing. It is virtually unheard of for induced effects in another sector to be larger than the direct effect, so we would not expect only 25 jobs in commercial fishing itself but more than 40 in a downstream sector. In the original document, jobs values are presented per dollar instead of per million, so it's easy to see how there could be a typo with a large number of leading zeros.

overstate the output effects of retailers and wholesalers by 2 to 4 times, via double counting of pass-through sales.

In order to provide a more updated evaluation, we pulled estimated multipliers from the latest data (2016) in the IMPLAN input-output software (Scott and Olson, 2008). These multipliers are 1.62 for output, 1.35 for value added and 23.82 jobs per $million, but they contain clear problems that are likely related to data availability and to the nature of estimation within IMPLAN. With respect to IMPLAN, we mean that there is no modeling of "downstream" effects on businesses using inputs generated by commercial fishing. This observation is made more obvious by noting that 0.53 of the 1.62 multiplier value is attributed outside of the sectors tallied in Hasbrouck et al. (2011). The primary reason we take issue with these estimates is seafood processing would likely not exist without commercial fishing as a primary industry: the RI processing industry is located dockside and depends directly on the landings of RI commercial fishing operations. Similarly, based on conversations with people familiar with the industry, it is likely that 25-50% of wholesale seafood dealers' business is directly attributable to RI commercial fishing.

To generate more realistic estimates we modify the IMPLAN table in the following manner. Using estimates from the present study, we re-estimate multiplier effects on the total RI economy by adding direct effects of the full value of $67.05 million for processors and dealers, as well as 25%

of the value of wholesalers ($246.26 million becomes $61.57 million), to be conservative. Since we are also using the more conservative *output* multipliers, the wholesale revenue values are adjusted down to the value of margin, leaving only 18.3% of that figure, or $11.27 million. These figures are then scaled by the X-Vessel value of $88.39 million to get multipliers on a per $million basis. The multipliers represent total effects across the Rhode Island economy, including direct effects on commercial fishing, from a $1 million increase in X-Vessel value of landings. Our resulting estimates are:

Table 6: Adjusted IMPLAN 2016 Multipliers for X-Vessel Revenues

	Output Multiplier	**Value Added Multiplier**	**Jobs per $million**
Total RI Economy	3.06	1.98	32.43

To summarize the above analysis, we pulled updated 2016 data from IMPLAN which then required modification to reflect the on-the-ground reality in Rhode Island. The oft-cited numbers from the 2011 Cornell University study (2.49 sales multiplier, 40.35 jobs per million) turned out to be fairly close to ours. Unlike Cornell, we used a more conservative output multiplier, but we also included indirect and induced effects on the remainder of the Rhode Island economy. Based on experience, it is unlikely that sufficiently high quality data exist to statistically differentiate between the accuracies of the two sets of estimated multipliers.

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