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Northeast Trip Cost Data - Overview, Estimation, and Predictions

Chhandita Das

NOAA Fisheries, Northeast Fisheries Science Center/Integrated Statistics, 13 Church Street, Woods Hole, MA 02543

US DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
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Penny Pritzker, Secretary
National Oceanic and Atmospheric Administration
Kathryn Sullivan, Acting NOAA Administrator
National Marine Fisheries Service
Samuel D. Rauch III, Acting Assistant Administrator for Fisheries
Northeast Fisheries Science Center
Woods Hole, Massachusetts
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EXECUTIVE SUMMARY

Fisheries trip cost data are needed to accurately assess the economic impacts proposed management regulations. These data serve as input in a variety of analyses conducted by the Social Sciences Branch (SSB) at the Northeast Fisheries Science Center. Lack of these data would create constraints on the type of economic analysis that SSB economists can provide to fisheries decision-makers in the New England Fishery Management Council, the Mid-Atlantic Fishery Management Council, and National Marine Fisheries Service (NMFS), on behalf of the Secretary of Commerce, to help them make informed management decisions.

This document gives an overview of the latest eight years of trip cost data, from 2005-2012. It explains the data collection process, types of data collected, and data coverage and quality. Several summary statistics of the data by selected vessel and trip characteristics are also presented. A modeling framework for estimation and prediction of costs is also given. This process will allow estimation of vessel level aggregate trip cost, which in combination with a vessel's annual cost can give an overall fisheries cost assessment. This analysis is expected to improve the capacity of the SSB in conducting more comprehensive research and analysis.

1 INTRODUCTION

Economic data about the costs of operating commercial fishing businesses are used in many analyses required for frameworks and amendments related to fisheries management plans. Examples include regulatory flexibility analyses and economic impact assessments for proposed regulatory actions. These analyses are needed by the National Marine Fisheries Service (NMFS) to meet the legislative requirements of the Magnuson-Stevens Fishery Conservation and Management Act, the National Environmental Policy Act, Executive Order 12866, and the Regulatory Flexibility Act. Beyond that, these economic data also serve as input for other analyses, such as estimating economic profitability profiles, fleet efficiency, and productivity indices. The Social Sciences Branch (SSB) of the Northeast Fisheries Science Center is primarily responsible for conducting these analyses, which would be incomplete without an accurate understanding of the financial costs faced by commercial fishing businesses.

Commercial fishing vessels typically incur two major types of costs: annual costs and trip costs. Annual costs include all those costs which fishing vessel owners bear irrespective of whether they take a fishing trip or not. Trip costs are those costs which are typically incurred during a fishing trip. This document focuses on fishing vessels' trip related cost data. Section II discusses the data collection methodology; section III discusses the types of trip cost data collected and provides summary statistics of these data. An econometric modeling framework for estimation and predictions of trip costs is presented in section IV. Finally, section V concludes this discussion.

2 DATA COLLECTION METHODOLOGY

In the Northeast, the trip costs data are collected as a part of the Northeast Fishery Observer Program's (NEFOP) data collection effort. The Fisheries Sampling Branch oversees the NEFOP, which collects, processes, and manages the data obtained during commercial fishing trips. Biological and economic data are collected by trained personal (officially known as observers) for scientific and management purposes. The economic data are obtained either via personal observation or by interviewing the captain.

Although, the NEFOP has been collecting trip related cost data since 1989, this study focuses only on the past eight years, from 2005-2012. An overview of the observer program coverage during the study period is presented in the following section. This analysis helps us understand the types of vessels and trips typically covered by the NEFOP.

2.1 Coverage

The observer program coverage was assessed by evaluating annual changes in the percentages of total number of commercial trips and vessels observed each year. Vessel log reports were used to calculate the total number of trips taken during a year, and the observer data were used to calculate frequencies of observed trips. Based on the vessel log report, 908,172 commercial fishing trips took place during the study period, 2005-2012.[1] Table 1 shows overall number of vessels and trips and the number observed by year. The table shows that on average, 41% of the vessels and 3.60% of trips were observed each year. However, since the same vessels could be observed in multiple years, Table 2 shows the number of unique vessels that were observed during this study period. The data show that 1,999 unique vessels were observed during the study period. Out of these, 191 vessels were observed in all years from 2005- 2012, and 1,289 vessels were observed more than once but not every year. Only 519 vessels were observed in just a single year during this time period.

Next, the coverage was further explored by calculating the percentage of trips observed by vessel length, principal gear, and species for each trip. Principal gear and species for each trip were identified by the gear and species that accounted for the maximum share of the revenue for that trip. Principal variables for the universe of trips were calculated by using vessel logbook data and dealer data (for species prices). The principal variables for the observed trips were calculated by using the observer data.[2] The vessels' physical characteristics were calculated using permit data. These results are shown from Table 3 to Table 6.

2.1.1 Length Categories

Table 3 shows the frequencies and percentages of trips observed by vessel length categories. For this analysis, the vessels were grouped into three size categories, *Large*, *Medium, and Small.* Vessels longer than 80 ft were labeled as *Large* vessels between 40 ft to 80 ft were labeled as *Medium*, and vessels smaller than 40 ft were labeled as *Small*. *Unclassified* category included vessels that had missing information on length in the permit database.

Table 3 shows the majority of the trips were accounted for by the *Medium* size vessels, followed by the *Small* and *Large* vessels. However, the percentage coverage by the observer program was highest for the *Large* vessels. On average, the percentage of observed trips for the *Small* vessels were about 2%, for *Medium* vessels about 4%, and about 10% for the *Large* vessels. The coverage percentages steadily increased over the years for *Large* and *Medium* vessels, with the exception of a slight decline in the observed trips in 2006.

[1] Recreational trips were identified based on trip category values in the vessel trip records and were not included in this analysis.
[2] For calculating aggregate landing and revenue per trip, only valid landings were considered excluding the discarded landings, as noted in the observer data.

2.1.2 Principal Gear Groups

The observer coverage by principal gear groups is discussed in Table 4. Principal gear for each trip was identified by the gear with the maximum revenue share for that trip. Then these gears were mapped into eight different gear groups: *Dredge, Gillnet, Handgear, Longline, Midwater Pair Trawl, Midwater Trawl, Pot/Trap*, and *Trawl*. All principal gears not included in the eight groups mentioned earlier, were grouped under *Others* gear group. There were also several trips where nothing was caught that were labeled separately as *No Catch*. Table 4 shows the trip frequencies by principal gear group along with the numbers and percentages of trips observed for each gear group.

Table 4 shows that the majority of the trips primarily used *Gillnet, Pot/Trap,* or *Trawl* in every year from 2005-2012. However, the observer coverage for *Pot/Trap* remained close to 0% in all years. The percentage coverage for all other gear groups have increased over time with occasional fluctuations. Coverage for *Midwater Pair Trawl* and *Midwater Trawl* have substantially increased in recent years, amounting to over 40%. This is because of the increased effort by the NEFOP to observe the groundfish vessels which primarily use trawl gears.

2.1.3 Principal Species Groups

Principal species were determined by the maximum revenue share for each trip. These species were then mapped into fifteen groups. Species were grouped based on their common names, commercial importance, and common management rules. For example, the *Groundfish Large Mesh* group includes cod, flounder, haddock, white hake, halibut, pollock, redfish, and wolffish. *Groundfish Small Mesh* includes red hake, silver hake, and ocean pout. *Midatlantic Mixed Trawl* includes black sea bass, fluke, and scup. Trips with no catches were grouped under *No Catch* species group. The trip frequencies by the principal species groups are shown in Table 5 and Table 6, along with the number and percentage of trips observed for each group.

Tables 5 and 6 show that lobster was the principal species group for the majority of the trips, followed by either Mid-Atlantic Mixed trawl, ground fish-large mesh, or scallop in this eight year study period. The observer coverage for most species was below 10% until 2009. Since 2009, coverage of ground fish-large mesh, herring, monkfish, and skate has increased by a large percentage. Although, the majority of the trips in all 8 years had lobster as a principal species, its observed trips were less than 1%. There has been no coverage for red crab, surf clam ocean quahog (SCOQ), and tilefish trips since 2009.

The analysis shows the observer coverage varies largely within different vessel and trip types. Although, the overall coverage percentages for most of trip types are small, the absolute numbers of trips covered are often large because of the high number of total trips. Therefore, the numbers of observed trips are often sufficient for drawing inferences.[3]

3 DATA OVERVIEW

This section elaborates on the trip related costs. The methods for identifying and removing data anomalies are also discussed here. Finally, several summary statistics of the cost

[3] Dillman et al.'s (2009, page 57) formula about the sample size needed for population estimates of a given size is used as a guidance.

data are presented. The data analysis was conducted using only the latest 5 years' of data, i.e. 2008-2012. All cost values were converted to 2012 dollars for the rest of the analysis.[4]

The observer questionnaire contains eight different cost related questions. The observer requests this information from the captain while at sea. These questions are about expenses of bait purchased for the trip, damages or losses encountered during the trip, food purchased for crew and captain during the trip, lubricating oil, fresh water, and other commonly used supplies purchased for the trip. The captain is also asked to provide information on the amount of ice and fuel used, and the prices at which ice and fuel were purchased are also recorded. During the interview process, it is emphasized that the cost reporting should pertain to the associated trip only. If some costs are distributed over trips, the captain is requested to give his best estimate of the cost share of the trip in question.

3.1 Data Quality Assessment

Before analyzing these cost data, it was necessary to remove any anomalies that may exist in the data. Data anomalies were identified by plotting each individual cost item and aggregate cost values in a scatter diagram. Costs were also plotted against trip duration and vessel length. A cost was considered to be an outlier based on its distance from the mean values as well as its position with respect to the rest of the distribution and was subsequently removed from summary calculations. Also, several trips had positive total trip costs but had not provided any information on fuel cost (fuel usage) for those trips. These trips were also eliminated from the analysis as it is expected that a vessel will incur some fuel cost if it has left port for a fishing trip. Trips with very low cost values (less than $10) were also eliminated from the summary calculations. This process led to an elimination of 2% of the total observations.

3.2 Data Summary

Table 7 shows the summary statistics of the individual cost items along with their shares in total trip costs for the 5 year period under consideration. The ice cost and fuel cost were calculated by multiplying the usage of these items with their corresponding prices. Some trips had reported fuel (or ice) quantities but reported no corresponding prices; monthly mean prices for each year were used to calculate the total fuel (or ice) cost for these trips.

The average cost is highest for fuel, followed by food and damage. The data show that the average expenses of bait, water, supplies, and oil were less than $100. Moreover, bait, damages, supplies, and water, all have zero median costs, indicating 50% or more trips had no expenses for these items during the study period. An explanation for zero median bait cost is that many vessels do not use bait. Also, damage costs are only incurred when vessels suffer some damage during a trip, which is possibly not a regular occurrence. Crew members often bring their own supplies so these costs do not occur on every trip. Water is often included with docking fees, so separate charges for water are not often reported.

As expected, fuel costs account for the maximum share of total trip costs, averaging about 78%. The next highest share is for food costs followed by ice costs and damage costs.

[4] Producer Price Index for unprocessed finfish was used to make these conversions.

However, the mean shares of total costs for all items, except fuel, are below 10%. Water has the lowest share, which is less than 1.00%.[5]

Table 8 shows summary statistics of the total trip costs at different levels of aggregation. The table shows that the average trip cost for all observed trips is $4,013 with a standard deviation of $7,366. Out of all the trips considered for this analysis, 64% were single day trips (trip duration ≤ 24 hours), and 36% were multiday (trip duration >24 hours). The average total cost for single day trips is $335, which is about 3.00% of the average costs of the multiday trips ($10,468).

The summaries of total trip costs by vessel lengths are reported in Table 9. Average total trip cost for small vessels ($279) is lower than the same for medium ($2,750) and large vessels ($15,819). These cost differences could be a result of the trip characteristics of the small vessels. The majority of the trips by small vessels were single day trips (95%) and used gillnets (76%) which are typically associated with low average costs. On the other hand, the majority of the trips by large vessels was multiday trips (96%) and used either dredge or trawl (75%) which on average has a high cost. The graphical representation in Figure 1 shows a higher dispersion in costs for larger vessels compared to medium and smaller vessels as well as for multiday trips compared to day trips.

The aggregate cost summaries by gear groups are presented in Table 10. Average aggregate costs are highest for *Midwater Trawl*, *Midwater Pair Trawl,* and *Dredge* gear groups and lowest for *Gillnet*, *Handgear,* and *Longline*. A similar pattern is observed for the multiday trips. For single day trips, *Midwater Trawl* gear group is associated with large average costs compared to the other gears. A graphical representation of the total cost distributions by gear groups are shown in Figure 2.

4 ESTIMATION AND PREDICTION

Generally, the total number of trips taken by all active commercial vessels in the Northeast is about 100,000 in a year. Since the observer program only covers a fraction of these trips, trip cost measures are not available for all these trips. However, analysts often need cost estimates for trips that were unobserved. The purpose of this analysis is to build sound and robust econometric models which can predict costs for all such trips. This section discusses the modeling framework for estimation and prediction of trip costs.

4.1 Estimation - the Modeling Framework

Typically, an ordinary least square method (OLS) is used to estimate fisheries cost. The challenge in using OLS with cost data is that it often leads to negative cost predictions. Therefore researchers often use OLS with the log of the dependent variable, and predict cost via exponentiating the predicted cost values in log scales. However, this retransformation, though often used, causes bias (Manning 1998; Jia and Rathi 2008; Manning and Mullahy 2001). The bias is worse if there is heteroscedasticity in the log-transformed model. To correctly predict when using the log-transformed linear model estimation, analysts have to apply proper adjustments with anti-log-transformation. However, this adjustment process for unbiasedness involves calculating a smearing factor which requires several steps, making the process very

[5] Total costs with missing and zero values were not included in these summary statistics calculation.

labor intensive. Consequently, an alternative method which has gained popularity among researchers while dealing with cost data is the generalized linear model (GLM).

The GLM can be viewed as a differentially weighted, non-linear, least-square estimation. The advantages in using GLM are that no adjustment is needed for anti-log transformation and GLM does not assume constant variance. GLM is also a preferred method for analyzing skewed data as often encountered while analyzing cost or expense data. These data are typically characterized by (a) nonnegative measurements of the outcomes and (b) a positively skewed empirical distribution of the nonzero realizations (Manning and Mullahy 2001; Moran et al. 2007). Several examples of GLM application can be found in health economics for analyzing health expense data (Knerer et al. 2005; Wu et al. 2007; Moran et al. 2007). Since trip cost data are similarly skewed, they were modeled using GLM. The skewness of the cost distributions is evident in Figure 3. The estimation was carried out by assuming a gamma distribution for the response variable and a log-link function.[6]

Independent variables that could potentially impact a vessel's trip costs were defined based on permit data, vessel log book, and dealer data and are described in Tables 11 and 12.[7] To account for the year specific impacts, dummy variables for the individual years included in the estimation data set were used. The tables show that vessels included in estimation data on average were 25 years old and 57 ft long, had horse power of 499, weighed about 69 tons, took 84 trips on average per year, and earned an annual gross revenue of $555,000. In addition, the trips included in the estimation set on average, 52 hours long, had a landed weight of 27,000 lb, earned a gross revenue of $40,000, hired 4 crew members, and paid an average price of $3.19 per gallon for fuel. Table 12 shows that the majority of the trips were single-day trips (62%), used either trawl or gillnet gears as their primary gears (84%), and primarily landed their catches in the New England Region (80%).

4.1.1 Estimates

The GLM estimates are presented in Table 13. The final model was selected based on log-likelihood value, mean absolute error (MAE), and root mean square error value (RMSE). A better fit is associated with high log-likelihood value and low MAE and RMSE values. For estimation, 19,805 trips were used, which are about 93% of the total valid observed trips. All variables included in the final model are significant. The estimates indicate that trip costs are higher for larger boats with higher gross tons per feet. As expected, trip cost is highly positively correlated with fuel price and trip duration. Consistent with the data summaries, a positive coefficient for multiday trip indicator implies trips lasting longer than a day cost significantly more than trips lasting 24 hours or less.

The total number of trips per vessel is used as a predictor to capture the activity factor of the vessels. The negative coefficient for this variable indicates vessels taking a large number of trips have lower trip costs. This might be because vessels often distribute their costs over trips. Therefore, vessels taking large number of trips might be able to reduce their per trip costs by economizing on their expenses by, for example, buying in bulk. Total trip revenue has a negative

[6] Other distributions (Inverse Gaussian and Normal) were considered, but Gamma was chosen based on log-likelihood value, AIC and BIC. Also, gamma distribution is frequently used in cost analysis with GLM (Moran et al. 2007; Knerer et al. 2005).

[7] Observations with illogical values for the possible independent variables (e.g. tripdur < 0) were deleted from the estimation data.

impact on trip cost, implying trips with high revenues have lower trip costs. Although this result may seem counter intuitive, it could be a result of a combination of factors. For example, trips could cost less because of shorter duration and low cost gear usage but might be associated with higher revenues because of concentrating on higher valued species. *Gillnet* gear dummy has a significant negative coefficient implying lower costs for trips primarily using gillnet gear than other types of gears. This result is consistent with the data summary results. Estimates also reveal that trip costs were significantly higher in year 2008 compared to the other years considered for the model estimation.[8]

4.2 Prediction

This section discusses predictions for all the trips (observed and unobserved) taken during this 5-year period. The independent variables for the predictions data set are described in Tables 14 and 15. The tables show that the vessels included in the prediction data set were on average 24 years old and 48 feet long, had horse power of 407, weighed 42 tons, took about 94 trips per year, and earned a revenue of about $313,000. The trips in the prediction data set on average were 26 hours long, hired 2 crews, paid on average $3.10 per gallon for fuel, and earned a revenue of $8,000 with a landing weight of 6,000 lb. Table 15 shows that the trips in the prediction data set were largely single day trips (82%). The data show that 43% trips used primarily trawl or gillnet, and about 68% trips landed their catch in the New England region.

Cost predictions were generated by using the estimates from Table 13, and summaries of these predicted costs are presented in Table 16. For comparison purposes, this table also displays the known cost summaries for the trips in the estimation set. All dollar values are in 2012 dollars for the prediction analyses as well. Similar to the estimation data set, the prediction data excludes trips which had illogical values for some independent variables (E.g., negative age calculation and extreme values for some independent variables). For summary calculations, extreme cost predictions were removed, which were identified via plotting the predicted cost values for all trips and also against vessel length.

The table shows that the average predicted cost is $1,798 with a standard deviation of $6,123 for all trips in the prediction set. The low predicted average cost can be explained by the fact that the percentage of single day trips in the prediction data set (82%) was higher than the estimation data set (62%), whose average cost is substantially lower than the multiday trips. The predicted average cost for single day trips is $375 which is comparable to the same for the observed average cost ($335). The same results hold for the predicted costs for the multiday trips as well.

Predicted cost summaries by vessel length categories and trip duration are reported in Table 17. As noted for the observed trips, the predicted costs were highest for large vessels and lowest for the small vessels. The predicted costs for single and multiday trips display a similar trend as the observed costs. In comparison to the observed costs, considering all trips, the average predicted costs are slightly lower for the medium vessels, and slightly higher for the large and small vessels. The highest dispersion in the predicted costs is noted for the large vessels on multiday trips (Figure 4).

Cost predictions by gear groups are presented in Table 18. The highest predicted costs are reported for *Midwater Trawl* and *Midwater Pair Trawl*, and the lowest predicted costs are

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[8] Four dummies to represent each year from 2008 to 2011 were considered but only the significant dummy variables were included in the final model.

estimated for *Gillnet* and *Handgear*. These results are consistent with the observed costs. The high divergence between the observed and predicted average costs, as recorded for *Dredge* and *Pot/Trap*, could result from a different composition of trip types in the prediction data set compared to the estimation data set.

5 CONCLUDING REMARKS

This document explains the Northeast Fisheries Science Center's effort to collect trip cost data as a part of the Northeast Observer Data Collection Program (NEFOP). A comprehensive analysis is presented here that considers the most recent eight years (2005- 2012) of data. Frequencies of trips taken and percentages of those observed by the NEFOP are presented by vessel and trip characteristics. The data collection method and the types of cost data collected are also discussed. Several summary statistics and graphical representations are given by vessel and trip characteristics. The data were reviewed for possible outliers before conducting this analysis. A modeling approach is also discussed to enable cost predictions for trips that were not observed by the NEFOP. Summaries of predicted costs based on model-coefficients are presented in comparison to observed costs. The predicted costs are consistent with the observed costs in most cases. The inconsistencies mostly resulted from the different composition of trips in the prediction data set compared to the observed trips data.

Although this document attempts to give an overview of vessels' trip costs, it does not include all possible costs that a vessel may accrue during a trip. However, a reasonable estimate of trip costs can be obtained from this analysis. The trip related costs along with the vessels' annual costs can be combined to give an overall assessment of vessels' fishing business costs. An estimate of net revenues then can be obtained by subtracting these cost values from the gross revenue figures. This cost information will improve the capability of the Social Sciences Branch to produce analyses that require cost or revenue data such as the estimation of profitability profiles and evaluation of the economic impacts of quota changes on Groundfish sectors.

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Table 1. Number of trips and vessels observed 2005-2012.

	2005	2006	2007	2008	2009	2010	2011	2012
Observed Trips	4,478	2,393	2,861	2,927	3,212	4,996	5,576	5,043
Total Trips	132,585	133,971	126,449	109,007	107,664	104,370	98,755	95,371
Percentage	3.38	1.79	2.26	2.69	2.98	4.79	5.65	5.29
Observed Vessels	1,041	928	1,018	1,063	991	900	830	839
Total Active Vessels	2,865	2,801	2,700	2,286	2,159	2,183	2,026	1,980
Percentage	36.34	33.13	37.70	46.50	45.90	41.23	40.97	42.37

Table 2. Frequency of unique number of vessels observed.

# of years observed	Frequency	Percentage
All eight years	191	9.55
More than one year	1289	64.48
Only one year	519	25.96

Table 3. Frequency and percentage of trips observed by length categories and by year.

	2005			2006			2007			2008		
Length Categories	**Total Trips**	**Obs Trips**	**Obs %**	**Total Trips**	**Obs Trips**	**Obs %**	**Total Trips**	**Obs Trips**	**Obs %**	**Total Trips**	**Obs Trips**	**Obs %**
Large	6,287	578	9.19	6,495	290	4.46	6,227	346	5.56	5,474	529	9.66
Medium	74,514	2,897	3.89	75,102	1,475	1.96	69,794	1,773	2.54	65,767	1,804	2.74
Small	42,507	725	1.71	41,721	402	0.96	39,003	448	1.15	36,906	334	0.91
Unclassified	9,277	278	3.00	10,653	226	2.12	11,425	294	2.57	860	260	30.23
All	132,585	4,478	3.38	133,971	2,393	1.79	126,449	2,861	2.26	109,007	2,927	2.69

	2009			2010			2011			2012		
Length Categories	**Total Trips**	**Obs Trips**	**Obs %**	**Total Trips**	**Obs Trips**	**Obs %**	**Total Trips**	**Obs Trips**	**Obs %**	**Total Trips**	**Obs Trips**	**Obs %**
Large	5,134	533	10.38	5,127	578	11.27	5,183	669	12.91	5,077	623	12.27
Medium	64,028	2,057	3.21	59,971	3,248	5.42	58,583	3,842	6.56	57,380	3,541	6.17
Small	37,744	409	1.08	38,520	967	2.51	34,200	978	2.86	31,958	794	2.48
Unclassified	758	213	28.10	752	203	26.99	789	87	11.03	956	85	8.89
All	107,664	3,212	2.98	104,370	4,996	4.79	98,755	5,576	5.65	95,371	5,043	5.29

Table 4. Frequency and percentage of trips observed by principal gear groups and by year.

	2005			2006			2007			2008		
Gear Groups	Total Trips	Obs Trips	Obs %	Total Trips	Obs Trips	Obs %	Total Trips	Obs Trips	Obs %	Total Trips	Obs Trips	Obs %
Dredge	20,759	368	1.77	23,197	243	1.05	19,664	362	1.84	15,199	647	4.26
Gillnet	16,897	1,545	9.14	16,800	1,007	5.99	18,620	1,184	6.36	18,582	900	4.84
Handgear	8,299	0	0	8,908	1	0.01	8,899	1	0.01	5,584	1	0.02
Longline	1,652	292	17.68	1,491	99	6.64	1,402	84	5.99	1,254	76	6.06
Midwater Pair Trawl	690	110	15.94	676	28	4.14	321	15	4.67	335	49	14.63
Midwater Trawl	350	44	12.57	275	18	6.55	195	10	5.13	50	16	32.00
Pot/Trap	43,443	12	0.03	45,466	4	0.01	42,576	14	0.03	36,529	23	0.06
Trawl	37,759	2,025	5.36	33,846	980	2.90	31,336	1,137	3.63	29,868	1,137	3.81
Other	1,955	67	3.43	2,371	8	0.34	2,499	29	1.16	772	54	6.99
No Catch	781	15	1.92	941	5	0.53	937	25	2.67	834	24	2.88
All	132,585	4,478	3.38	133,971	2,393	1.79	126,449	2,861	2.26	109,007	2,927	2.69
	2009			2010			2011			2012		
Gear Groups	Total Trips	Obs Trips	Obs %	Total Trips	Obs Trips	Obs %	Total Trips	Obs Trips	Obs %	Total Trips	Obs Trips	Obs %
Dredge	13,573	489	3.60	10,748	338	3.14	11,375	390	3.43	10,879	422	3.88
Gillnet	19,518	877	4.49	16,812	2,257	13.42	17,457	2,374	13.6	15,874	1,987	12.52
Handgear	6,216	2	0.03	7,076	28	0.40	6,326	42	0.66	6,120	15	0.25
Longline	1,365	88	6.45	1,176	184	15.65	1,105	115	10.41	1,624	218	13.42
Midwater Pair Trawl	394	104	26.40	299	129	43.14	296	126	42.57	282	150	53.19
Midwater Trawl	72	16	22.22	72	33	45.83	62	28	45.16	143	32	22.38
Pot/Trap	36,614	12	0.03	39,806	3	0.01	35,251	0	0	34,355	15	0.04
Trawl	28,392	1,538	5.42	26,614	1,964	7.38	24,635	2,394	9.72	22,985	2,143	9.32
Other	634	61	9.62	815	38	4.66	917	86	9.38	1,102	47	4.26
No Catch	886	25	2.82	952	22	2.31	1,331	21	1.58	2,007	14	0.70
All	107,664	3,212	2.98	104,370	4,996	4.79	98,755	5,576	5.65	95,371	5,043	5.29

Table 5. Frequency and percentage of trips observed by principal species groups and by year, continued.

	2005			2006			2007			2008		
Species Groups	Total Trips	Obs Trips	Obs %	Total Trips	Obs Trips	Obs %	Total Trips	Obs Trips	Obs %	Total Trips	Obs Trips	Obs %
Dogfish	539	29	5.38	629	43	6.84	914	71	7.77	1,002	76	7.58
Groundfish Large Mesh	16,844	1,778	10.56	16,642	743	4.46	18,224	887	4.87	19,593	978	4.99
Midatlantic Mixed Trawl	18,990	451	2.37	17,319	178	1.03	16,690	293	1.76	10,066	208	2.07
Groundfish Small Mesh	892	33	3.70	777	20	2.57	1,388	37	2.67	1,311	15	1.14
Herring	1,103	187	16.95	1,070	38	3.55	1,084	39	3.60	629	81	12.88
Lobster	38,062	76	0.20	39,325	35	0.09	36,350	18	0.05	32,654	32	0.10
Mackerel	333	8	2.40	333	13	3.90	292	7	2.40	160	11	6.88
Monkfish	7,395	634	8.57	5,871	338	5.76	5,428	303	5.58	4,924	243	4.94
Red Crab	63	0	0	64	0	0	52	2	3.85	54	3	5.56
Scallop	26,250	577	2.20	26,344	316	1.20	20,558	417	2.03	17,256	698	4.04
Surf Clam/Ocean Quahog (SCOQ)	206	35	16.99	226	14	6.19	210	4	1.90	234	8	3.42
Skate	1,364	104	7.62	1,670	71	4.25	1,993	165	8.28	2,072	106	5.12
Squid	2,509	78	3.11	3,716	102	2.74	2,915	57	1.96	3,437	59	1.72
Tilefish	103	4	3.88	116	6	5.17	130	2	1.54	129	1	0.78
Other	17,151	469	2.73	18,928	471	2.49	19,284	534	2.77	14,654	384	2.62
No Catch	781	15	1.92	941	5	0.53	937	25	2.67	832	24	2.88
All	132,585	4,478	3.38	133,971	2,393	1.79	126,449	2,861	2.26	109,007	2,927	2.69

Table 6. Frequency and percentage of trips observed by principal species groups and by year.

	2009			2010			2011			2012		
Species Groups	Total Trips	Obs Trips	Obs %	Total Trips	Obs Trips	Obs %	Total Trips	Obs Trips	Obs %	Total Trips	Obs Trips	Obs %
Dogfish	2,190	116	5.30	2,843	273	9.60	4,105	245	5.97	4,617	378	8.19
Groundfish Large Mesh	19,778	1,174	5.94	12,974	2,210	17.03	10,061	2,841	28.24	10,012	2,517	25.14
Midatlantic Mixed Trawl	10,755	302	2.81	13,272	439	3.31	12,393	316	2.55	11,477	260	2.27
Groundfish Small Mesh	1,605	82	5.11	1,571	93	5.92	1,436	62	4.32	1,520	54	3.55
Herring	731	155	21.20	888	180	20.27	871	237	27.21	981	216	22.02
Lobster	32,913	21	0.06	34,824	55	0.16	30,191	35	0.12	29,610	50	0.17
Mackerel	216	14	6.48	132	8	6.06	115	2	1.74	128	7	5.47
Monkfish	3,972	184	4.63	3,628	350	9.65	4,085	480	11.75	4,039	404	10.00
Red Crab	41	0	0	55	0	0	55	0	0	42	0	0
Scallop	15,735	512	3.25	10,701	383	3.58	11,920	416	3.49	11,209	486	4.34
Surf Clam/Ocean Quahog (SCOQ)	194	0	0	290	0	0	256	0	0	126	0	0
Skate	2,149	102	4.75	2,858	474	16.59	3,073	487	15.85	2,441	317	12.99
Squid	2,911	156	5.36	2,999	175	5.84	3,118	232	7.44	3,519	111	3.15
Tilefish	139	0	0	120	0	0	99	0	0	128	0	0
Other	13,458	369	2.74	16,263	334	2.05	15,646	202	1.29	13,515	229	1.69
No Catch	877	25	2.85	952	22	2.31	1,331	21	1.58	2,007	14	0.70
All	107,664	3,212	2.98	104,370	4,996	4.79	98,755	5,576	5.65	95,371	5,043	5.29

Table 7. Summary statistics of individual cost items over the analysis period (2008-2012).

Cost Items	N	Mean	Median	Std Dev	Max	Mean Share
Bait cost	21,021	16	0	155	3,600	1.51
Damage cost	20,660	229	0	1,662	50,000	4.48
Food cost	21,058	258	23	499	4,000	6.44
Fuel cost	21,311	3,188	301	6,001	68,940	78.17
Ice cost	21,069	207	14	438	4,185	5.13
Oil cost	17,882	70	9	187	3,600	2.41
Supply cost	20,175	66	0	267	7,080	2.58
Water cost	20,848	6	0	23	600	0.11

Table 8. Summary statistics of total costs at different levels of aggregations.

Aggregate Costs	N	Mean	Std Dev	Max
Total Trip Cost	21,311	4,013	7,366	76,725
Single Day Trip Cost	13,576	335	442	8,200
Multiday Trip Cost	7,735	10,468	9,151	76,725

Table 9. Summary Statistics of total cost by trip duration types and by length categories.

Length Categories	All Trips				Single Day Trips				Multiday Trips			
	N	Mean	Std Dev	Max	N	Mean	Std Dev	Max	N	Mean	Std Dev	Max
Large	2,852	15,819	9,571	75,180	114	2,332	1,695	8,200	2,738	16,380	9,350	75,180
Medium	14,272	2,750	5,391	76,725	9,455	358	371	7,781	4,817	7,446	7,249	76,725
Small	3,417	279	429	6,305	3,246	235	310	6,305	171	1,114	1,065	5,422

Table 10. Summary statistics of total cost of different trip types by gear categories.

Gear Groups	All Trips				Single Day Trips				Multiday Trips			
	N	Mean	Std Dev	Max	N	Mean	Std Dev	Max	N	Mean	Std Dev	Max
Dredge	2,223	12,011	10,946	64,884	376	583	567	7,781	1,847	14,337	10,590	64,884
Gillnet	8,262	338	596	12,557	7,524	230	272	6,305	738	1,442	1,374	12,557
Handgear	87	337	1,365	12,838	82	177	143	872	5	2,975	5,514	12,838
Longline	663	790	1,099	10,008	542	421	536	4,334	121	2,442	1,416	10,008
Midwatwer Pair Trawl	544	11,382	7,475	56,455	35	3,373	1,230	8,200	509	11,933	7,409	56,455
Midwater Trawl	123	16,578	10,398	51,448	10	2,368	2,516	6,608	113	17,835	9,881	51,448
Pot/Trap	44	3,936	5,017	25,543	19	571	458	2,074	25	6,494	5,401	25,543
Trawl	8,999	5,117	7,554	76,725	4,756	407	379	6,524	4,243	10,396	8,253	76,725
Others	271	2,440	2,977	19,116	175	1,385	1,273	6,606	96	4,364	4,053	19,116
No Catch	95	3,826	5,839	28,551	57	568	861	4,148	38	8,714	6,679	28,551

Table 11. Summary statistics of the continuous variables considered in model estimation.

Variable	Variable Definition	N	N missing	Mean	Std Dev	Minimum	Maximum
Vessel level variables							
age	Vessel's age	20407	0	25	11	0	117
vhp	Vessel Horse Power	20407	0	499	400	110	5020
hold	Hold capacity of the vessel (in lbs)	18945	1462	93345	133652	0	1000000
len	Vessel length in feet	20407	0	57	21	25	150
gtons	Gross tons	20407	0	69	67	2	476
vhplen	Vessel horse power per feet	20407	0	8	4	3	63
tonpft	Vessel gross tons per feet	20407	0	1	1	0	5
vessrev_ths	Vessel revenue (in $1000)	20332	75	555	612	0	5296
trip_freq	Number of trips	19885	522	87	58	1	279
Trip level variables							
crew	Numbe of crew per trip	13150	7257	4	2	1	14
tripdur	Trip duraion in hours (dateland-datesail)	20407	0	52	73	1	431
fuelpr	Average monthly fuel price by year	20407	0	3	1	1	6
trprev_ths	Trip Revenue(in $1000)	20323	84	40	170	0	3352
trplb_ths	Trip catch volume (in 1000 lbs)	20136	271	27	105	0	2560

Table 12. Frequency distribution of the discrete variables considered in model estimation.

Variable	Variable Definition	Frequency	Percentage
Trip Landing Region			
MA	Mid-Atlantic	3970	19.45
NE	New-England	16240	79.58
NA	Not Available	197	0.97
Trip Duration Types			
Single Day	Trip duration 24 hours or less	12698	62.22
Multiday	Trip duration over 24 hours	7709	37.78
Trip's Principal Gear Groups			
Dredge		2218	10.87
Gillnet		7585	37.17
Handgear		87	0.43
Longline		643	3.15
Pot/Trap		42	0.21
Trawl		9527	46.69
Others/No-catch		305	1.30

Table 13. Generalized Linear Model (GLM) parameter estimates using all observed trips.

Parameter	Estimate	Standard Error	95% Confidence Limits		Z	$Pr > \|Z\|$
Intercept	4.2102	0.12	3.98	4.44	36.07	$< .0001$
length	0.0188	0.00	0.02	0.02	17.18	$< .0001$
log_fuelpr	0.7261	0.05	0.62	0.83	13.99	$< .0001$
gillnet	-0.3843	0.06	-0.49	-0.27	-6.84	$< .0001$
trip_freq	-0.0023	0.00	0.00	0.00	-5.42	$< .0001$
tripdur	0.0083	0.00	0.01	0.01	42.54	$< .0001$
tonpft	0.361	0.03	0.30	0.42	11.21	$< .0001$
trprev_ths	-0.0002	0.00	0.00	0.00	-10.13	$< .0001$
multdaytp	0.9089	0.04	0.84	0.98	25.58	$< .0001$
yr08	0.0746	0.03	0.01	0.14	2.19	0.0282

Number of observations: 19,805; Quasi-likelihood: 338,155.96;
Mean Absolute Error: 1390; Root Mean Square Error: 4236.69

Table 14. Summary statistics of the continuous variables considered in the prediction data.

Variable	Variable Definition	N	N missing	Mean	Std Dev	Minimum	Maximum
Vessel Level Variables							
age	Vessel's age	502212	7	24	11	0	86
vhp	Vessel horse power	502219	0	407	241	25	5020
hold	Hold capacity of the vessel (in lbs)	434172	68047	44650	81651	0	1000000
len	Vessel length in feet	502219	0	48	17	16	159
gtons	Gross tons	502219	0	42	46	2	496
vhplen	Vessel horse power per feet	502219	0	9	4	1	63
tonpft	Vessel gross tons per feet	502219	0	1	1	0	5
vessrev_ths	Vessel revenue (in $1000)	501985	234	313	413	0	5270
trip_freq	Number of trips	502100	119	94	50	1	402
Trip level variables							
crew	Number of crew per trip	501275	944	2	1	0	15
tripdur	Trip duration in hours (dateland-datesail)	502219	0	26	49	0	1027
fuelpr	Average monthly fuel price by year	502219	0	3	1	2	4
trprev_ths	Trip revenue(in $1000)	496366	5853	8	30	0	749
trplb_ths	Trip catch volume (in 1000 lbs)	496460	5759	6	38	0	1756

Table 15. Frequency distribution of the discrete variables in prediction data.

Variable	Variable Definition	Frequency	Percentage
Trip Landing Region			
MA	Mid-Atlantic	159238	31.71
NE	New-England	342134	68.12
NA	Not Available	847	0.17
Trip Duration Types			
Single Day	Trip duration 24 hours or less	414225	82.48
Multiday	Trip duration over 24 hours	87994	17.52
Trip's Principal Gear Groups			
Dredge		60836	12.11
Gillnet		85630	17.05
Handgear		28493	5.67
Longline		6137	1.22
Pot/Trap		178402	35.52
Trawl		132732	26.43
Others/No-catch		9989	1.99

Table 16. Total trips costs observed and predicted.

Cost Types	N	Mean	Std Dev
Total Trip Costs			
Observed	21,311	4,013	7,366
Predicted	496,173	1,798	6,123
Single Day Trip Costs			
Observed	13,576	335	442
Predicted	409,213	375	221
Multi Day Trip Costs			
Observed	7,735	10,468	9,151
Predicted	86,960	8,492	12,623

Table 17. Observed and predicted cost summaries by trip duration types and vessel length categories.

Length Category	Observed Costs			Predicted Costs		
	N	Mean	Std Dev	N	Mean	Std Dev
	All trips			***All trips***		
Large	2,852	15,819	9,571	25,035	16,083	18,473
Medium	14,272	2,750	5,391	300,423	1,462	3,881
Small	3,417	279	429	170,715	293	161
	Single day trips			**Single day trips**		
Large	114	2,332	1,695	3,242	1,447	588
Medium	9,455	358	371	239,019	428	223
Small	3,246	235	310	166,952	278	75
	Multi day trips			***Multi day trips***		
Large	2,738	16,380	9,350	21,793	18,260	18,851
Medium	4,817	7,446	7,249	61,404	5,486	7,290
Small	171	1,114	1,065	3,763	975	671

Table 18. Summary statistics of observed and predicted costs by principal gear types.

Gear Categories	Observed Costs			Predicted Costs		
	N	Mean	Std Dev	N	Mean	Std Dev
Dredge	2,223	12,011	10,946	60,730	6,183	12,600
Gillnet	8,262	338	596	85,630	307	470
Handgear	87	337	1,365	28,492	320	451 5
Longline	663	790	1,099	6,137	2,107	7,675
Midwater Pair Trawl	544	11,382	7,475	1,605	10,863	8,221
Midwater Trawl	123	16,578	10,398	398	13,422	14,275
Pot/Trap	44	3,936	5,017	178,392	696	2,847
Trawl	8,999	5,117	7,554	130,633	2,413	6,209
Others	271	2,440	2,977	4,145	1,421	2,680
No Catch	95	3,826	5,839	11	865	1,456

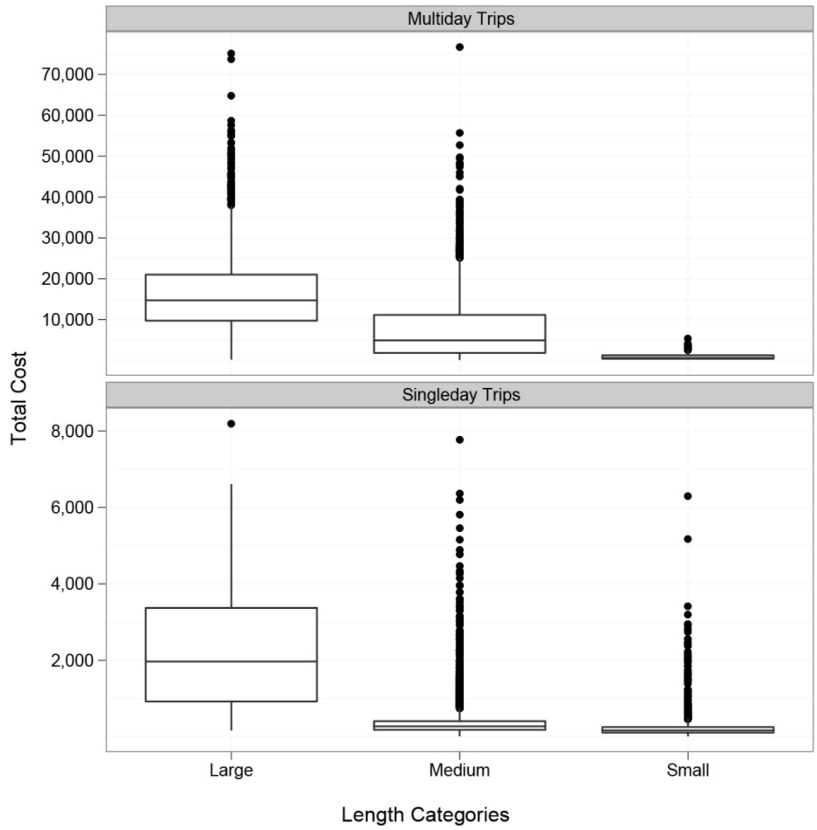

Figure 1. Total cost distributions by trip duration types and vessel length categories.

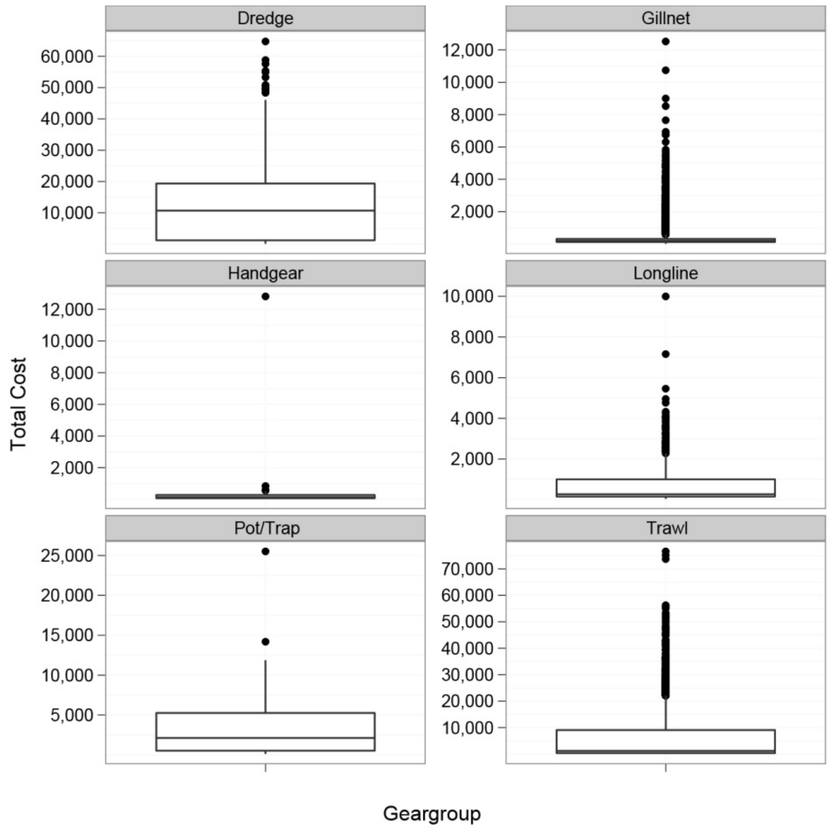

Figure 2. Total cost distributions by vessels' principal gear groups.

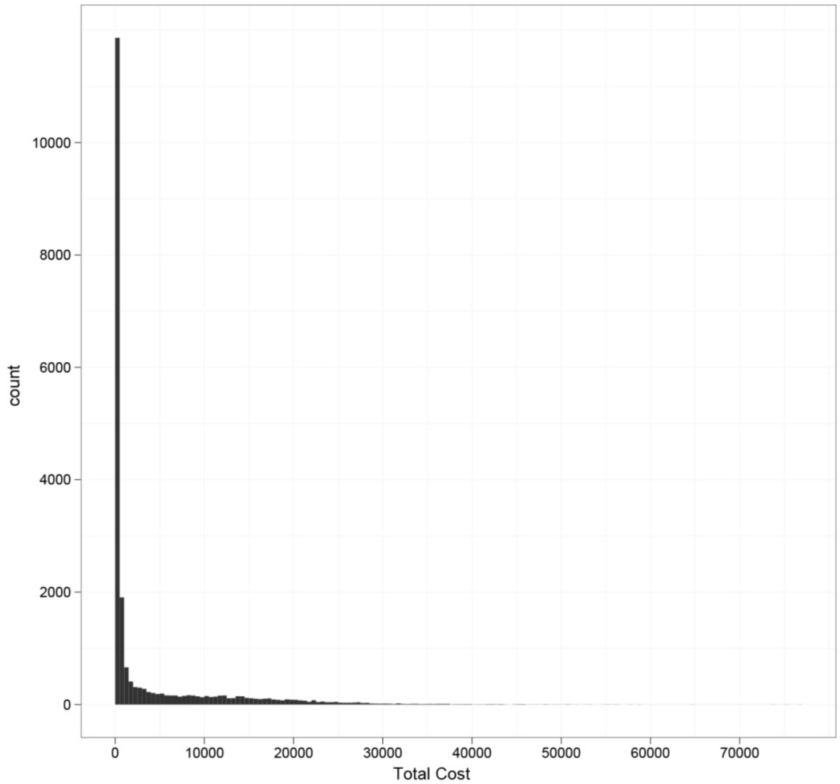

Figure 3. Histogram of the total cost distribution.

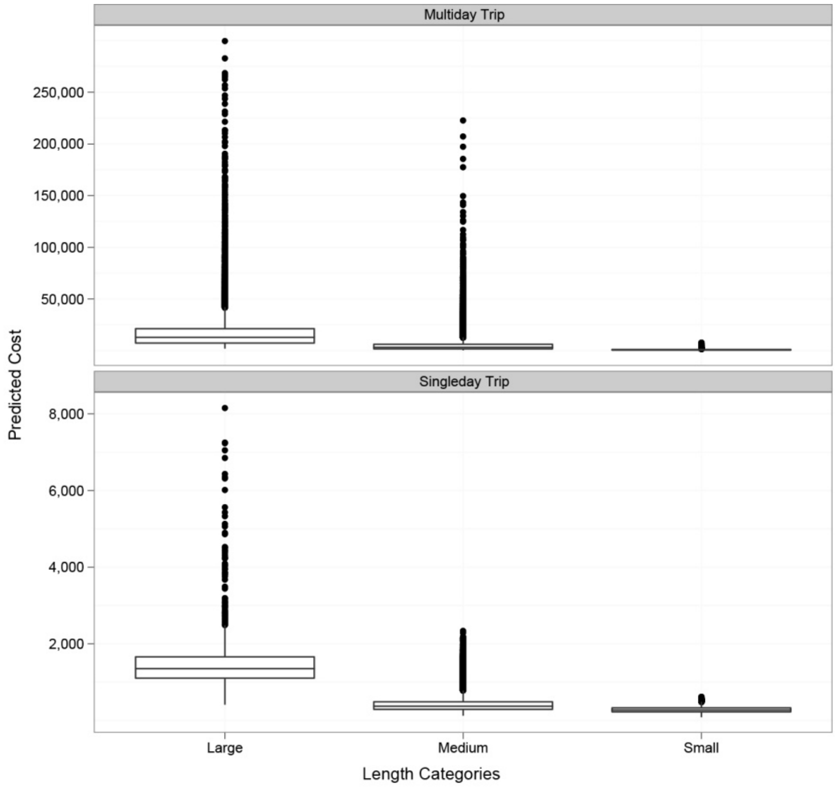

Figure 4. Distributions of predicted costs by trip duration types and vessel length categories.

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