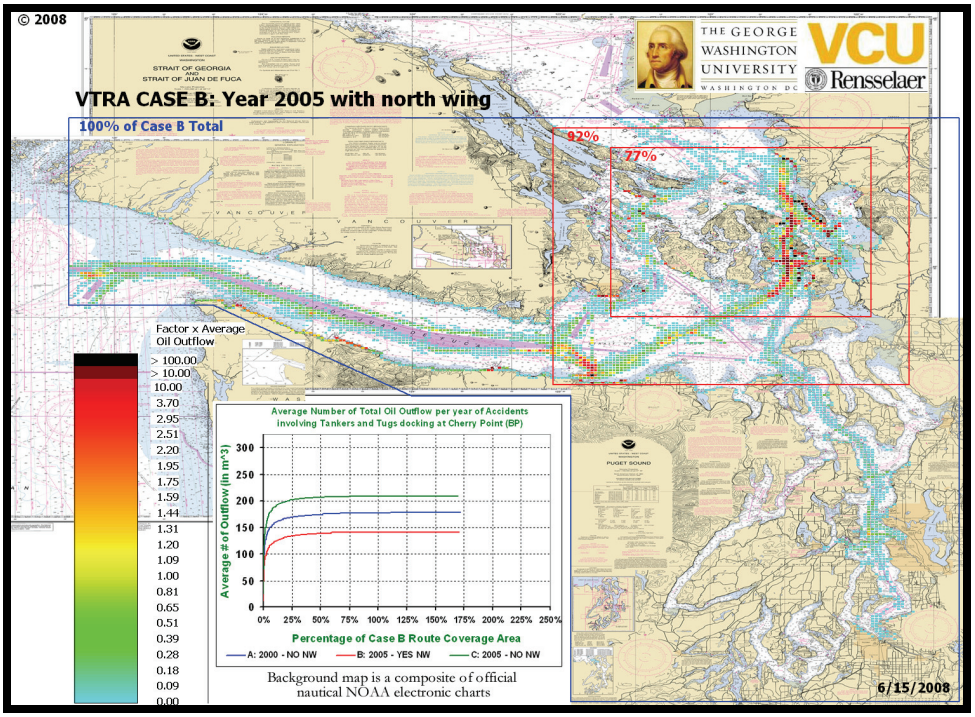
TECHNICAL APPENDIX F: FUTURE SCENARIOS



Assessment of Oil Spill Risk due to Potential Increased Vessel Traffic at Cherry Point, Washington

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F-1. Historical data on traffic levels

The Marine Exchange of Puget Sound collects data on commercial vessels that visit the Puget Sound. This data was provided from January 1992 to December 2006 as monthly counts of a variety of vessel types. Not all the vessels types included are used in the VTOSS database, so we used monthly visit counts from the Marine Exchange data where the vessel types matched those used in the simulation. Figure F-1. shows all the data provided by the Marine Exchange.

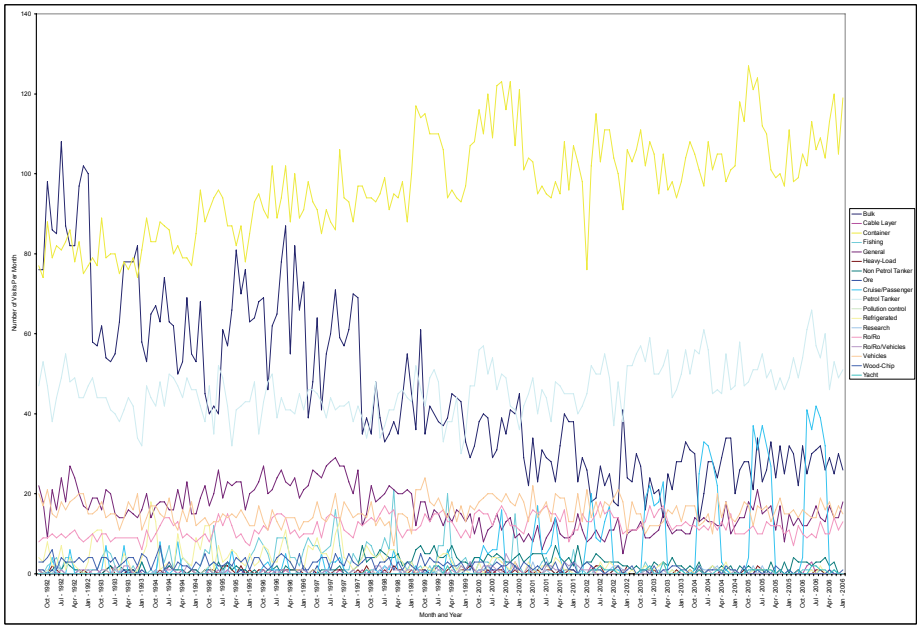

Figure F-1. Puget Sound Marine Exchange Visit Data

The USCG Seattle VTS collects data on the number of transits by VTS participating traffic within their area of responsibility. We should draw a distinction here between a visit and a transit. A visit occurs when a vessel enters the study area and then leaves again. In between, the vessel may make a number of shifts, or movements between ports within the area. A transit is counted every time the vessel moves (not including movements between docks in the same port. Thus each visit will lead to at least two transits (inbound and outbound) and, possibly, a number of shifts. Figure F-2 shows the Seattle VTS transit data, provided from January 1996 to December 2006.

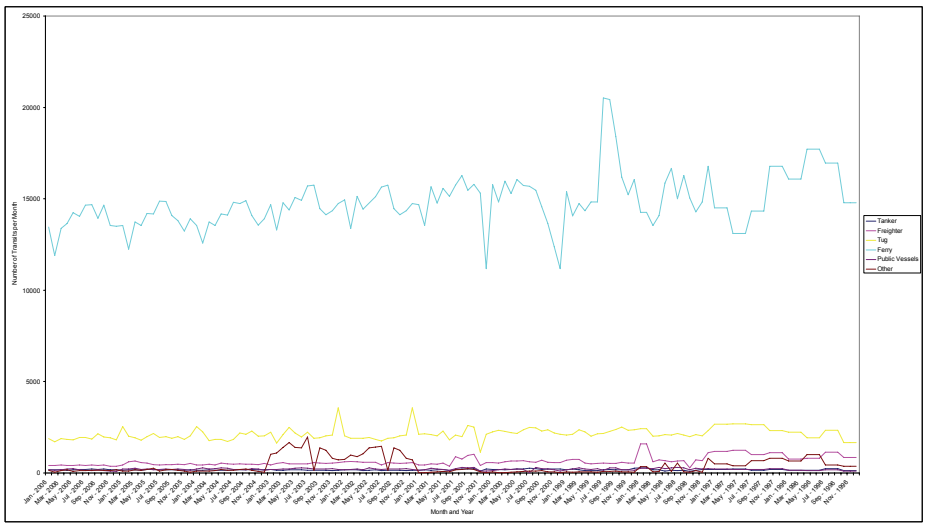

Figure F-2. US Coast Guard Transit Data

The Marine Exchange and Seattle VTS data was used to forecast traffic levels for non-BP vessels in 2025. This data was also used to find the change in traffic levels from 2000 to 2005. For BP vessels, projections were provided by BP.

F-2. BP's projection of Cherry Point Traffic

Table F-1 shows the projections provided by BP for both crude tankers and product vessels.

Table F-1. BP's projections of future traffic levels at the BP Cherry Point docks.

Vessel Traffic Scenario	Annual Total Vessel Range					Probability of Occurrence	
	crude vessels	product vessels		crude vessels	product vessels	within 10yrs	by 2025
Increased Crude Oil Delivery by Pipeline from Canada	170		to	220		very low	low
	15	155		20	200		
Current Range of Operations	320		to	400		low	medium
	150	170		180	220		
Growth Based On Historical Market Demand	340		to	370		medium	low
	170	170		185	185		
Growth Based On High Market Demand	350		to	450		very low	very low
	120	230		150	300		

From these projections, we need projections for the year 2025 at a low, medium, and high level. Our projections are somewhat limited by the scope of the Environmental Impact Study that the VTRA is an input to. We consider changes to BP traffic for the BP Cherry Point Refinery within currently permitted operating conditions. Thus the refinery handled 225,000 barrels of crude per day in 2005. The maximum permitted capacity under any previously authorized permits is 250,000 barrels per day. Thus they can at most handle an 11% increase in crude deliveries.

The projections provided by BP include a range from a 90% decrease in crude tankers arriving at the refinery (if most deliveries switch to a pipeline) up to a 17% increase in crude tanker visits (under the highest point in the range for the projections using historical market demand). We, therefore, use the 90% decrease assumed from the pipeline scenario for our low case (15 crude tanker visits) and the 17% increase assumed under historical market demand scenario for our high case (185 crude tanker visits). The 17% increase is higher than the 11% increase in barrels per day under historical permits, so we must assume that BP intended that these crude tankers to arrive at a lower capacity than currently seen. For the medium case, we use the middle of the range from the historical market demand scenario, or 177.5 crude tanker visits, which is a 13% increase.

The number of product tankers is not limited by the delivery capacity of the refinery, so the range is larger. The lowest number of product vessel visits included in the BP projections is 155, which is a 2% decrease from those in the 2005 simulation. The highest number of product vessel visits is 300, which is a 90% increase. These figures were used for the low and high cases. For the medium case, we again used the middle of the range for the historical market demand scenario, which is again 177.5 and a 13% increase from 2005 levels.

Table F-2 shows the changes in traffic levels used in the simulation for the low, medium, and high versions of the 2025 future scenario cases.

Table F-2. Percentage Changes from 2005 Traffic Levels Used in 2000 and 2025.

Traffic Type	2025		
	Low	Medium	High
BP Crude Tankers	-90%	+13%	+17%
BP Product Vessels	-2%	+13%	+90%

F-3. Overview of the development of future scenarios

The first step in determining forecasts for the non-BP traffic in 2025 is to examine the data. Separate forecasts are need for each vessel type where changes are forecasted. To maintain greater accuracy in traffic patterns, vessel types that are not forecasted to change will use 2005 transit data.

Figures F.3 through F.12 show the visit or transit data for each vessel type in the simulation for which historical data was available. Figures F.3, F.4, and F.5, for container vessels, bulk carriers, and cruise vessels show strong patterns. Container vessels visits have shown strong growth, while bulk carriers visits have been decreasing. Cruise vessels have shown seasonal growth, but the growth is slowing.

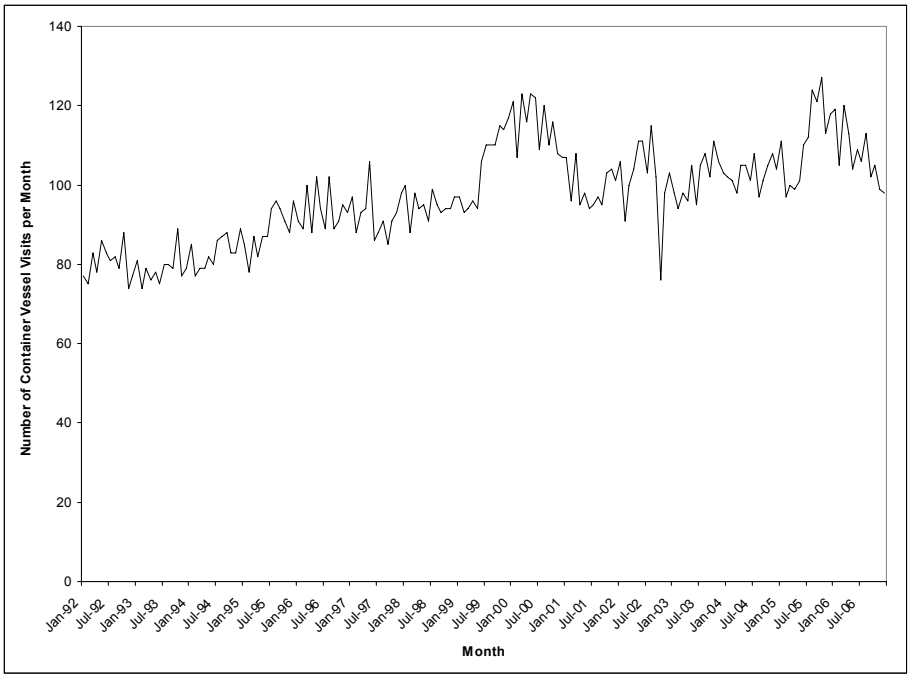

Figure F-3. Historical visit data for container vessels.

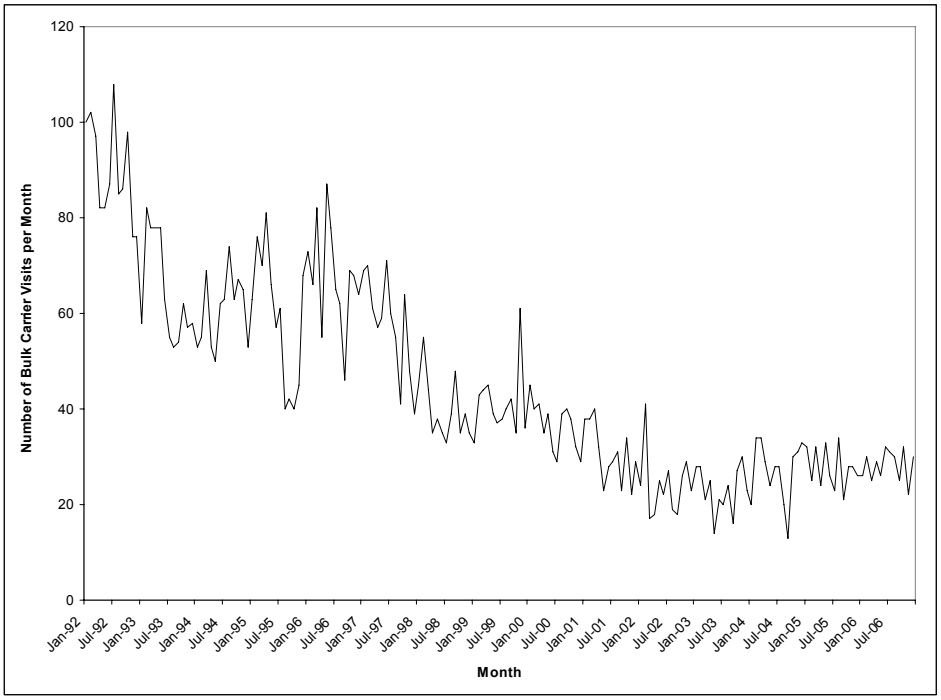

Figure F-4. Historical visit data for bulk carriers.

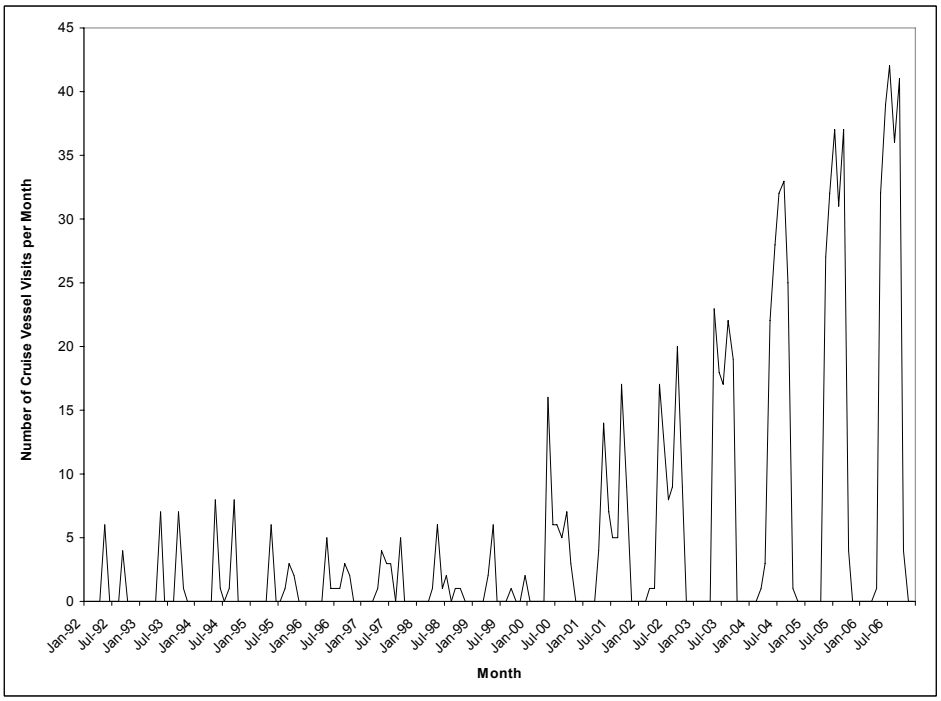

Figure F-5. Historical visit data for cruise vessels.

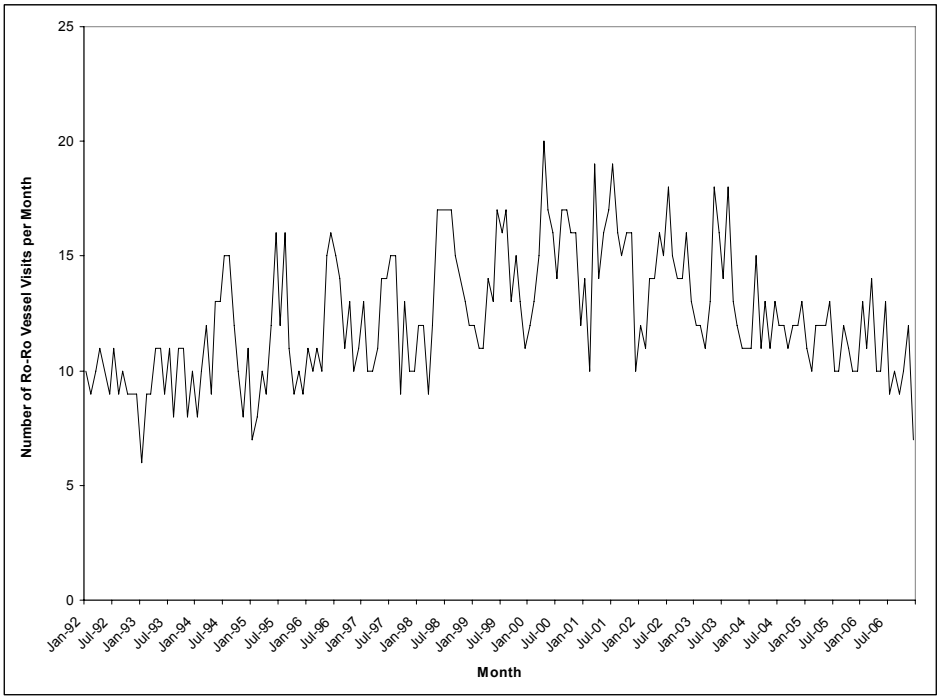

Figure F-6. Historical visit data for roll on-roll off vessels.

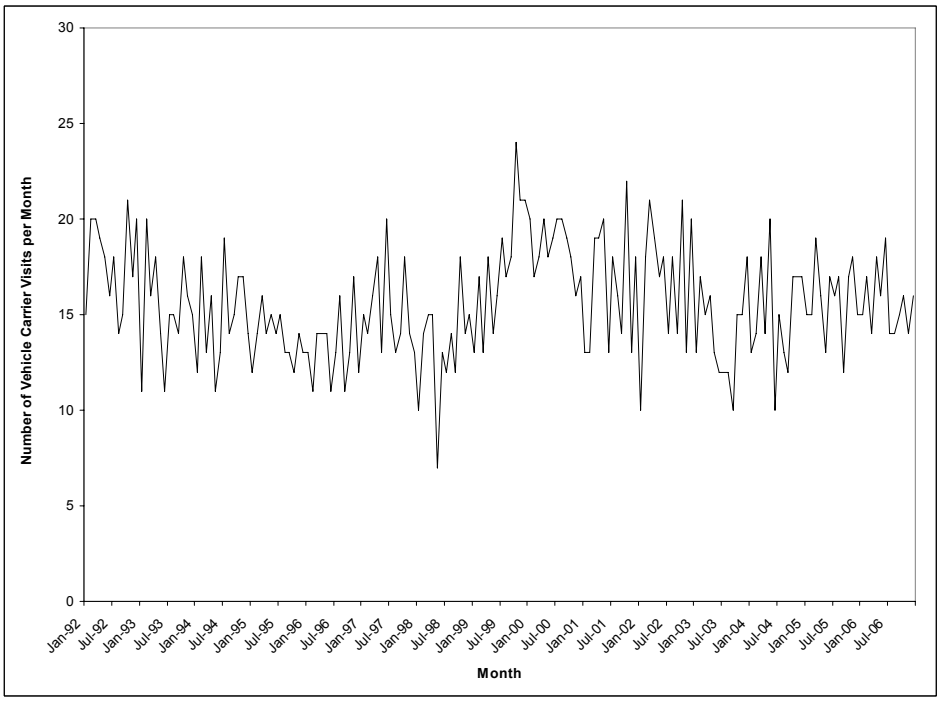

Figure F-7. Historical visit data for vehicle carriers.

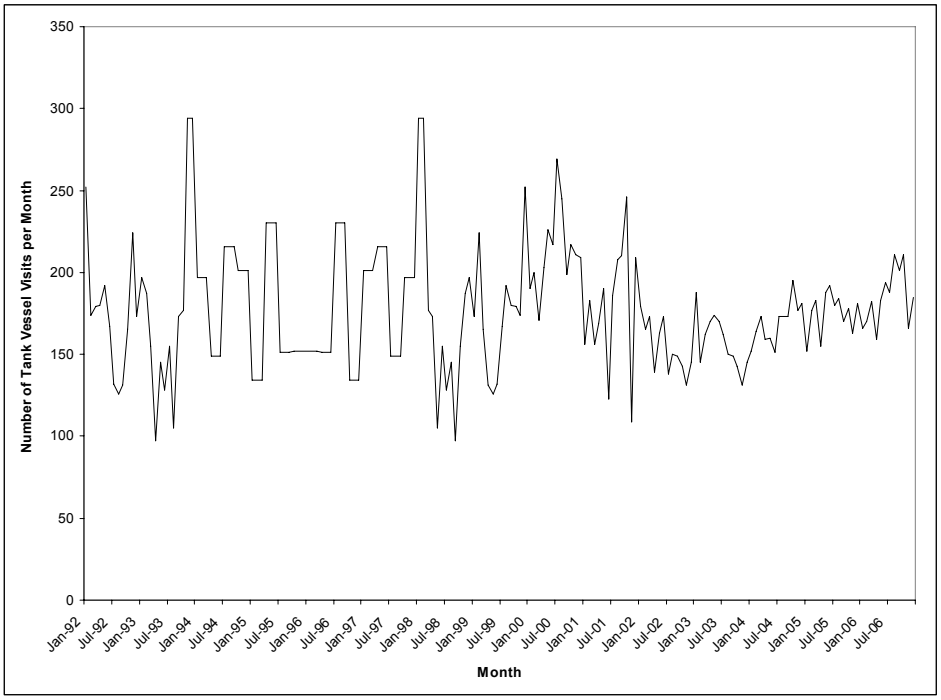

Figure F-8. Historical visit data for tank vessels.

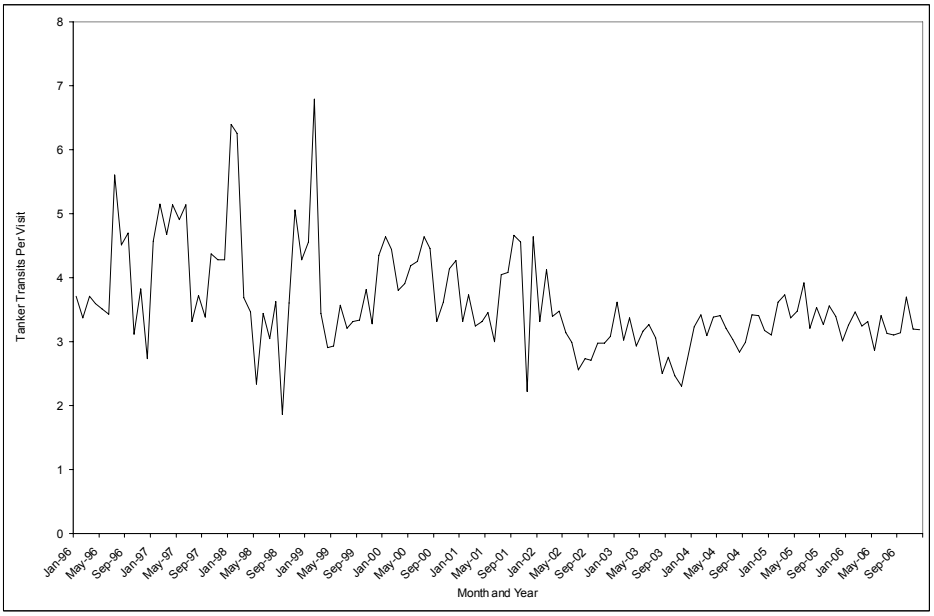

Figure F-9. Historical data on the number of transits per visit for tank vessels.

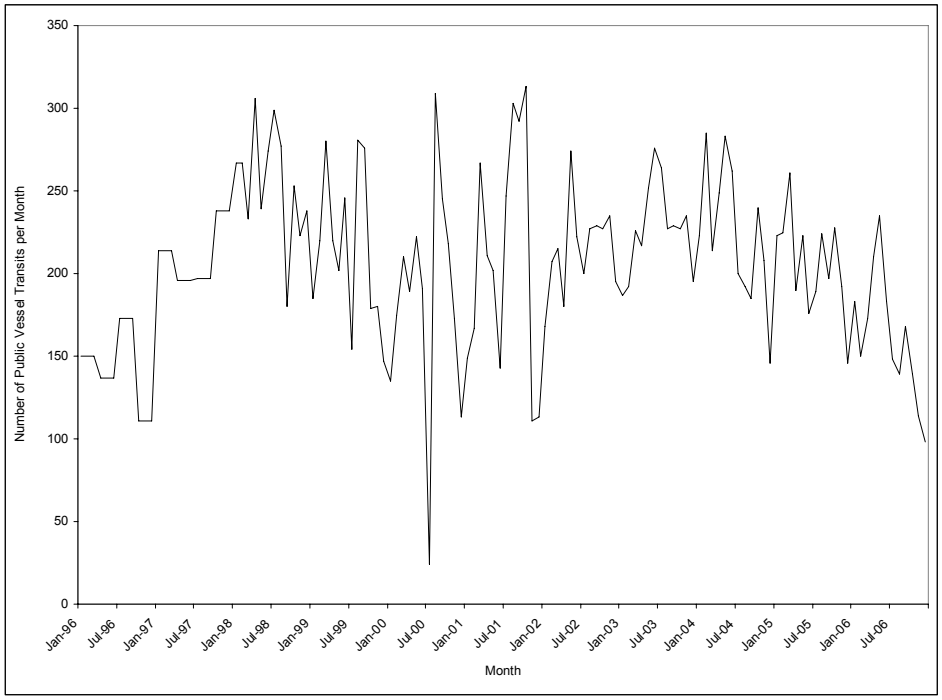

Figure F-10. Historical transit data for public vessels.

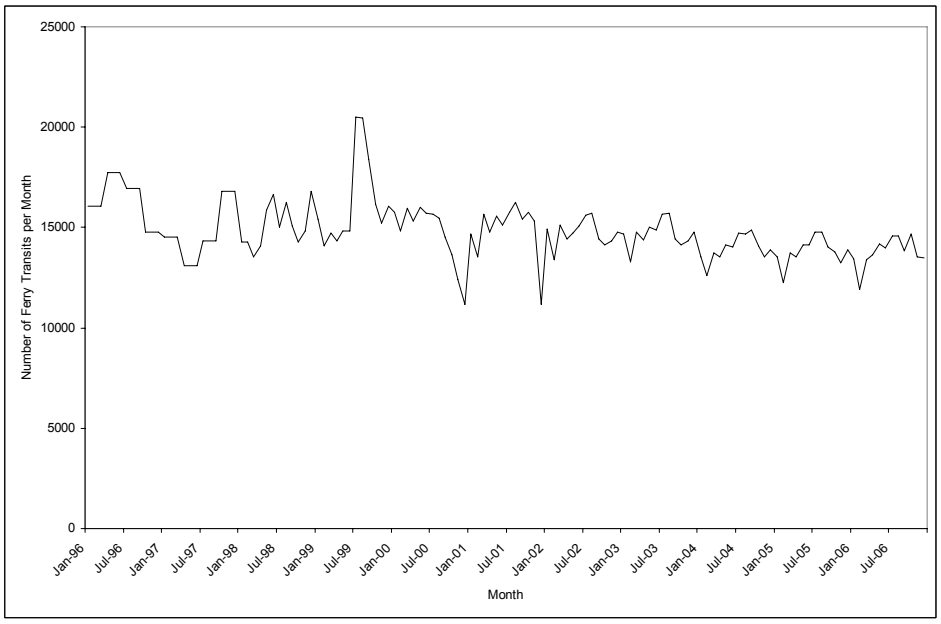

Figure F-11. Historical transit data for ferries.

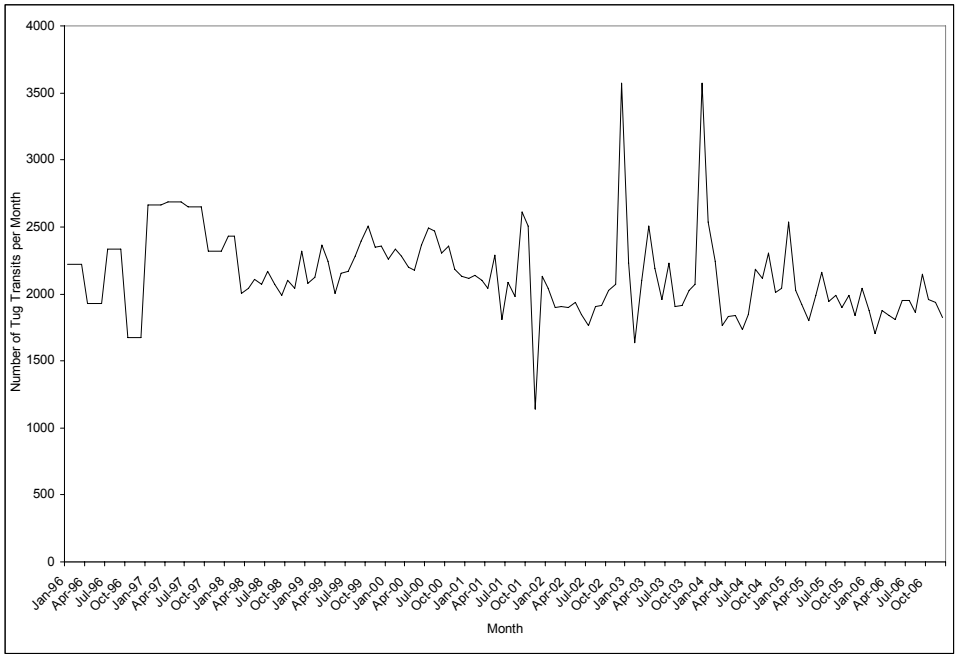

Figure F-12. Historical transit data for tugs with tows or barges.

Figure F-6, F.7, F.10, F.11, and F.12 show no obvious trends for ro-ro vessels, vehicle carriers, public vessels, ferries, or tugs. However, Figures F.8 and F.9 deserve more attention. Figure F-8 shows the historical number of visits by tankers there has been a lot of variability in these numbers, there is a pattern of steady growth since 2001. Figure F-9 shows the number of transits per visit. Recall that each visit must correspond to at least an inbound and an outbound transit. If the number of transits per visit is above two then the vessels must be performing shifts between ports in the study area. Thus we can see that tankers usually perform one or two shifts per visit and sometimes many more. From 1996 to 2001, there was a large variability in the number of shifts performed, but since then the average number of shifts per visit has settled down to about one. This is important as we can use forecasts for the number of visits for the number of non-BP tankers and the movement patterns between refineries is not shown to change from those in the 2005 data by Figure F-9.

F-4. Time Series Forecasting of Traffic Levels

With a visual understanding of the historical patterns in hand, we may now turn to statistical methods to achieve forecasts and an understanding of the range of forecasted traffic levels. The method used is called time series analysis, which allows us to model patterns of growth,

seasonal patterns, and historical dependencies in the data. The models used are called Seasonal, Auto-regressive, Integrative, Moving-Average models, SARIMA models for short. The range of possible models is large and various diagnostic tools can be used to find the best predictive model. We also obtain a confidence bound on the model, or a range within which the model predicts the traffic levels will fall. This allows us to use the models' predicted traffic levels for the medium case and the upper and lower bounds of the confidence interval for the high case and low case, respectively. It should be noted thought that we are attempting to forecast traffic levels based on 10-14 years of data with our forecast being for 19 years past the end of the data. Thus the range of uncertainty is obviously large.

Figures F. 13 to F.20 show the models fitted to the historical data. The model is shown as a solid line and the historical data is shown as individual points. The upper and lower confidence bounds are shown as dotted lines. A flat forecast, such as in Figure F-13 for bulk carriers, from the last historical data point shows that the traffic level is not forecasted to change and so the traffic levels for these vessel types are kept at the 2005 levels. We can see in Figure F-13 that bulk carriers have decreased over time, but then visit levels have flattened off and are forecasted to remain steady in the future.

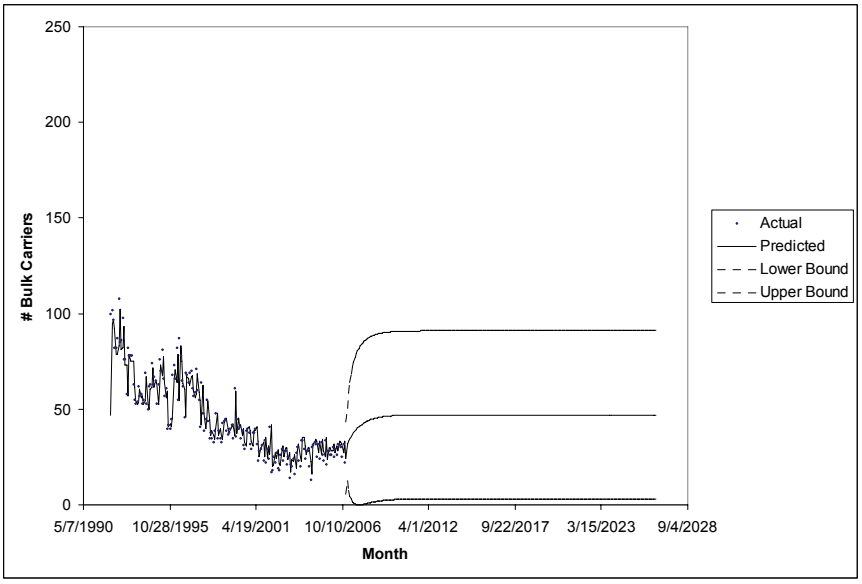

Figure F-13. The statistical forecast for bulk carrier visits.

Figure F-14 indicates a steady increase in container vessel visits. Taking this forecast, the low, medium, and high cases use a 54% decrease, a 20% increase and a 93% increase respectively. Figures F.15 and F. 16 show steady levels for ro-ro vessels and vehicle carriers. The increasing upper bound is a side-effect of the data transformations used for statistical fitting purposes.

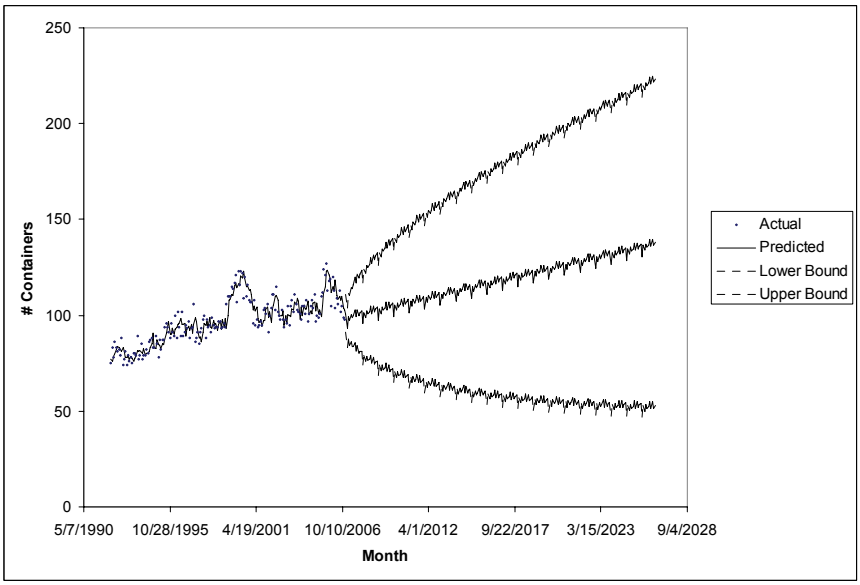

Figure F-14. The statistical forecast for container vessel visits.

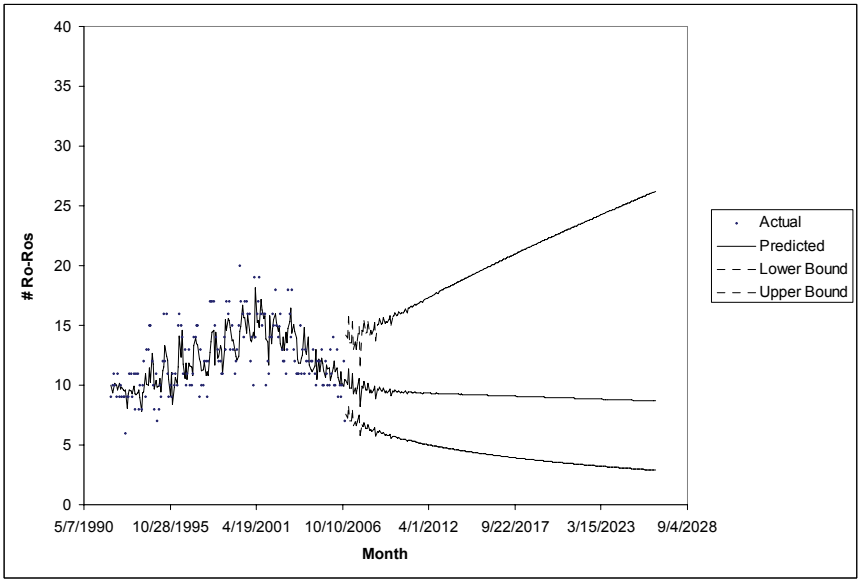

Figure F-15. The statistical forecast for ro-ro vessel visits.

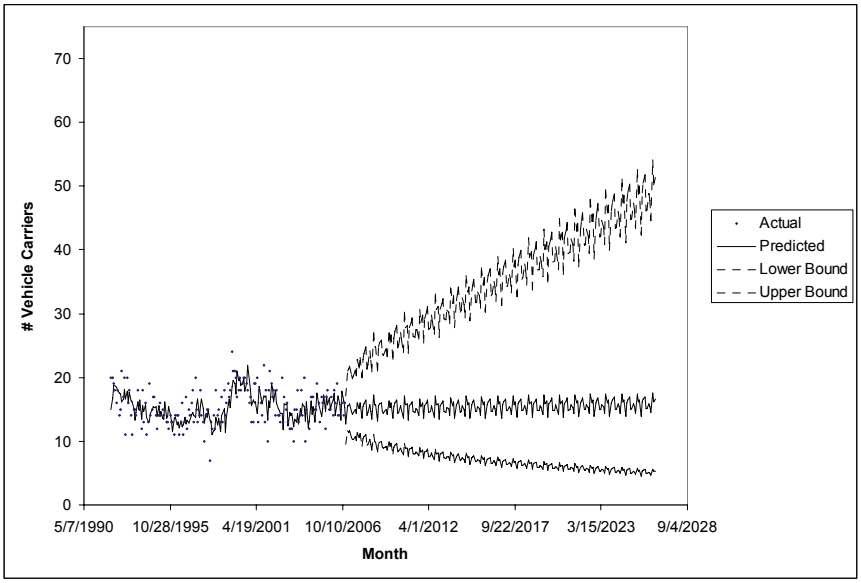

Figure F-16. The statistical forecast for vehicle carrier visits.

Figure F- 17 shows a steady increase in tanker visits to the area. Thus for non-BP tankers, the low, medium, and high cases use a 54% decrease, a 55% increase and a 162% increase respectively. The high range is a result of the volatility in the historical data.

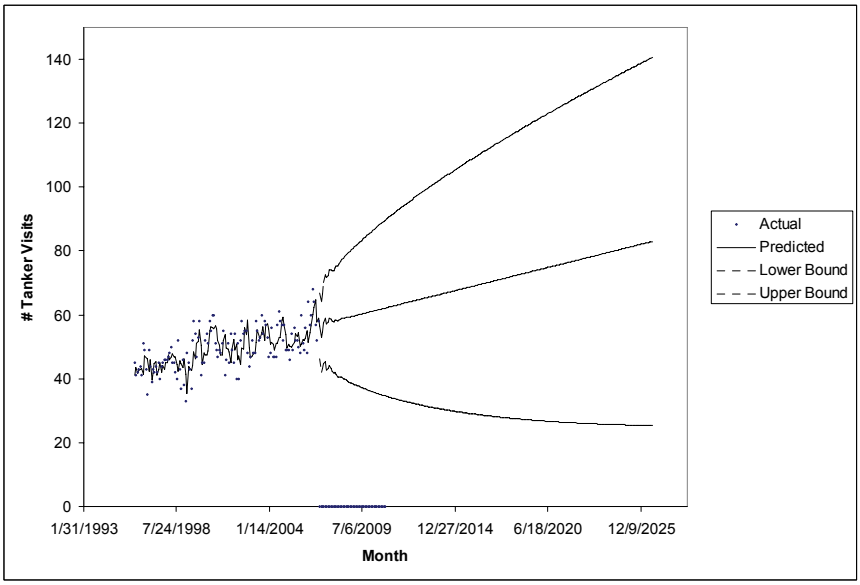

Figure F-17. The statistical forecast for tank vessel visits.

Figure F- 18 confirms our initial observation from the data about the number of shifts that tankers perform. There is no forecasted change in shifts evidenced by the historical data. Figures F.19 and F.20 show no change either for tug and ferry transits.

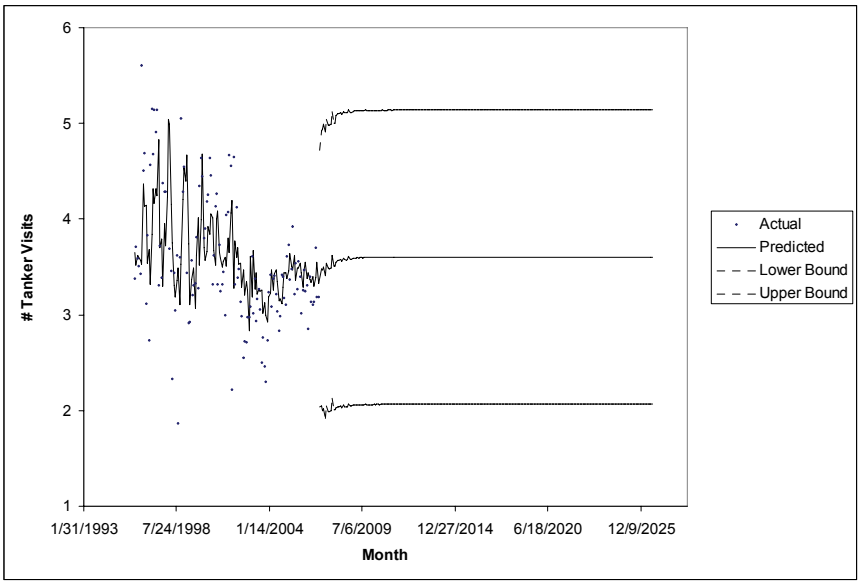

Figure F-18. The statistical forecast for tanker transits per visit.

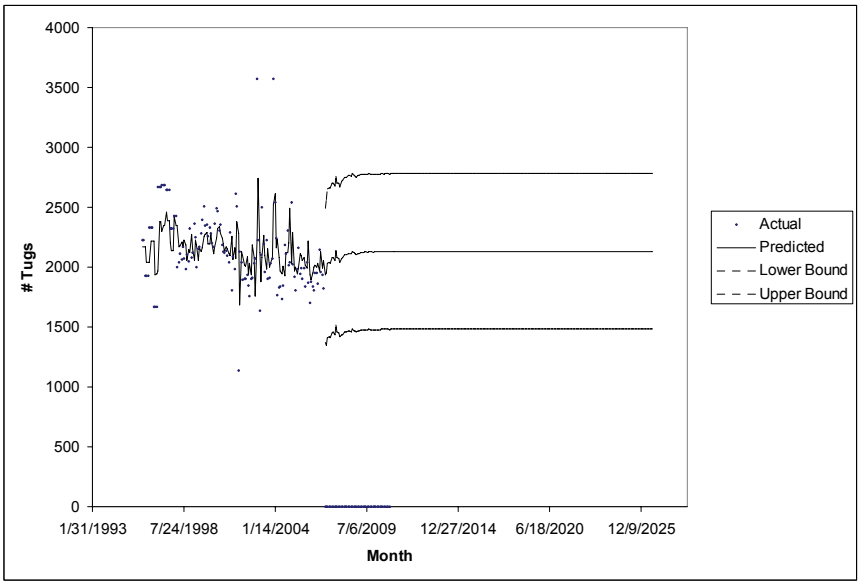

Figure F-19. The statistical forecast for tug transits.

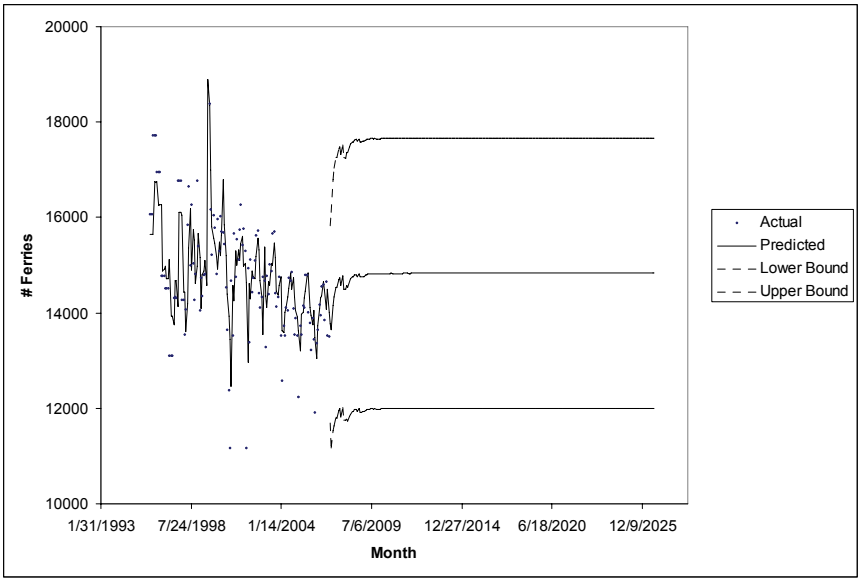

Figure F-20. The statistical forecast for ferry transits.

F-5. Traffic Levels Projected for 2025

Taking all forecasts together, along with the historical traffic levels in the year 2000, we can obtain the traffic levels for our year 2000 and year 2025 cases. The traffic levels for vessel types that do not have a forecasted change used the historical transit data for the year 2005. For the traffic types where changes had to be modeled, stochastic arrival models were fitted to the 2005 data and the parameters of these models were calibrated to achieve the forecasted levels. Table F-3 shows changes made for the year 2000 and the year 2025 low, medium, and high cases as developed throughout this Appendix.

Table F-3. Percentage Changes from 2005 Traffic Levels Used in 2000 and 2025.

Traffic Type	2000	2025		
		Low	Medium	High
BP Crude Tankers	-20%	-90%	+13%	+17%
BP Product Vessels	-	-2%	+13%	+90%
Other Tank Vessels	+23%	-54%	+55%	+162%
Bulk Carriers	+30%	-	-	-
Container Vessels	-	-54%	+20%	+93%