Texas City Y Oil Spill
Natural Resource Damage Assessment
Technical Memorandum: Estimate of Lost Recreational Use Damages

September 28, 2017[1]

Natural Resource Trustees:
National Oceanic and Atmospheric Administration (NOAA)
U.S. Fish and Wildlife Service (USFWS)
U.S. National Park Service (NPS)
Texas Parks and Wildlife Department (TPWD)
Texas General Land Office (GLO)
Texas Commission on Environmental Quality (TCEQ)

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1 Introduction

On March 22, 2014 the bulk carrier M/V *Summer Wind* and the oil tank-barge *Kirby 27706* collided in Galveston Bay near Texas City, Texas. As a result of the collision the #2 starboard tank of *Kirby 27706* was punctured, discharging approximately 168,000 gallons (4,000 barrels) of Intermediate Fuel Oil (IFO-380) into the Houston Ship Channel and state and federal waters of the Gulf of Mexico (Texas City Y Spill or the spill). Some of the oil came ashore on Galveston-area beaches over the next few days. Much of the remaining surface oil traveled down the Texas coast and ultimately came ashore on beaches as far south as Padre Island National Seashore in Corpus Christi, Texas. Overall, oil was observed on over 160 miles of shoreline, including salt marsh, sandy beaches, and mangroves.

The Department of Interior (DOI), as represented by the United States Fish and Wildlife Service (USFWS) and the National Park Service (NPS), the National Oceanic and Atmospheric Administration (NOAA) on behalf of the Department of Commerce (DOC), the Texas Commission on Environmental Quality (TCEQ), the Texas General Land Office (GLO) and the Texas Parks and Wildlife Department (TPWD) for the State of Texas (collectively, the Trustees) are acting as the Trustees for this spill. In coordination with the Responsible Party (RP), Kirby Inland Marine, LP (Kirby), the Trustees conducted a Natural Resources Damage Assessment (NRDA) for this spill.

Among the impacts of the spill were losses to recreational[4] users of the marine and coastal environment. Recreational activities such as beach use, boating and fishing were impacted due to direct oiling, closures/advisories, and the reasonable expectation of oiling as a result of the spill. The presence of oil on beaches or in the water degraded the quality of or accessibility to recreational activities. For example, some beaches were closed due to oiling or cleanup activities; other beaches that were lightly oiled remained open, but could still have had impaired recreational activities. These impacts can be quantified by observing changes in recreational use as a result of the spill. During a spill such as this, recreators can respond in several ways: they may cancel a trip outright and engage in some other activity (lost trips); they may change their destination (substitute trips); or they may still take their planned trip but receive less value/enjoyment due to the oiling (diminished-value trip).

The Oil Pollution Act of 1990 (OPA 90; 15 CFR 990.52(a)) states that “Trustees must quantify the degree, and spatial and temporal extent of such injuries relative to baseline.” Existing information and data were collected during the NRDA to identify affected recreational activities and estimate losses caused by the spill. Baseline and lost recreational use is measured in “user days,” defined as any time an individual engages in recreation associated with a Trust resource for at least part of the day. Damages are then calculated by applying the estimates of lost user

[4] For the purposes of this assessment, recreation is defined as any non-commercial activity on or along the coast that was affected by the spill. These activities include (but are not be limited to) swimming, sunbathing, walking along the beach, fishing, and boating.

days to a valuation model. The Trustees assessed 63,359 lost user days and $1,739,885[5] recreational use damages as a result of this spill.

This technical memorandum summarizes the Trustees' estimate of lost recreational use damages and is organized as follows:

- Section 2: Describes the exposure of recreation areas and the pathway by which users were affected;
- Section 3: Presents the quantification of lost user days using existing data;
- Section 4: Presents the valuation of lost user days; and
- Section 5: Concludes with a calculation of total recreation damages.

2 Exposure and Pathway

During the spill, recreational use was affected by direct oiling, closures/advisories, and recreators' reasonable expectation of oiling, all of which may impair the quality of recreation and impose damages. Thus, exposure and pathway are documented by evidence of direct oiling and closures, as well as by evidence that the public was aware of the spill and may have modified their behavior as a result. This section describes evidence of direct oiling, documented closures/advisories, and public awareness of the spill.

2.1 Direct Oiling

Shoreline Cleanup and Assessment Technique (SCAT) is a systematic method for surveying an affected shoreline following an oil spill. These data are collected during response to provide information on shoreline oiling conditions in order to develop the objectives and strategies for cleanup operations. SCAT data provide a measure of the timing, spatial extent, and degree of oiling during a spill. For this spill, coastal areas were oiled at various times, beginning on March 24, 2014.

Following the collision, oil began coming ashore along Galveston Bay and on the Gulf side of Galveston Island. SCAT data documented initial oiling on March 24, 2014.The maximum extent of oiling occurred between March 24, 2014 and March 31, 2014 and extended 62.92 miles along the coast of Galveston Island, Bolivar Island, and areas along Galveston Bay, including the Texas City Dike. When the final SCAT survey was completed in the Galveston Bay area on April 29, 2014, 2.02 miles of very light oiling remained.

Further down the coast, recreational use was impacted by oiling along shoreline areas of Mustang Island and Padre Island. SCAT data documented initial oiling along Mustang Island on March 30, 2014. The maximum extent of oiling occurred on March 30, 2014 and extended 13.36 miles. When the final SCAT survey was completed on April 24, 2014, 3.04 miles of light tarballs remained on Mustang Island. Padre Island experienced 55.33 miles of oiling between March 31,

[5] This damages value is compounded and adjusted for inflation to June, 2017, when the analysis was last revised.

2014 and April 2, 2014, resulting in closures to off road vehicle access between April 1, 2014 and April 4, 2014. Partial closures and cleanup activities continued to limit access until the 8th of April when the Park was again fully accessible to the public.

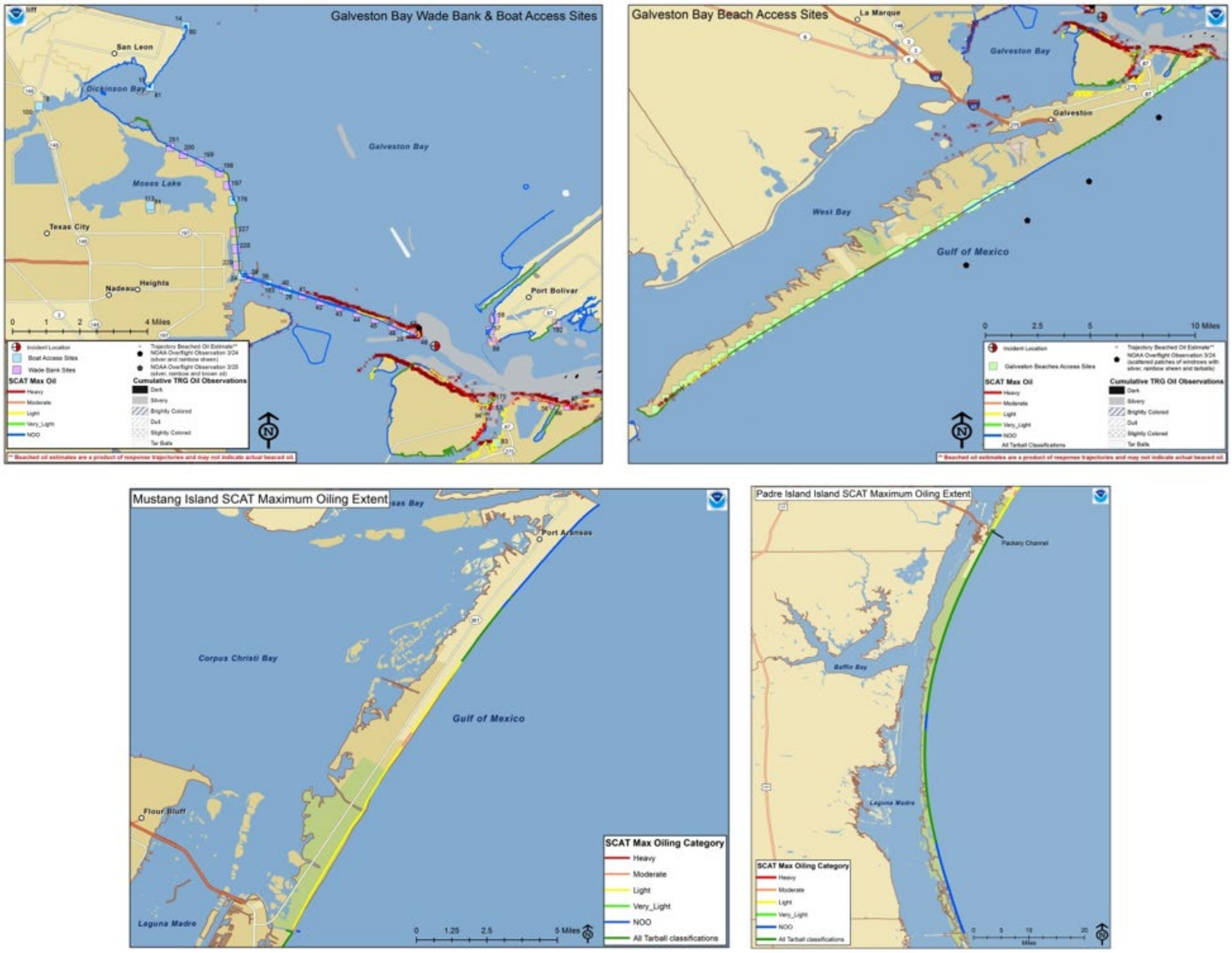
Table 1: Oiling Dates

Location	Initial Oiling Date	Maximum Oiling Dates	Maximum Degree of Oiling	End of SCAT Operations
Galveston Bay	3/24/14	3/24/14 – 3/31/14	Heavy to NOO[1]	4/29/14
Galveston Island Beaches	3/24/14	3/24/14 – 3/31/14	Heavy to very light	4/17/14
Mustang Island	3/30/14	3/30/14	Moderate to NOO	4/24/14
Padre Island	3/31/14	3/31/14, 4/2/14	Moderate TB[2] to NOO	4/28/14

[1] NOO – No observed oil
[2] TB – Tarball

The data for maximum extent of oiling are shown in Figure 1 along with annotations for recreational access points for beach use and fishing in the Galveston area.

Figure 1: Areas Where Oiling Affected Human Use[6]



2.2 Closures

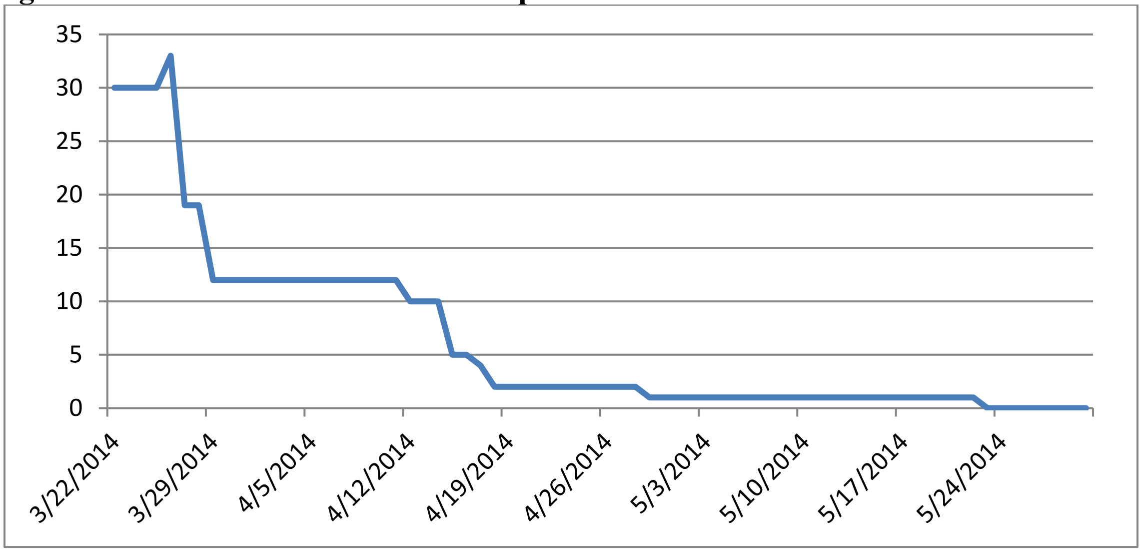
Fishing access sites and beaches were closed during oil spill response actions. These closures were effective from March 24, 2014 to March 27, 2014 in East Beach Park and Stewart Beach Park located on the northern tip of Galveston Island, and from March 23, 2014 to April 17, 2014 in Seawolf Park located on Pelican Island. Beaches were closed under the Galveston County Dune Protection Plan (Galveston County, 2006) to “protect the safety of beach users”.

Fishing access closures occurred on various dates for 12 boat ramps and 32 wade-bank fishing sites. Fishing access site closures were determined by TPWD according to the presence of oil and cleanup actions.

Beaches were closed to vehicular traffic at Padre Island National Seashore from April 1-4, 2014.

[6] Full size maps are presented in the appendix.

Figure 2: Number of Closed Boat Ramps and Wade Bank Sites in the Galveston Area



2.3 Advisories

On March 25, 2014, the Galveston County Health District issued a Public Health Statement warning of health risks associated with "contact with oil on shorelines, beaches and other contaminated waterways". Recommendations included avoidance of fishing and swimming in oil-spill affected waters. The release also suggested that inhalation of oil vapors from wind-blown waves could cause health problems.

On March 27, 2014, the Texas Department of State Health Services issued a Fish and Shellfish Consumption Advisory. The advisory urged individuals to avoid consuming "fish, shrimp or crabs from areas where oil is present". The department did not issue an end of advisory announcement but did remove the advisory from its website in the summer of 2014.

2.4 Public awareness

The U.S. Coast Guard and Unified Command provided 15 press releases describing the incident, response actions and port/ferry closures in Galveston Bay from March 23, 2014 through March 27, 2014, when the port in Galveston Bay re-opened to all marine traffic. On March 27, 2014, the Unified Command issued a press release announcing landfall of oil in Matagorda Bay providing six more updates to these response activities and those in Galveston Bay through August 1, 2014.

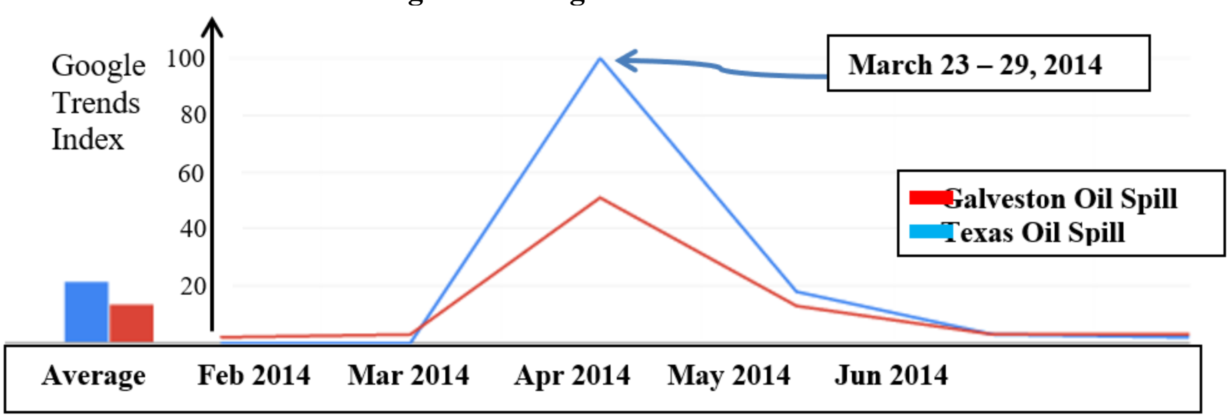
The Vanderbilt Television News Archive recorded two national news stories mentioning the spill on March 23, 2014 (ABC and NBC). Examples of other national and local news coverage related to the spill are summarized in Table 2.

Table 2: Examples of News Coverage of Oil Spill

Date	Source	Title
3/23/2014	Fox News (Foxnews.com, 2014)	*Oil Spills Into Galveston Bay After Ships Collide*
3/24/2014	U.S. News and World Report (Neuhauser, 2014))	*'Significant' Oil Spill Closes Houston Ship Channel, Fouls Wildlife*
3/24/2014	Christian Science Monitor (Unger, 2014)	*Galveston Oil Spill: Does Oil Boom Mean More Spills?*
3/25/2014	KPR Houston (Peralez, 2014)	*Galveston Bay Oil Spill Crews Face Rough Water Wednesday*
3/25/2014	National Geographic (Dell'Amore, 2014)	*Galveston Oil Spill Threatening Crucial Bird Refuge*
3/26/2014	Texas Tribune (Satija, 2014)	*Galveston Bay Oil Spill Threatens the Area's Lucrative Fishing Industry*
3/28/2014	Houston Press (Wray, 2014)	*Galveston Oil Spill Has Put Texas Oysters and Seafood Off the Menu*
3/29/2014	The Weather Channel (Weather.com, 2014)	*Galveston Bay Oil Spill: Coast Guard Investigating Cause of Spill*

Google Trends searches for "Galveston Oil Spill" and "Texas Oil Spill" increased dramatically in the last week of March 2014 as summarized in Figure 3.

Figure 3: Google Trends Searches[7]



3 Quantification of Lost User Days

In order to quantify user days lost as a result of the spill, actual use during the spill was measured and compared to a predicted baseline. The baseline use is the level of use that would have occurred but for the spill. In order to determine baseline, historical data is used in conjunction with weather, holiday, day of the week, and other information to predict the use that would have

[7] The scale of the vertical axis is an index produced by Google Trends with the highest value being 100 and corresponding to the largest relative search count. Google does not provide the absolute search magnitudes. (Google.com, 2016)

occurred during the spill period. These adjustments are important to reflect the behavioral response to key variables affecting recreational behavior.

At the early stages of the assessment, it was determined that there were numerous existing datasets that could be used to evaluate the recreational impacts of the spill. Thus, rather than executing an extensive original data collection effort, the existing data derived from multiple sources were used to estimate baseline and lost user days associated with the spill. As an exception, TPWD did increase several of their ongoing recreational use monitoring activities to produce spill-specific counts of users at potentially affected fishing access sites. This served as an extension of regular data collection efforts and relied on existing data collection protocols. This NRDA also makes use of, where appropriate, original data collection efforts undertaken by representatives of the RP.

In addition to estimating lost user days for the affected areas where data are available, these data are sufficient to provide reasonable approximations of usage and loss patterns for the remaining areas where data are not available. Extrapolating to the remainder of the affected area allows a full characterization of the recreational losses using existing data. Specifically, the data available to estimate baseline user days and losses consist of beach visitation data from six Galveston public beaches (where visitors pay to enter the parking area for the beach), a waterfront park, two State Park beaches, paid parking along the Seawall, and data from roving counts of fishing activity at both boat ramps and wade-bank fishing access points.

3.1 Modeling Approach

In order to estimate lost user days, predictive statistical models are applied to various beach use and fishing datasets to predict baseline use (i.e. but for the spill use). Recognizing that conditions such as weather also affect recreational decisions, various control variables are included for these conditions described below. Beach use data is available in three different forms: daily parking revenue; visitor counts; and credit card transaction records for pay-by-phone parking. Fishing data were collected from roving counts of individuals for shoreline or ‘wade-bank’ fishing and counts of empty trailers or slips at boat-ramp areas for boat-based fishing. Table 3 summarizes the types and sources of the data used in this assessment.

Table 3: Recreational Use Data

Activity	Location	Source	Years/Months Included	Outcome Observation Type	Transformations / Notes
Recreational Boating					
	Texas City Dike & Surrounding	TPWD	2008-2015; March-May	Empty Trailers and Slips	97.5 % recreation; 2.6 people per boat; 1.43 turnover rate
Shoreline Fishing					
	Texas City Dike & Surrounding	TPWD	2013-2014; March-May	Individuals Fishing	2.93 turnover rate
General Shoreline Use					
	R. A. Apfel Park	Galveston Island Parks Board	2009-2015; March-November	Daily Parking Revenues	$8/car, 2.5 people per car
	Stewart Beach		2006-2015; March-October	Daily Parking Revenues	$8/car, 2.5 people per car
	Dellenera Park		2007-2015; January-December	Daily Parking Revenues by Vehicle Type	$8/car[1], 2.5 people per car
	Pocket Park 1		2008-2015; March-September	Daily Parking Revenues	$8/car, 2.5 people per car
	Pocket Park 2		2008-2015; March-September	Daily Parking Revenues	$8/car, 2.5 people per car
	Seawolf Park		2008-2015; January-December	Daily Parking Revenues by Vehicle Type	$6/car, 2.5 people per car; $10/bus, 30 people per Bus
	Seawall Boulevard	City of Galveston	2013-2015; January-December	Individual Car Parking Purchases	2.5 people per car
	Galveston Island State Park	TPWD	2011-2015; March-September	Individuals Entering Park	Only day visits
	Mustang Island State Park	TPWD	2011-2014; March-September	Individuals Entering Park	Only day visits
	Padre Island National Seashore	NPS	2003-2014; April	Vehicles entering park	2.7 people per car

[1]Dellenera Park has different rates for RVs in Summer and Holidays: $41 for Winter, $47 for Winter Holidays, $46 for Summer and $52 for Summer Holidays. The turnover rate transforms the instantaneous boating and fishing counts into estimates of total visitation, and is detailed further in the document.

The final column in Table 3 lists the modifications made to data in order to translate into user days. These modifications and the reasons for them will be further discussed in their respective analysis sections. For each of these datasets, a statistical model estimated on data from outside of the specified spill-period predicts baseline by calculating the fitted values of the model for the days in the spill period. These predictions represent the expected values of these data but for the oil spill. The loss calculation is then the difference between these predictions and observations during the spill period, converted into individual user days lost where appropriate.

Representatives of the RP collected additional original recreational use data. These data included overflight-photo/video based counts of Galveston Island beaches and two types of counts of users at Texas City Dike. Stationary counts on the Texas City Dike recorded entrances to the Dike and whether vehicles had trailers with boats or not. The second form of counts on the Dike entailed periodic roving counts of users around the area of the dike and recorded whether users were engaged in fishing or not. Where possible, these additional observations inform calculations, particularly for areas and activities not covered by the existing visitation data such as non-fishing use of the Texas City Dike.

A critical part of any NRDA is the determination of the spill (injury) period. Depending on the scenario, the spill period can be determined by observable impacts (e.g. oil on the beach, advisories, or closures), empirical results (e.g. calculated return to baseline recreational use), or a combination of both. For this assessment, spill periods were chosen based on closures, response actions and the period of observed oiling rather than relying solely on empirical results. Evaluation of the various recreational datasets indicated that use quickly returned to baseline levels following cleanup and reopening of parks and beaches. Furthermore, the relative short duration of the spill and natural variation in the data make it difficult to discern any longer term impacts.

For this assessment, three spill periods were applied to three different regions. For sites on Galveston Island, the spill-period began on March 23, 2014 and lasted through April 17, 2014. This is based on direct observations of oiling and the timing of access site closures in the area. For Mustang Island, the spill period lasted from March 30, 2014 through April 7, 2014, based on the timing of response actions. On Padre Island, the spill period lasted only from April 1, 2014 through April 4, 2014, based on impacts to off road vehicle use due to oiling and cleanup activities. The spill periods are summarized in Table 4.

Table 4: Lost Recreational Use Spill Periods

Area	**Spill Period**	
	Start	**Finish**
Galveston Bay and Island	3/23/2014	4/17/2014
Mustang Island	3/30/2014	4/7/2014
Padre Island	4/1/2014	4/4/2014

A set of control variables help the statistical estimation procedure capture the effects of annual trends, seasons, days of the week, weather, water temperature and holidays. The choice of control variables and their treatments favor parsimony and consistency across datasets to avoid overfitting variable data. To avoid increasing variability there are fewer (potentially correlated) control variables than could potentially be included. Table 5 describes the specific control variables used and the treatment of each.

Table 5: Control Variables

Variable	Type	Source	Treatment
Year	Discrete	Calendar	Indicator for each year
Month	Discrete	Calendar	Indicator for each month
Day of Week	Discrete	Calendar	Indicators for each day
U.S. Holidays[1]	Discrete	Calendar	Indicator for each holiday
Maximum Daily Temperature	Continuous	NECI, 2016[2]	Linear
Total Daily Precipitation	Continuous	NECI, 2016[2]	Linear
Maximum Daily Water Temperature	Continuous	NOAA[3]	Linear

[1]Friday/Saturday/Sunday (FSS) except Independence Day: If on Monday (M): previous FSS & M; Tuesday (T): previous FSS & MT; Wed: Just July 4; Thursday (R) : R & FSS; Fri: FSS
[2]Galveston: Scholes Field Airport. Mustang: Corpus Christi Airport.
[3] Galveston only. Station ID#8771013, if missing replaced with average of linear regression prediction from stations 8771341 and 8771450.

Poisson regressions use the above control variables and recreational outcome data to generate baseline predictions by fitting predictions to the control variable values during the spill. Poisson regressions are a common statistical routine for data such as the count data of recreation outcomes (described above) which only take whole-number values. The Poisson regression model uses historical observations of control variables and outcomes to generate the most likely outcome conditional on a set of control values. These most likely outcomes form the baseline.

Several modeling approaches informed the investigation of the data for this NRDA, but the results reported here are the preferred models of visitation to predict baselines for each dataset. Almost all datasets' results use Poisson regressions which omit spill period data for estimation, then predict baseline use by fitting regression values for those days. The exception is wade-bank fishing which uses only day-type conditional averages because of the very small amount of baseline data (only one year) in this dataset.

Extensive model selection investigations resulted in the selection of Poisson over two alternative models, Negative Binomials and Ordinary Least Squares. In each modeled dataset the average root-mean-squared-error of model predictions for the Negative Binomial model is higher, favoring the Poisson model. While the average model performance of Ordinary Least Squares is not always poor, those models too often lead to impossible values (i.e., predicted user days with negative values), favoring the Poisson model as it is restricted to positive predictions. Additionally, the Poisson regression models used to predict baseline for each of the datasets fit the data well: parameter estimates conform to expectations in the sense that beach use is higher on holidays, weekends and warmer months/days and declines in response to rain. Table 6 below summarizes the monthly, daily, holiday and weather control variables for each modeled dataset. Some datasets have missing data for certain winter months when revenue collection does not take place. The coefficients of each variable in these Poisson regression results can loosely be interpreted as the percentage increase in the average visits when the variable is increased by one unit (holding every other variable constant at its own average). Months are indicator variables and represent the average percentage increase in average visitation relative to the base month (March here as it is the first month contained in all datasets). Sunday is the base day of the week and weather variables are treated continuously.

Table 6: Summary of Poisson Regression Parameters[8]

		Boat Fishing	**Dellen. Park**	**Pocket Park 1**	**Pocket Park 2**	**RA Apfel**	**Stewart Beach**	**Seawolf Cars**	**Seawolf Buses**	**Seawall Blvd**	**GISP**	**MISP**
Month	*Jan*	-	-1.19	-	-	-	-	-0.78	-0.51	-0.66	-	-
	Feb	-	-0.99	-	-	-	-	-0.83	-0.42	-0.79	-	-
	Apr	0.79	-0.19	-0.44	-0.49	-0.34	-0.46	-0.14	*0.17*	-0.53	-0.14	-0.49
	May	2.16	*0.04*	-0.52	-0.13	-0.08	-0.37	-0.03	0.39	-0.60	*-0.02*	-0.37
	Jun	-	0.19	-0.92	-0.37	-0.36	-0.49	0.15	*0.15*	-0.78	-0.04	0.16
	Jul	-	0.31	-1.11	-0.34	-1.06	-0.55	0.23	*-0.16*	-1.03	-0.06	0.50
	Aug	-	*0.05*	-1.42	-0.64	-1.41	-0.94	*0.01*	-0.64	-0.99	-0.47	0.09
	Sep	-	-0.57	-1.67	-0.88	-1.47	-1.50	-0.05	-0.70	-1.28	-0.82	-0.85
	Oct	-	-0.92	-	-	-2.09	-1.53	0.48	*0.20*	-1.13	-	-
	Nov	-	-0.94	-	-	-0.52	-	0.33	0.62	-1.01	-	-
	Dec	-	-1.24	-	-	-	-	-0.10	-0.33	-1.02	-	-
Day of Week	*Mon*	-4.10	-0.79	-0.99	-0.98	-1.21	-0.94	-0.66	-0.78	-0.93	-0.98	-0.82
	Tue	-2.70	-1.04	-1.72	-1.41	-2.28	-1.43	-0.70	-0.56	-1.11	-1.14	-0.92
	Wed	-1.66	-1.02	-1.53	-1.30	-2.15	-1.37	-0.73	-0.70	-1.12	-1.15	-0.92
	Thu	-0.55	-0.87	-1.36	-1.01	-2.04	-1.30	-0.67	-0.37	-1.03	-0.94	-0.85
	Fri	-2.17	-0.27	-1.16	-0.71	-1.71	-1.04	-0.30	0.24	-0.63	-0.76	-0.49
	Sat	-0.58	0.41	-0.02	0.15	0.05	-0.01	0.26	0.24	0.06	0.19	0.44
	Easter	-	0.71	0.77	0.79	0.90	0.85	0.50	*0.02*	0.50	0.61	0.35
	Memorial	-	0.93	0.90	0.81	0.96	0.95	0.60	*-0.01*	0.18	0.83	1.13
	Independence	-	0.47	0.78	0.54	1.02	0.72	0.16	*0.35*	-0.33	0.83	0.49
	Labor	-	0.43	0.95	0.59	1.08	0.86	0.48	-1.02	0.39	0.81	0.75
	Columbus	-	*-0.15*	-	-	1.64	-0.27	-0.13	-1.02	-0.14	-	-
	tmax	0.06	0.02	0.03	0.01	0.03	0.04	0.02	0.02	0.03	0.03	0.03
	preciptotal	*2.38*	-0.51	-1.33	-1.04	-1.15	-0.71	-0.38	-0.44	-0.63	-0.67	-0.28
	watertempmax	-0.10	0.02	0.04	0.05	0.05	0.03	0.00	*-0.01*	0.01	0.01	-
	constant	4.57	-0.32	-1.04	-0.45	0.58	1.09	2.75	*-0.72*	3.29	2.95	3.80

[8] Numbers in italics are not statistically significant at the 95% level. Gulf Island State Park (GISP) and Mustang Island State Park (MISP) are abbreviated.

Full sets of results are presented as appendices to this memorandum. The next sections summarize each of the datasets and associated estimates and extrapolations beginning with Galveston and moving down the coast to Mustang Island and finally Padre Island National Seashore. Details on assumptions, datasets, statistical model results and some discussion of estimation sensitivities are included as appendices.

3.2 Galveston

This section describes the assessment of general shoreline use and recreational fishing use on Galveston Island and the nearby Texas City Dike area.

3.2.1 Shoreline use on Galveston Island

Galveston Island is a popular location for beach recreation including swimming, fishing and sunbathing. In addition to beaches, the Seawall Urban Park contains piers, rocky intertidal and riprap areas for fishing, picnicking and other shoreline recreational activities. Data from city-owned parks, a state park, and municipal parking paid by mobile phone were used to estimate shoreline losses. These data sources only cover a subset of impacted recreation areas. Information from these estimates and the attributes of the remaining shoreline segments were used to extrapolate to losses for the remainder of the island.

3.2.1.1 City Parks Data

The Galveston Island Parks Board provided up to seven years of daily revenue data from seven pay-parking locations (six beach, one fishing-pier/picnic-area). The total daily values reveal estimates of the number of cars entering the park on a given day using the published cost-per-car parking fee values at each park. Lower-bound estimates of cars parked at each park each day are daily revenue divided by the undiscounted cost-per-vehicle. These vehicle entry fees are $8 with the exceptions of Seawolf Park, where cars are $6 and buses are $10, and Dellenera Park, where RVs follow a seasonal pricing system ($41 for winter, $47 for winter holidays, $46 for summer and $52 for summer holidays) and the appropriate price is applied to each vehicle type and season. There are discounts for seniors, children, and veterans at some parks, but there is insufficient available information to adjust the estimates for these categories. This omission may undercount use on any given day.

It is possible to gain entry to these parks with an annual pass. The initial purchase of an annual pass at $25 is recorded in daily revenue (and distributed across all parks), but subsequent visits are not reported. Anecdotal discussions with park staff indicated that roughly 25% of daily visitors already have annual passes and are not included in the revenue data. Thus, a 25% increase is applied to both baseline and spill-period estimates to account for this use and no adjustment is made to net out the initial purchase of a pass.

It is also possible to access these parks on foot without paying a fee. Specifically, RA Apfel and Stewart Beach each have designated free parking areas outside the entrances to the parks, while many of the other parks have free parking, hotels, and/or residential areas in close proximity. Since walk-on users do not pay a fee to access city parks, they are not included in the revenue data and the resulting estimates of use. Given a lack of available data to estimate the number of walk-on users, no explicit adjustment is made to account for these user days. For this reason, it is likely that the estimates of recreational use are conservative and may underestimate actual park visits.

A Poisson regression and full set of control variables was used to estimate baseline at the city parks. The estimate of total lost user days, from March 23, 2014 to April 17, 2014 was 28,367 user days out of a baseline of 43,357 user days, or a 66% loss of visitation. Table 7 shows baseline and loss calculations of car visitation for each park resulting from Poisson regression predictions. Car visits are transformed into user-days by assuming an average party size of 2.5[9] for cars and RVs and 30 for buses. As with the other models in the assessment, the regression models are estimated on data excluding the spill period. There are several missing observations for each of the parks during the spill period. For Stewart Beach, R.A. Apfel, and Seawolf Parks these are primarily due to known closures. For the other parks, it is unclear whether these were days at which park personnel were not present to collect revenue or whether visitation was indeed zero on those days. Galveston City Park managers indicated that staff are placed at parks on any days they expect to receive visitors. Thus, all missing observations during the spill and baseline periods are treated as zero visitation days. It is possible that some visitation did occur on these missing-data days at non-closed sites during the spill period, however the magnitude is unknown and thus no adjustment is made to include these visits.

Another analytical decision for these data is whether to pool the data or not (a single model with individual constant parameters for each park versus individual models for each park). There are potential reductions in statistical uncertainty from pooling the data, but using cross-validation[10] to examine model predictions, the individual models exhibit lower error rates. Consequently, the results in Table 6 are from individual Poisson models where each park has its own parameter estimate for each of the control variables described in the previous section.

Table 7: Galveston City Parks, March 23 to April 17, 2014

Park	**Vehicles**		**People Per**	**Annual**	**User Days**		**%Loss**
	Baseline	**Lost**	**Vehicle**	**Passes**	**Baseline**	**Lost**	
Dellenera Park	129	42	(x2.5)	25%	403	131	32%
Pocket Park 1	997	603	(x2.5)	25%	3,115	1,883	60%
Pocket Park 2	191	140	(x2.5)	25%	596	438	74%
RA Apfel	3,082	2,494	(x2.5)	25%	9,633	7,795	81%
Stewart Beach	5,999	2,359	(x2.5)	25%	18,746	7,370	39%
Seawolf Park Cars	3,344	3,307	(x2.5)	25%	10,451	10,336	99%
Seawolf Park Buses	14	14	(x30)		413	413	100%
Total	**13,756**	**8,959**			**43,357**	**28,367**	**66%**

[9] This value is below estimates found elsewhere such as 3.08 people-per-car for the Gulf of Mexico region weighted average for single-day trips from the Deepwater Horizon Spill Assessment using the Local Valuation Survey (Department of the Interior, 2016).

[10] A standard model selection process is described in more detail in Appendix 7.1.

3.2.1.2 Galveston Island State Park

Galveston Island State Park (GISP) is an approximately 2,400 meter stretch of beach roughly halfway down Galveston Island. TPWD collects visitation data for GISP. Estimates of baseline use were generated using data collected from March through September, 2011 to 2015. The GISP data were recorded as individual person counts. GISP allows for both day and overnight visitation and thus these entrance types are counted separately. This assessment included losses only for day visitation as there were no significant changes observed in the overnight data. Visitors recorded as TPWD employees were included in the estimates because these are recreational visits by staff rather than work visits.

As with the City parks, a Poisson regression and full set of control variables was used to estimate baseline at GISP. The estimate of total lost user days, from March 23, 2014 to April 17, 2014 at GISP is 516 out of a baseline of 4,879, or 11% loss of visitation (see Table 8). One caveat for this estimate involves a unique result from GISP on a single day, March 29, 2014, which was a special event: the first annual "Beach and Bay Day." This event received significant promotion and all entry fees were waived from 8:00am – 4:30pm[11]. For this event, the park received 833 daytime visitors while the statistical model predicts a baseline visitation of 470, leading to a net 363 user day reduction in estimated losses for the spill period. This single day nets out approximately 50% of the lost user day estimate at GISP. There is no principled approach to correcting for this likely source of error. Having no pre-spill data to train the model on this unique event, any attempt to account for this outlier in the estimation would not be consistent with the approach used throughout the assessment. This event is included in the data without adjustment with the acknowledgement that this will lead to a non-trivial but unquantified downward bias in the estimated losses for GISP. This event may also affect the extrapolation for beaches southwest of GISP, as described in the extrapolation section below. There are likely other such special events in the data that may explain outliers but the impact of such events may affect estimates positively or negatively and the net effect of all such events is unknown.

Table 8: Galveston Island State Park, March 23 to April 17, 2014

Day Use Visitors			% Loss
Baseline	**Spill**	**Lost**	
4,879	**4,363**	**516**	**11%**

3.2.1.3 Seawall Boulevard Parking

An additional dataset for Galveston Island general shoreline use applies to Seawall Boulevard. These data are from a paid parking area along Seawall Boulevard, immediately adjacent to an approximately 2,400 meter length of shoreline composed of beach, rocky intertidal and piers. There is significant recreation along this stretch of shoreline including swimming, sunbathing, wading, and fishing. There are potentially resource-independent purposes for parking along the Seawall (such as visiting shops and restaurants opposite the shoreline) but many of these activities, although they may not involve physical contact with the shoreline or water, are indeed resource dependent (e.g., enjoying a Gulf view from a restaurant patio is an interaction with

[11] Personal communication with Trey Goodman, Park Superintendent, Galveston Island State Park.

Trust resources). For purposes of this assessment, individuals choosing not to visit the Seawall due to the spill are appropriately recorded as lost user days due to the spill. Trips with no dependence on the resource should be invariant to the spill. Therefore, it is appropriate to include empirical declines in parking along Seawall Boulevard as lost use attributable to the spill.

The data for analyzing the losses along Seawall Boulevard are collected by the City of Galveston and include records of daily cell phone parking transactions (credit card payments made by cell phone from July 1, 2013 to April 30, 2015 including time parked, amount charged, and license plate numbers). Observations representing charges for annual passes were excluded, as well as any charges for parking longer than 12 hours in order to focus on single-day visits to the shoreline (consistent with the treatment of GISP). Counts of vehicle visits were generated by identifying transactions with unique license plates on a given day regardless of the number of transactions. That is to say, there are observations of multiple transactions on some days for some license plates and these were treated as one vehicle visit.

As with the other City Parks, it is possible to park for free with an annual pass (and thus not generate a transaction in the database). A 25% adjustment was applied to account for these visits. Additionally, although the City of Galveston estimates that parking fee compliance is only at 56% (Barnett, 2015), the source of this estimate is unclear and no adjustment was made for non-compliance.

A full set of control variables was used in a Poisson regression to model Seawall Boulevard parking. The model estimated 2,870 vehicle visits lost along the Seawall out of an estimated baseline of 9,545, or a 30% loss of visitation. Applying the person per car (2.5) and annual pass multipliers (25% adjustment) generates an estimate of 8,968 lost user days along Seawall Boulevard during the spill period (see Table 9).

Table 9: Seawall Boulevard, March 23 to April 17, 2014

Vehicles		People Per Vehicle	Annual Passes	User Days		% Loss
Baseline	**Lost**			**Baseline**	**Lost**	
9,545	2,870	2.5	25%	29,828	**8,968**	**30%**

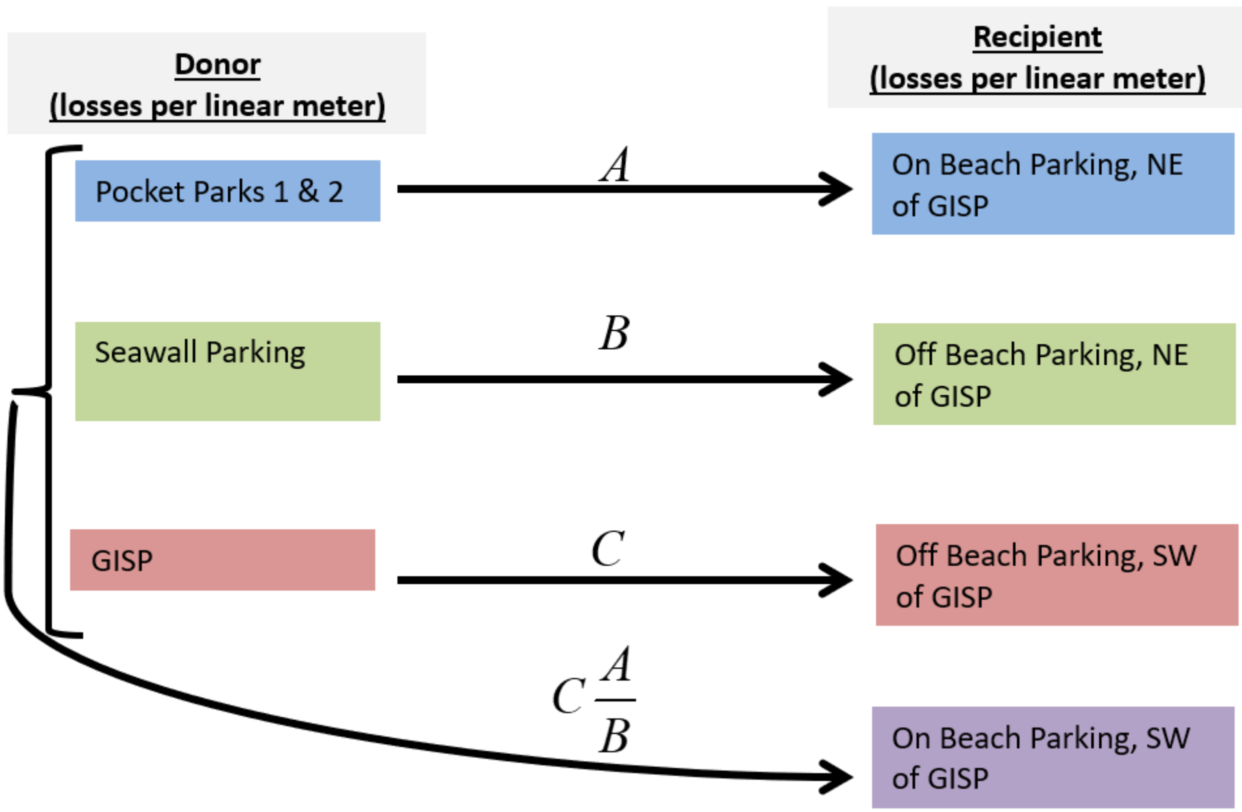
3.2.1.4 **Extrapolation**

As mentioned above, available datasets do not provide full spatial coverage for Galveston Island. Completely accounting for losses along the Galveston shoreline necessitates extrapolating from these data to portions of Galveston which do not have data. The extrapolation used estimated losses per linear meter of shoreline[12] from segments with data (donors) and applied these same loss rates onto similar segments without data (recipients). Spatially, recipient segments were divided into two regions: northeast (NE) of GISP or southwest (SW) of GISP. Within each

[12] The Trustees used length calculations for beach segments provided by RP representatives (*TCY_RP_Segments_Calculations.xls*).

region, beaches either have or do not have on-beach parking. Following a site investigation[13], it appeared that this attribute is important in explaining beach visitation. This spatial and attribute partition leads to four recipient categories of beach length: NE of GISP with on-beach parking; NE of GISP without on-beach parking; SW of GISP with on-beach parking; and SW of GISP without on beach parking. The donor segments were: Dellenera and Pocket Parks 1 & 2; Seawall Boulevard; GISP. The fourth category of recipient losses was calculated using the losses per meter in GISP reduced by the ratio of losses on the Seawall to those from the average of Dellenera and the Pocket Parks. The figure below demonstrates the extrapolation plan diagrammatically with the letters A, B and C representing the respective lost user days per linear foot calculations; Table 10 summarizes the results of this extrapolation. Based on the extrapolation, there were 11,084 lost user days for the areas in Galveston which do not have original data.

Figure 4: Extrapolation on Galveston Island



[13] A site visit to Galveston, TX was performed to evaluate recreational access points affected by the spill. The site visit on March 27-28, 2015 was timed to coincide with the anniversary of the Texas City Y injury to allow proper inferences to be made about baseline visitation in the area. Information was also collected from concessionaires and park entrance fee collectors to better understand seasonal/daily use patterns, how revenue is collected, and alternative ways to access coastal resources in the area.

Table 10: Extrapolation on Galveston Island

Donors					
Location		**Donor ID**	**Meters**	**Lost User Days**	
				Total	**Per Meter**
Pocket Parks and Dellenera		A	1,193	2,452	2.1
Seawall Blvd		B	19,760	8,968	0.5
GISP		C	2,412	516	0.2
Recipients					
Location	**Parking Access**	**Donor**	**Meters**	**Lost User Days**	
				Per Meter	**Total**
NE of GISP	On Beach	A	686	2.1	1,410
	Off Beach	B	17,102	0.5	7,761
SW of GISP	Off Beach	C	6,011	0.2	1,285
	On Beach	C x (A / B)	13,284	0.05	627
Total			**37,083**		**11,084 (21% loss)**

3.2.2 Fishing and Boating on/near Galveston Island

Galveston and surrounding areas, such as the Texas City Dike, support popular sport and tournament fishing recreation. The Trustees assessed losses to boat-based recreational fishing (based on data collected at boat ramps) as well as losses to known shoreline fishing locations (based on data collected at wade banks).

3.2.2.1 Boat Ramps

Roving counts and onsite intercept interviews (collected by TPWD) were used to produce estimates of recreational boating losses due to the spill. The data are 'roving' counts of empty trailers and boat slips at selected sites. Unlike the shoreline datasets described in previous sections, these roving data are instantaneous counts conducted on a sub-sample of days. Although these features present analytical challenges, the data are sufficiently varied across time and conditions to provide a reliable source of information to estimate baseline and determine lost user days for boating recreation. The data provided contain observations from March, April and May beginning in April 2008 and were collected from 84 sites, including 12 sites which were at least partially closed following the spill.[14]

The baseline boat model used the same calendar, weather and holiday controls used for beach use on Galveston, and additionally uses the hour of the day that instantaneous counts were conducted. The model pools observations from all sites impacted during the spill, but omits data from the remaining unaffected sites. This omission of non-impacted sites was based on cross-validation and is discussed further in appendix 7.1. The impacted sites were pooled because the lower frequency of data collection in roving counts prevents identification of individual models for some sites when estimated separately.

[14] One of the sites experiencing closures (the Schaper Public Ramp, designated site 26) was not included in damages calculations as it had been already scheduled for closure unrelated to the spill. Although excluded from damages calculations, this site was used in the pooled baseline model.

As the data used to model boating recreation are from instantaneous counts, there is a remaining step to convert predictions and losses from instantaneous counts into daily values. There are a few potential approaches to this conversion and the methodology used here exploits the fact that the timing of both the counts and interviews is known. Interview data were collected between 8am and 6pm. We assume that this data collection window encompasses approximately all visits in a day. The interview timestamps are combined with duration information to estimate the percent of total daily boat trips that are taking place at a given hour of the day. For example, the interview data collected during the 9am-10am window estimates that an instantaneous count during that window will observe 70% of the day's total visitors. Since the majority of the instantaneous counts cluster around this time window (i.e. 88% of the counts occur between 8-11 am) this value is used to convert instantaneous counts into total daily boat trips. Thus, in the model, the instantaneous count was multiplied by 1/0.7 or 1.43 to obtain an estimate of total daily boat trips which was then multiplied by 2.6, the average party size in interview data from affected sites, to generate an estimate of boating user days.

The approach above turned the instantaneous count into a full day estimate of boating user days. A final step interpolated the use during the spill period for days on which a roving count was not conducted. For days when a site was reported closed, the use level was counted as a zero. If a site was open but a count was not conducted that day and a count was conducted on at least one day of the spill-period of the same day type (month and weekday/weekend[15]) then the average value of those spill period day type counts is used for the count that day. With the interpolated counts completing the counts during the spill, lost user days were calculated as the difference between baseline and actual user days, summarized in Table 11. There were a total of 2,442 lost boat user days.

Table 11: Galveston Bay Boating

	Instantaneous Count	Boat Trips (x1.43)	Boat User Days (x2.6)
Baseline	1,074	1,536	3,979
Spill	415	595	1,537
Lost	659	941	**2,442**
			(61% loss)

3.2.2.2 Galveston Bay Shore Fishing (Wade Bank Sites)

TPWD roving counts and interviews at wade bank sites provided estimates of recreational shore fishing losses due to the spill. These data are similar in structure to the data used to estimate boating losses, but were only collected in 2013 and 2014. Due to the smaller size of this dataset, the baseline was not constructed from a Poisson regression model because there was insufficient data to estimate a reliable regression model. For this reason, the baseline consists only of conditional means reported from 2013 (conditional on weekend/weekday and month, for each

[15] The weekend/weekday distinction is for the interpolation only and driven by the relatively small number of spill-specific roves. The baseline estimation model includes the full day of week controls as used for shoreline estimates.

impacted site). The nature of these data and lack of control variables introduces uncertainty in the shore fishing loss model, but these data are the best available to determine loss.

Count data for wade banks does not contain timing data and so the method used to expand instantaneous predictions to user days for boat ramps was not feasible. An alternative multiplier for wade banks is constructed from the interview data using the average percent of individuals present at any given hour of the day. This average percentage across the day for wade bank interviews is approximately 34%, resulting in a multiplier of 2.9. An interpolation of use during spill-period days without counts (identical to methodology applied to boat ramps) estimated 1,483 lost user days, summarized in Table 12.

Table 12: Galveston Bay Shore Fishing (Wade Bank Sites)

	Instantaneous Count	User Days (x2.9)
Baseline	1,952	5,721
Spill	469	1,375
Lost	1,483	**4,346 (76% loss)**

3.2.3 Non-Fishing Shoreline Use on Texas City Dike

Since the TPWD wade bank surveys are intended to capture fishing pressure, they do not count individuals not engaged in recreational fishing but engaged in other recreational shoreline use. Thus, any additional non-fishing recreational shoreline use on the Texas City Dike is not reflected in the wade bank estimates above. These users were similarly affected by the spill and closure of the Texas City Dike and are incorporated into this assessment using counts conducted by RP representatives. These RP generated data include roving counts recording individuals engaged in fishing and non-fishing recreation. By calculating the ratio of non-fishing recreation to fishing recreation on the Dike for each count/location pair, an adjustment can be made to the wade bank estimates above. The average of these ratios is 1.37 non-fishing users for each fishing user. This adjustment was applied to wade bank fishing predictions and losses on the Dike, and is an additive component of damages. Based on the adjustment, there are an additional 3,873 estimated lost users days for non-fishing shoreline use on the Texas City Dike (see Table 13).

Table 13: Non-Fishing Shoreline Use on Texas City Dike

	Fishing	Non-Fishing (x1.37)
Baseline	3,621	4,966
Spill	797	1,093
Lost	2,824	**3,873 (78% loss)**

3.3 Mustang Island

Mustang Island is approximately 170 miles southeast of the spill and experienced limited oiling several days after the spill. Mustang Island State Park (MISP) comprises approximately one third of the island length, the remaining is beach area publically accessible from the town of Port

Aransas, Texas. Models of MISP visitation data generate estimates of lost user days and are then extrapolated to the remainder of the beach length.

3.3.1 **Mustang Island State Park**

MISP is an approximately 11,000 meter stretch of beach comprising the southern third of Mustang Island. MISP is a popular recreational site supporting Trust resource dependent activities such as swimming, surfing, fishing and bird watching. This assessment uses MISP individual visitation data (collected by TPWD) from March through September for the years 2011 to 2014. MISP has both day and overnight visitation. As with GISP, losses were only estimated for day visitation as there were no significant changes observed in the overnight data. The estimation procedure for MISP is similar to that used for Galveston Island, with the exception that there are no available controls for water temperature and a different spill period is applied. The spill period for Mustang Island (March 30, 2014 to April 7, 2014) is based on the timing of response actions. The estimate of total lost user days at MISP is 553 out of a baseline of 1,584, or 35% loss of visitation (See Table 14).

3.3.2 **Mustang Island Extrapolation**

The northern two thirds of Mustang Island is comprised of public-access beaches. As with MISP, these beaches support recreation such as swimming, surfing, kayaking and walking along the beach, with access from a more urban environment. There are no reliable visitation data available for these beaches. Therefore, an extrapolation method was employed to assess losses. The extrapolation took losses per meter from beach segments with data (MISP) and applied these to the remainder beach length. This extrapolation results in 993 additional lost user days (see Table 14).

Table 14: Mustang Island Extrapolation

	Meters	**Baseline User Days**	**Lost User Days**
Mustang Island State Park	10,977	1,584	553
Port Aransas	19,711	2,845	993
Total Mustang Island			**1,546 (35% loss)**

3.4 Padre Island National Seashore

Padre Island National Seashore (PAIS), a unit of the National Park Service, encompasses 130,434 acres, and is the longest remaining undeveloped stretch of barrier island in the world. The National Seashore protects 70 miles of coastline, dunes, prairies, and wind tidal flats teeming with life. It is a safe nesting ground for the Kemp's Ridley sea turtle and a haven for 380 bird species. PAIS is a prime destination for recreational use in southern Texas. The Gulf beach and Laguna Madre allow visitors to fish, camp, bird watch, and swim. Some popular activities include riding bicycles, four-wheel drive vehicle use, picnicking, and observing the hatching of sea turtles.

During the beach closure period of April 1 to 4, 2014 Padre Island National Seashore remained open to the public; however, closures were in effect for beach vehicular use. Although long-term user data is collected for the park, it is only available on a monthly basis. A special effort was made during the beach closure period to count total park use. During this period, 4,282 users entered the park and 49 vehicles turned around at the gate[16] before entering the park.

Lost user days at PAIS cannot be estimated via a statistical model because of the lack of historical daily use data (visitation is only reported monthly). However, the degree of oiling and magnitude of clean-up activities at PAIS were very similar to Mustang Island State Park. Therefore, baseline and lost user days at PAIS were estimated by transferring the percent loss from Mustang Island for the equivalent spill period (April 1 to 4). By dividing the observed visitation by the % of baseline observed on Mustang Island implies an average daily baseline of 1,625 user days during the spill period. This is close to the prior 10-year daily average visitation at PAIS for the month of April (1,729). Using this baseline estimate, there are an estimated 2,217 lost user days at PAIS (see Table 15).

Table 15: Padre Island National Seashore Lost Use, April 1 to April 4, 2014

Estimated User Days During Spill	Mustang Island Loss % 4/1-4/4	Implied Baseline at PAIS	Lost User Days
4,282	34%	6,499	**2,217 (34% loss)**

3.5 Total Lost User Days

The sections above summarize the Trustees' assessment of a total lost user days. The total lost user day estimate, summarized in Table 16, is 63,359.

Table 16: Summary of Lost User Days

Estimation		Lost User Days	% Loss
	Boat Fishing	2,442	61%
	Shoreline Fishing	4,346	76%
	City Parks	28,367	66%
	Seawall Boulevard	8,968	30%
	Galveston Island State Park	516	11%
	Mustang Island State Park	553	35%
Extrapolation			
	Padre Island National Seashore	2,217	34%
	Galveston Extrapolation	11,084	21%
	Port Aransas Extrapolation	993	35%
	Texas City Dike Non-fishing Use	3,873	78%
Total		**63,359**	**40%**

[16] Notices advising visitors of the beach vehicular closure were posted outside the gate.

4 Valuation

The tradeoffs that individuals are willing to make to engage in outdoor recreation are an indication of the value that they place on those activities. When an oil spill affects recreators, their value for those activities diminishes. Recreators can respond to an oil spill in several ways. They may cancel a trip outright and engage in some other activity (lost trips), they may change their destination (substitute trips), or they may still take their planned trip but receive less value due to the oiling (diminished-value trip). Any modification in their behavior caused by the spill reflects a reduction in value.

Recreation behavior is commonly modeled using an approach known as the random utility maximization (RUM) model. By observing the tradeoffs individuals make with respect to different recreation sites and the travel cost associated with accessing them, it is possible to estimate the change in value resulting from impacts to a set of recreation sites. The economic literature shows that these values are site and scenario-specific.

In order to directly value the damages incurred by recreational users due to the Texas City Y Spill, Trustees would need to conduct a survey of a representative sample of users that visit both the affected sites as well as a reasonable set of substitute sites. This survey would collect information on coastal recreation trips as well as a set of demographics, including household income. This direct estimation of a recreational demand model for residents of the entire Texas coast would be a substantial assessment effort.

An alternative approach, known as "benefits transfer," relies on the use of existing studies, data, or other information to evaluate the value lost due to the spill. This approach has been used extensively throughout past NRDAs such as the Athos Spill (2007), the Chalk Point Spill (2002), and the Bouchard B120 Oil Spill (2009). A successful benefits transfer approach requires the identification of appropriate information that best reflects the impacts of the spill in question. This approach should approximately match the results from a primary study (such as the survey described above), if one had been done.

There is existing published research that models recreational beach use in Texas (Parsons, et al. 2009)[17]. This research was published in Marine Resource Economics and utilized survey responses from a probability sample of 884 Texas residents living within three hours of the coast who took 2,692 trips to 65 beach sites over a five month period in 2001. The authors modeled recreation demand using a 'linked' model that separately models site choice decisions alongside trip frequency decisions. This type of model can account for lost, substitute, and diminished value trips and has been utilized widely in other peer-reviewed studies.

Parsons et al. (2009) lists per user-day values for several closure scenarios; however, these scenarios do not match the decline in use observed during the Texas City Y spill. The specific user-day value can vary based on the number of sites that are closed/affected by the spill, as well as the degree to which use declined at those sites. For example, a spill that results in a 100% decline in use across 10 sites will have a larger decline in per-trip value than a spill that results in

[17] This dataset focuses on beach use (including surf-cast fishing), but does not include boating trips.

a 50% decline in use across only five of those sites. To more correctly identify losses due to the Texas City Y spill, RP representatives obtained the original survey data used in Parsons et al. (2009) and provided them to the Trustees. This assessment uses those survey data in the construction of a nested repeated discrete choice model of beach recreation in Texas.

The nested repeated discrete choice approach simultaneously models site choice and participation decisions. Under the RUM hypothesis, an individual i selects recreation site j in participation nest k if it generates the highest utility from the available set of J, K alternatives (maximum of the conditional indirect utility function $u_{jk} = v_{jk} + \varepsilon_{jk}$, where $V = \beta' X$ and X is a vector of observable determinants of choice including travel cost and a full set of alternative specific constants). Assuming that ε is distributed as generalized extreme value, the probability of observing an individual choosing site j,k is (McFadden 1974):

$$\Pr(j,k) = \frac{a_k \exp(\frac{v_{jk}}{\theta_k})\left[\sum_{l=1}^{J_k} \exp(\frac{v_{lk}}{\theta_k})\right]^{\theta_k - 1}}{\sum_{m=1}^{K} a_m \left[\sum_{l=1}^{J_m} \exp(\frac{v_{lm}}{\theta_m})\right]^{\theta_m}},$$

which can also be presented as the product of the conditional probability of choosing site j, given nest k, aggregated across choice occasions, c, times the marginal probability of choosing nest k (Haab & McConnell 2002). This probability is useful for calculating the number of trips predicted to any one site:

$$T_j = \sum_i \sum_c \Pr_{i,c}(j|k)\Pr_i(k).$$

Welfare changes are calculated using a variation of the log-sum formula derived by Hanemann (1978) and Small and Rosen (1981). Given a constant marginal utility of income and an attribute change from q to q^* (assuming no change in the price of access occurs) the expected consumer surplus for individual i takes the form

$$WTP_i = \frac{1}{\beta_{TC}}\left[\ln\left(\sum_{m=1}^{K} a_m \left[\sum_{l=1}^{J_m} \exp(\frac{\tilde{v}_{lm}^*}{\theta_m})\right]^{\theta_m}\right) - \ln\left(\sum_{m=1}^{K} a_m \left[\sum_{l=1}^{J_m} \exp(\frac{\tilde{v}_{lm}}{\theta_m})\right]^{\theta_m}\right)\right].$$

A calibration approach is used to identify the attribute change, q^*, resulting from the spill. This approach adjusts the coefficients on the site constants, $\beta_x x_j$ in a recursive manner until the model's predicted use at an individual site, $\tilde{T}_j$, matches observed percentage declines due to the spill, such that

$$\frac{\left(\tilde{T}_j^* - \tilde{T}_j\right)}{\tilde{T}_j} = \%UD.$$

A similar calibration approach has been used in prior NRDAs, specifically the Cosco Busan (2012) and Deepwater Horizon (2016) lost recreational use assessments.

The estimated WTP_i is an individual-level value per choice occasion, c. In order to appropriately represent damages on a "value per lost user day" basis, the total consumer surplus loss for all recreators must be allocated to the total number of lost user days, such that

$$WTP = \frac{C * \sum_i WTP_i}{\sum_j \left(\tilde{T}_j^* - \tilde{T}_j\right)}.$$

Travel cost models require the analyst to specify several inputs related to the price of traveling to each recreational site in the model. Travel cost for a site/origin pair is defined as:

$$TC_{i,j} = 2 \times miles_{i,j} \times \frac{permilecost}{partysize_n} + 2 \times hours_{i,j} \times \frac{HHincome_i}{2080} \times \frac{1}{3},$$

where $miles_{i,j}$ is the one-way driving distance to a site, $permilecost$ is the marginal per-mile driving cost, $partysize_i$ is the number of people traveling together, $hours_{i,j}$ is the one-way driving time to a site, and $HHincome_i$ is annual household income.

Trustees followed a standard approach in construction of the travel cost variable and use inputs common in published literature and prior NRDAs. Driving distances between respondent origins and destinations were constructed for the original NPS survey using MileMakerPC, and those values are used here without modification. Marginal per-mile driving cost is drawn from AAA's annual report titled "Your Driving Costs" for 2001[18] and is the sum of the average operating costs (gas & oil, maintenance, and tires) and the average per-mile depreciation cost[19]. These two components comprise per-mile out-of-pocket costs, which are then allocated across all individuals in the vehicle using the average of individual-reported group size[20]. The sample mean party size is used for non-participants. Opportunity cost of time (the second component in the equation above) is the product of the driving hours (taken directly from the original study without modification) and 1/3 hourly household income[21].

The magnitude of the change in use at affected sites informs the magnitude of the welfare loss due to the spill. Since impacts due to the Texas City Y spill varied by location and magnitude,

[18] 2001 was the year the survey was conducted and the AAA value from 2001 represents the costs the respondents faced when making recreation decisions.

[19] AAA changed their approach to calculating per-mile depreciation in 2008, which produces a lower value. Trustees used the 2008 per-mile depreciation value and adjusted it to 2001 using the Consumer Price Index. The per-mile value used in the analysis is 16.7 cents.

[20] A small number of respondents in the original survey report large group sizes (max=73), possibly indicating that individuals traveled in multiple vehicles. Trustees adopted the Texas City Y RP's proposed cap of four adults per vehicle, with a total group size cap of 5.68. Given the small number of affected observations, the ultimate result on per-trip value of this adjustment is a negligible increase.

[21] Survey data provided by the RP did not include income values for the 323 respondents who did not report taking trips. Trustees imputed those individuals' income using a truncated linear regression (lower limit=0) of reported income on log age, Spanish, college, fulltime employed, female, owns a pool, and owns surf-cast fishing gear variables.

several independent valuation scenarios were run for these different spill periods. To account for the three regions and overlapping spill periods presented in Table 4, observed declines in user days were aggregated across regions (Galveston, Mustang, and Padre Islands) and five independent sub-spill periods. These five sub-periods were bounded by the dates of each of the respective spill periods and are presented in Table 17. The dollar value losses were then evaluated for each sub-period independently, and for comparison across all regions simultaneously.

Table 17: Loss Percentages for Calibrating Valuation Model

Sub-Period		Baseline	Loss	Percent Loss		
3/23/14-3/29/14	Galveston	42,919	21,677	51%		
3/30/14-3/31/14	Galveston	14,884	5,095	34%	35%	
	Mustang	1,182	456	39%		
4/1/14-4/4/14	Galveston	17,164	6,439	38%	36%	40%
	Mustang	1,732	601	35%		
	Padre	6,499	2,217	34%		
4/5/14-4/7/14	Galveston	20,146	11,013	55%	53%	
	Mustang	1,515	489	32%		
4/8/14-4/17/14	Galveston	50,483	15,371	30%		

For example, in the first sub-period, a 51% decline in use was applied to all sites in Galveston. To calculate damages for that region/period, the resulting value per lost user day was then multiplied by the 21,677 observed lost user days in this region/period. The second sub-period modeled a 35% decline across all sites in Galveston and Mustang. The resulting value per lost user day was then multiplied by the 5,551 observed lost user days in this region/period. Damages across the five period/region combinations are additive.

Results are shown in Table 18 below. The Benefits Transfer column utilizes the most equivalent per-user day values from Parsons et al. (2009) and is included for comparison. The values are drawn from the authors' loss-per-trip ratios from the multinomial logit model for the "All Beaches in Galveston," "All Beaches in Corpus," and "All 6 PI Beaches" scenarios. Model 1 is the result of the 5 region/period combinations. For comparison, model 2 is the result of estimating region and period-wide damages in a single model. All dollar values are updated to 2017 using the Consumer Price Index (CPI). The CPI is a measure of the price level of a representative basket of consumer goods and services. Measured and reported by the Department of Commerce's Bureau of Labor Statistics, the CPI allows an adjustment for the change in nominal prices over time.

Table 18: Valuation Model Results

<table>
<tr><th colspan="2" rowspan="2">Sub-Period</th><th colspan="2">Model 1</th><th colspan="2">Model 2</th></tr>
<tr><th>% loss</th><th>WTP_{ld}</th><th>% loss</th><th>WTP_{ld}</th></tr>
<tr><td>3/23-3/29</td><td>Galveston</td><td>51%</td><td>$26.03</td><td rowspan="5">40%</td><td rowspan="5">$25.84</td></tr>
<tr><td>3/30-3/31</td><td>Galveston
Mustang</td><td>35%</td><td>$23.62</td></tr>
<tr><td>4/1-4/4</td><td>Galveston
Mustang
Padre</td><td>36%</td><td>$25.62</td></tr>
<tr><td>4/5-4/7</td><td>Galveston
Mustang</td><td>53%</td><td>$24.26</td></tr>
<tr><td>4/8-4/17</td><td>Galveston</td><td>30%</td><td>$24.77</td></tr>
</table>

5 Total Recreation Use Damages

Damages were calculated by multiplying the lost value per lost user day from Model 1 with the respective numbers of lost user days. This value was adjusted to 2017 using the CPI; however, it must still be adjusted for the social rate of time preference for environmental goods.

The social rate of time preference for environmental goods reflects injury to the public from impairment to an environmental resource that remains uncompensated. Even though the assessment assumes actual user day impacts ended April 17, 2014, the interim losses have remained uncompensated since that time. Empirical social rates of time preference (or discount rates) vary, but NRDAs have commonly adopted a 3% annual rate. From 2014 to 2017, this amounts to an adjustment factor of 1.09.

The combination of the two adjustments means that lost recreational use damages from the spill, based on 63,359 lost user days, are $1,739,885 ($2017). Table 19 shows the breakdown of damages by region. These values will be updated at the time of compensation.

Table 19: Damages Summary

Region	Lost Trips	Damages
Galveston Area	59,595	$1,636,262
Mustang Island	1,546	$41,560
Padre Island	2,217	$62,063
Total	**63,359**	**$1,739,885**[22]

[22] This damages value is compounded and adjusted for inflation to June, 2017, when the analysis was last revised.

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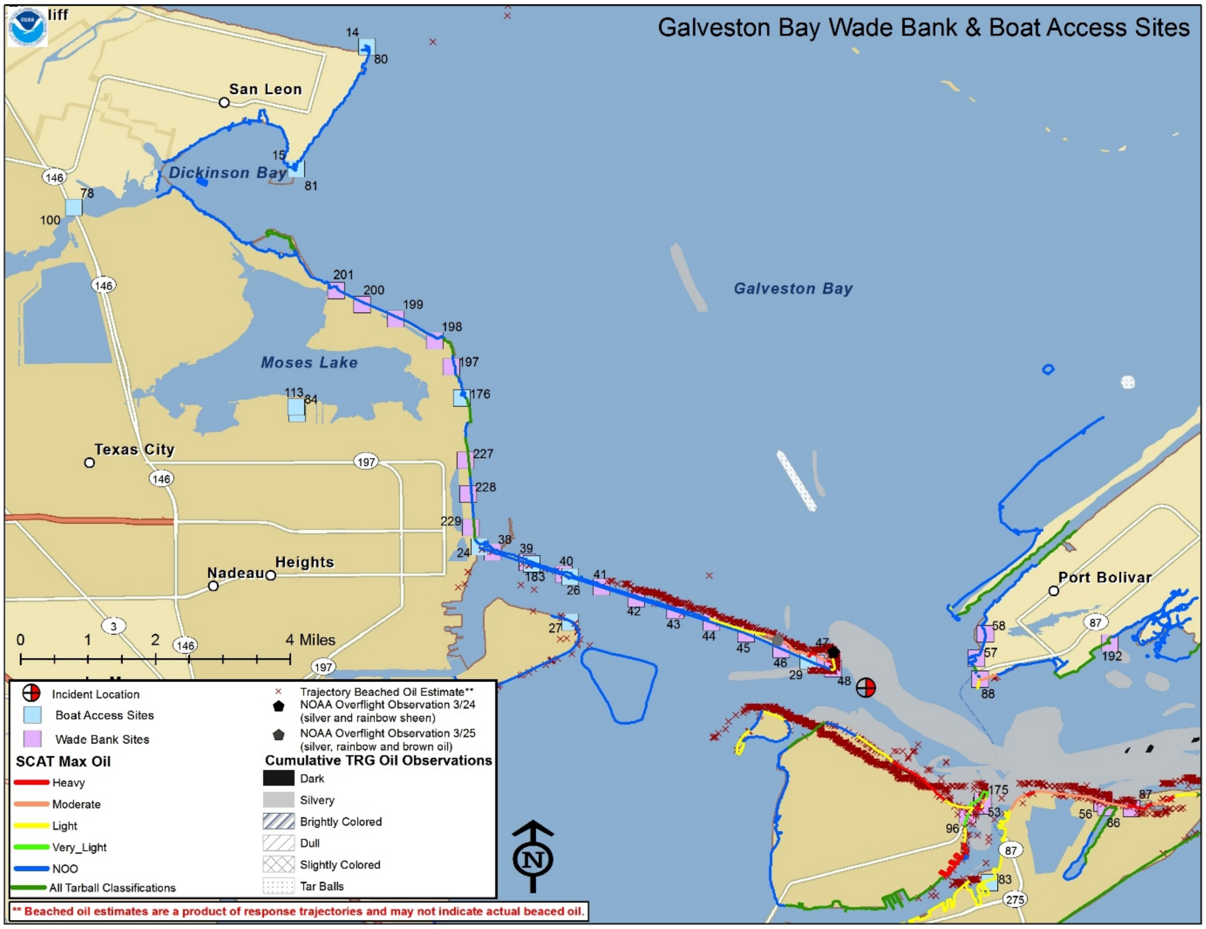
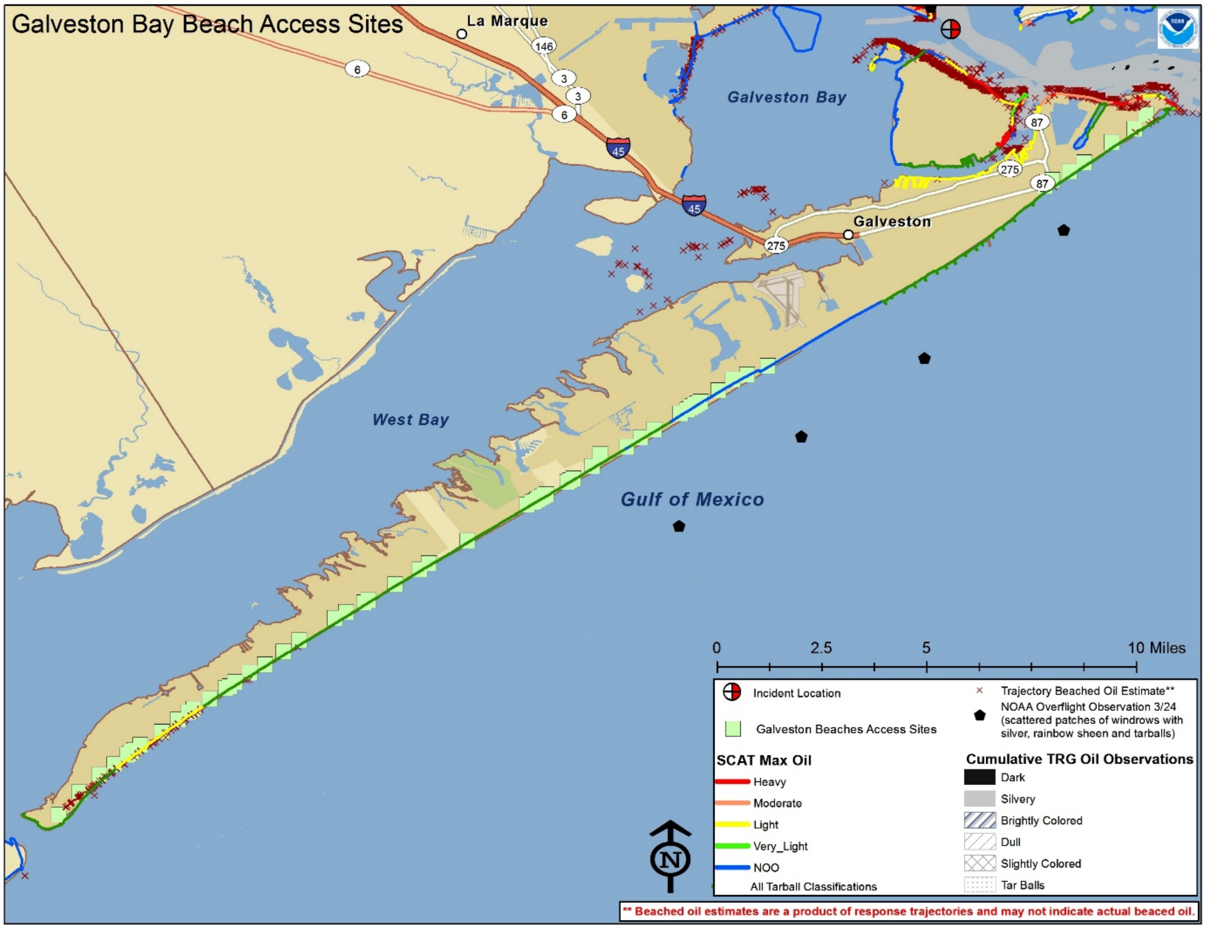
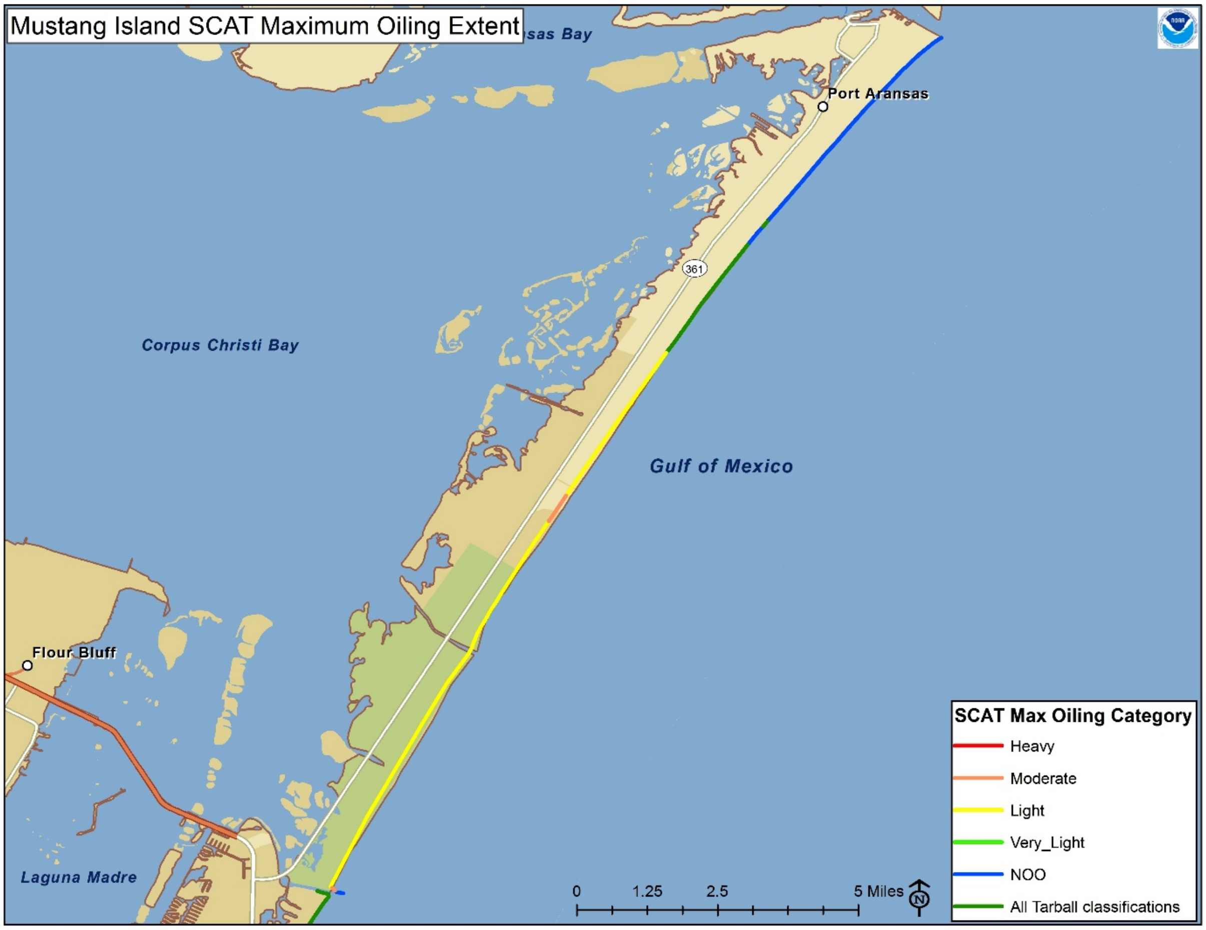
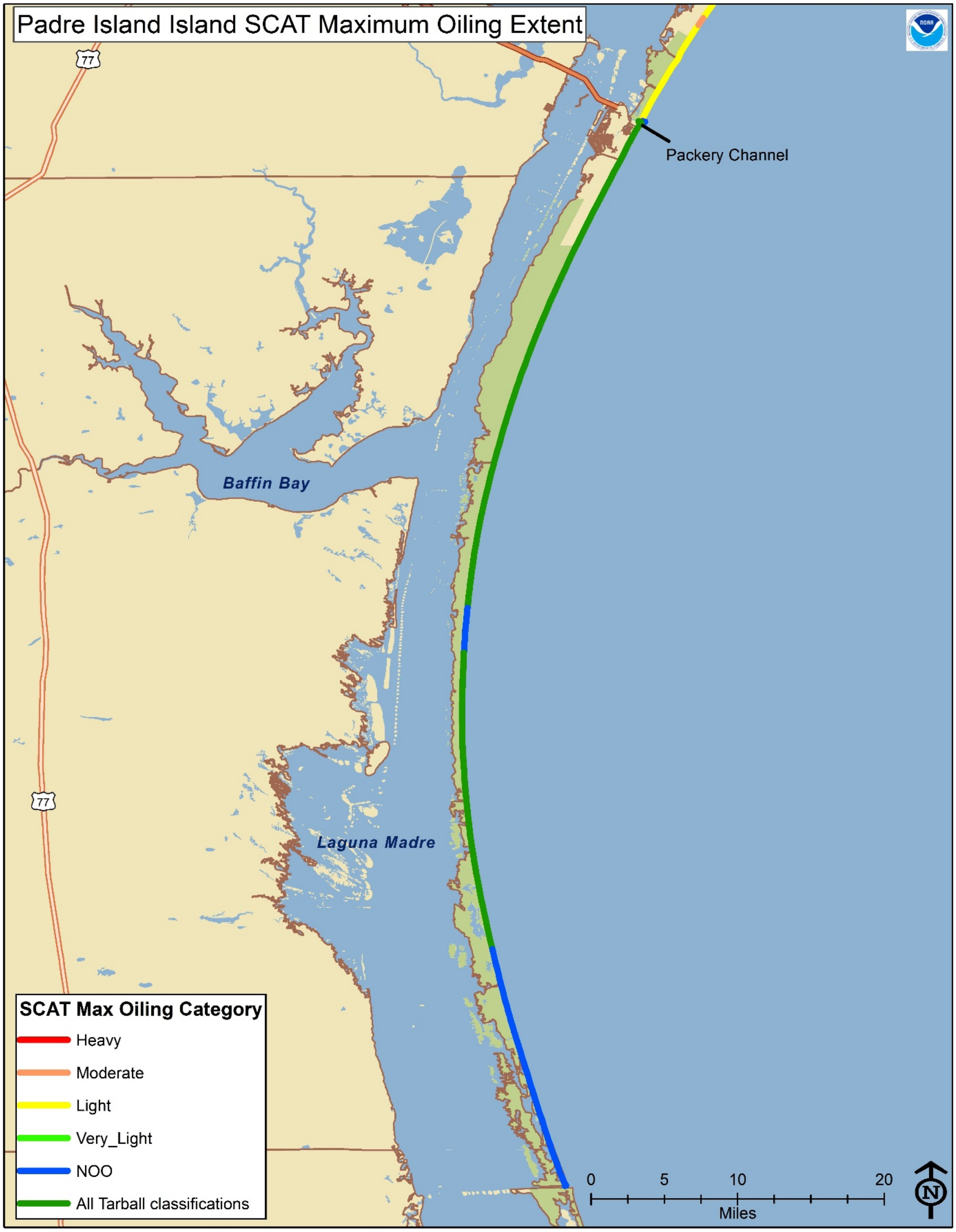
7 Appendices

7.1 Maps




Galveston Bay Beach Access Sites
La Marque
Galveston Bay
Galveston
West Bay
Gulf of Mexico
0
2.5
5
10 Miles
Incident Location
Galveston Beaches Access Sites
Trajectory Beached Oil Estimate**
NOAA Overflight Observation 3/24 (scattered patches of windrows with silver, rainbow sheen and tarballs)
SCAT Max Oil
Heavy
Moderate
Light
Very_Light
NOO
All Tarball Classifications
Cumulative TRG Oil Observations
Dark
Silvery
Brightly Colored
Dull
Slightly Colored
Tar Balls
N
** Beached oil estimates are a product of response trajectories and may not indicate actual beaced oil.


Mustang Island SCAT Maximum Oiling Extent
Port Aransas
Corpus Christi Bay
Gulf of Mexico
Flour Bluff
Laguna Madre
361
0
1.25
2.5
5 Miles
SCAT Max Oiling Category
Heavy
Moderate
Light
Very_Light
NOO
All Tarball classifications

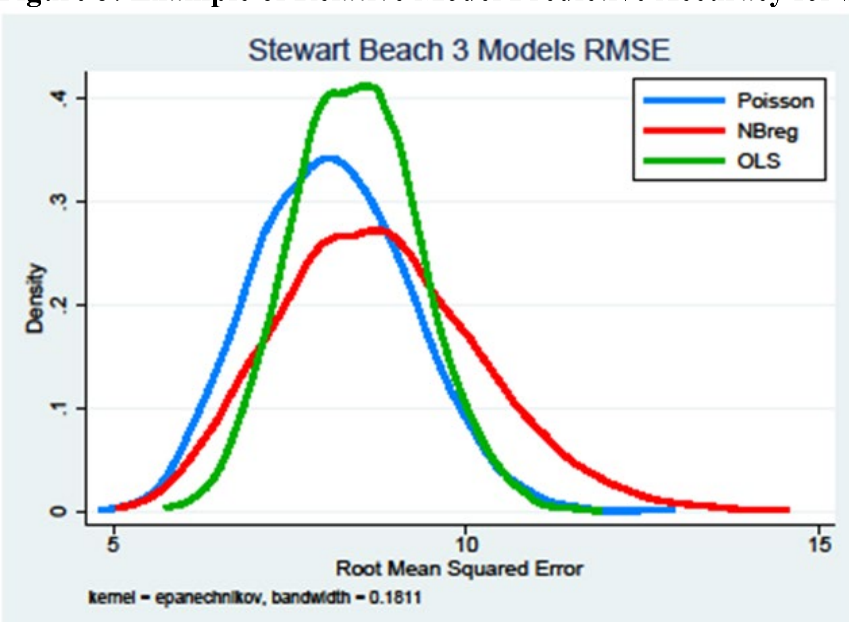

Padre Island Island SCAT Maximum Oiling Extent
77
Packery Channel
Baffin Bay
Laguna Madre
77
SCAT Max Oiling Category
Heavy
Moderate
Light
Very_Light
NOO
All Tarball classifications
0
5
10
20
Miles
N

7.2 Model Details and Sensitivities in Results to Model Decisions

This appendix discusses several of the modeling decisions for the analysis presented in the main text. The results presented in this technical memorandum are the preferred estimates of loss. This section does not record an exhaustive list of all possible modeling decisions as that would be impractical given the extent of the data and possible analytical choices.

As mentioned above the Poisson regression models produced a statistically estimated baseline for each dataset. The Poisson is a very commonly used model of count data (observations which take only whole-number values). The Poisson model has advantages in the ease of its estimation and the interpretability of regression coefficients as representing approximate percentage changes in probabilities of outcomes (count) as an explanatory variable increases by 1%. But the Poisson model is somewhat restrictive in that the model forces the variance of the error distribution to be equal to its mean. These tradeoffs led to the consideration of alternative models, particularly the Negative Binomial and Ordinary Least Squares Linear Regressions. Cross-validation is a useful tool to select the model for predictive performance. In cross-validation, a subset of the data is excluded from estimation and the excluded values are used to evaluate the predictive performance of the model, typically by calculating the square root of the mean squared differences between the predicted and actual values (RMSE). Across many of these comparisons model selection and variable choice relied on reducing RMSE. One example of the general results from these investigations is included in the graph below.

Figure 5: Example of Relative Model Predictive Accuracy for Stewart Beach



The cross-validation in the graph above begins by dividing the Stewart Beach dataset into 10 randomly assigned partitions and using the remaining nine to predict each other in turn and recording the RMSE for each. Then, by repeating this process 500 times, a distribution of the RMSE calculations emerges for each model. As was generally the case with all datasets and numerous permutations to these criteria, not only did the Poisson lead to average lower RMSEs but the distribution of the RMSEs for Poisson was uniformly lower, meaning that the model performs better on average and also has lower probabilities for larger errors than the Negative Binomial. This combined with the fact that errors for the Negative Binomial were generally positive (overestimation of visitation) led to the preference of the Poisson over the Negative Binomial. The graph does not present such a strong case against the Linear Regression; the preference over the Linear Regression was driven by the common outcome that predictions from the linear regression were too often outside the possible range, that is, below zero. Combining a preference for parsimony with the desire to produce practical and useful estimates led to the decision to proceed with Poisson models.

Beyond the overall model used, analysts must choose how to treat individual variables. The preferred approach was to treat continuous variables as linear and categorical variables with individual indicator values (1 if true, 0 if not, often referred to as ‘dummy variables’). The linear treatment of temperature in the main text bears some investigation as increases in temperature may not always lead to increased visitation (i.e. there could be days which are ‘too hot’). Possible non-linearities in temperature led to the investigation of a 5ºF categorical variable specification as well. The net change for boating (as an example) is an increase in lost user days of 84% above the estimate in the main specification (an additional 2,049 user days). The same sensitivity for Seawall parking led to a 16% increase in lost user-days (467) and for the city parks the categorical model led to a 5% increase in lost user-days (1,390). Quadratic and logarithmic specifications also did not appear to improve model fit with the former leading to an increase in lost user day estimates and the latter leading to results very close to the linear specification. The choice of the linear specification maintained a consistent approach across datasets and maintained parsimony but there remains a possibility that this analytical decision leads to a substantial downward bias in boat ramp losses.

Another analytical decision specific to the boat ramp data involves the definition of the baseline prediction dataset. The main analysis uses information from only sites affected by the spill with individual fixed effects for each site, allowing the analysis to control for individual site attributes. There was a consideration of using the entire set of sites with available data to train the baseline model with the hope of exploiting greater cross-sectional variation to yield more precise parameter estimates. Using cross-validation to evaluate model prediction performance between these two approaches, the error rates were higher in all specifications making use of all site data and so the decision to use only affected sites was made in favor of accuracy over precision.

7.3 Datasets used

This appendix lists (by data category) the filenames of each of the original data files for the construction of analysis datasets.

7.3.1.1 Boat Ramps
GB_BR_INTV.xls
GB_BR_ROVE.xls
GB_BR_INTV_2015.xls
GB_BR_ROVE_2015.xls
Texas City Y oil spill 2014 affected Boat Access and Wade Bank 061914.xls

7.3.2 Wade Banks
GB_WB_INTV.xls
GB_WB_ROVE.xls
GB_WB_ROVE_2015.xlsx
Texas City Y oil spill 2014 affected Boat Access and Wade Bank 061914.xls

7.3.3 Galveston City Parks
ADMISSIONS 2015.xls
Park Admissions 1-15-15 through 9-11-2015.xlsx
R. A. APFFEL GATE ADMISSIONS.xlsx
SB ADMISSIONS 2008-2014.xlsx
SEAWOLF GATE ADMISSIONS.xlsx
SEAWOLF PARK FISHING ADMISSIONS.xlsx
POCKET PARKS ADMISSIONS 2008-2014.xls
DP ADMISSIONS - 2008-2014.xls
SEAWOLF PARK SUB AND SHIP ADMISSIONS.xlsx
RA APFFEL ADMISSIONS 5-20-2014 THRU 12-31-2014.xlsx
PP1 admissions 5-20-2014 thru 12-31-2014.xlsx
PP2 admissions 5-20-2014 thru 12-31-2014.xlsx
Dellanera Park 5-20-2014 thru 12-31-2014.xlsx
Stewart Beach Revenues 5-20-2014 thru 12-31-2014.xlsx
Seawolf admissions 5-20-2014 12-31-2014.xlsx

7.3.4 Water Temperature
CO-OPS_8771341_from_20080101_to_20081231_phys.csv
CO-OPS_8771341_from_20110101_to_20111231_phys.csv
CO-OPS_8771341_from_20120101_to_20121231_phys.csv
CO-OPS_8771341_from_20130101_to_20131231_phys.csv
CO-OPS_8771341_from_20140101_to_20141231_phys.csv
CO-OPS_8771341_from_20150101_to_20150930_phys.csv
CO-OPS_8771450_from_20080101_to_20081231_phys.csv
CO-OPS_8771450_from_20090101_to_20091231_phys.csv
CO-OPS_8771450_from_20130101_to_20131231_phys.csv
CO-OPS_8771450_from_20140101_to_20141231_phys.csv
CO-OPS_8771450_from_20150101_to_20150930_phys.csv
CO-OPS_8771013_from_20080101_to_20081231_phys.csv
CO-OPS_8771013_from_20090101_to_20091231_phys.csv
CO-OPS_8771013_from_20100101_to_20101231_phys.csv
CO-OPS_8771013_from_20110101_to_20111231_phys.csv
CO-OPS_8771013_from_20120101_to_20121231_phys.csv

CO-OPS_8771013_from_20130101_to_20131231_phys.csv
CO-OPS_8771013_from_20140101_to_20141231_phys.csv
CO-OPS_8771013_from_20150101_to_20150930_phys.csv

7.3.5 **Seawall Boulevard**

Apr-14 Individual Transaction Report.xls
Aug-13 Individual Transaction Report.xls
Aug-14 Individual Transaction Report.xls
Dec-13 Individual Transaction Report.xls
Dec-14 Individual Transaction Report.xls
Feb-14 Individual Transaction Report.xls
Feb-15 Individual Transaction Report_1.xls
Jan-14 Individual Transaction Report.xls
Jan-15 Individual Transaction Report.xls
Jul-13 Individual Transaction Report.xls
Jul-14 Individual Transaction Report.xls
Mar-14 Individual Transaction Report.xlsx
Mar-15 Individual TransactionReport (as of mid-day 20150331).xlsx
Jun-14 Individual Transaction Report.xlsx
Sep-13 Individual Transaction Report.xlsx
Sep-14 Individual Transaction Report.xlsx
Master Boat and Wade Bank Counts_140903.xlsx
May-14 Individual Transaction Report.xlsx
Nov-13 Individual Transaction Report.xlsx
Nov-14 Individual Transaction Report.xlsx
Oct-13 Individual Transaction Report.xlsx
Oct-14 Individual Transaction Report.xlsx
Apr 2015.xls
Mar 2015.xls
May 2015.xls

7.3.6 **Galveston and Mustang Island State Parks**

Bus Obj Galveston Visitation 2011-2015.xls
Bus Obj Mustang Visitation 2011-2013.xls

7.4 Regression Estimates

This appendix lists the results, including coefficients and standard errors from Poisson regressions. P-values are indicated by asterisks (*** p<0.01, ** p<0.05, * p<0.1) . Categorical variables such as year, month and day of week (*Dow*) are listed as indicator or "dummy" variables for each value except a reference value, generally the lowest value in the sample. (For example if the first month for which a coefficient is reported is April, then the coefficient for each month is relative to March observations. Three weather variables are treated continuously and linearly; maximum daily temperature (*tmax*), total daily precipitation (*preciptotal*), and maximum daily water temperature (*watertemp_max*).

7.4.1 East Beach/ R.A. Apffel

R.A. Apffel Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
visits	1169	315.7147	613.895	1	7766.25
Year	1169	2011.979	1.921737	2009	2015
Month	1169	5.970915	1.830818	3	11
Dow	1169	2.986313	2.076817	0	6
BeachHoliday	1169	0.2001711	0.7569088	0	5
tmax	1151	85.23284	7.922538	56	100
preciptotal	1156	0.0573832	0.2256599	0	3.63
watertemp_max	1133	80.44946	8.834039	49.3	93.4

R.A. Apffel Poisson Regression

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

2010	-0.0748*** (0.00671)	*Monday*	-1.213*** (0.00605)
2011	-0.230*** (0.00655)	*Tuesday*	-2.277*** (0.0104)
2012	0.0626*** (0.00648)	*Wednesday*	-2.150*** (0.01000)
2013	0.304*** (0.00736)	*Thursday*	-2.039*** (0.00939)
2014	0.137*** (0.00673)	*Friday*	-1.709*** (0.00743)
2015	0.138*** (0.00756)	*Saturday*	0.0456*** (0.00394)
April	-0.335*** (0.00896)	*Easter*	0.900*** (0.00913)
May	-0.0848*** (0.0105)	*Memorial*	0.957*** (0.00740)
June	-0.356*** (0.0131)	*Independence*	1.022*** (0.00835)
July	-1.058*** (0.0145)	*Labor*	1.076*** (0.0109)
August	-1.406*** (0.0150)	*Columbus*	1.639*** (0.0711)
September	-1.465*** (0.0151)	*tmax*	0.0266*** (0.000712)
October	-2.094*** (0.0635)	*preciptotal*	-1.149*** (0.0141)
November	-0.516*** (0.0480)	*watertemp_max*	0.0511*** (0.000658)
		Constant	0.579*** (0.0476)
		Observations	1,117

7.4.2 Stewart Beach

Stewart Beach Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
visits	1543	491.3636	539.0074	1	3753
Year	1543	2011.426	2.232767	2007	2015
Month	1543	6.036293	1.954404	3	10
Dow	1543	2.993519	2.039801	0	6
BeachHoliday	1543	0.1963707	0.7797284	0	5
tmax	1517	84.86618	7.772823	56	100
preciptotal	1530	0.0662333	0.2578955	0	3.73
watertemp_max	1500	80.24976	8.627586	49.3	93.4

Stewart Beach Poisson Regression

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

2009	0.249*** (0.00501)	*Monday*	-0.940*** (0.00414)
2010	0.228*** (0.00545)	*Tuesday*	-1.430*** (0.00530)
2011	0.286*** (0.00493)	*Wednesday*	-1.366*** (0.00518)
2012	0.493*** (0.00489)	*Thursday*	-1.299*** (0.00503)
2013	0.606*** (0.00558)	*Friday*	-1.035*** (0.00425)
2014	0.495*** (0.00502)	*Saturday*	-0.0102*** (0.00305)
2015	0.418*** (0.00569)	*Easter*	0.853*** (0.00662)
April	-0.462*** (0.00595)	*Memorial*	0.949*** (0.00608)
May	-0.365*** (0.00716)	*Independence*	0.715*** (0.00558)
June	-0.486*** (0.00902)	*Labor*	0.858*** (0.00742)
July	-0.552*** (0.00974)	*Columbus*	-0.269*** (0.0326)
August	-0.937*** (0.0102)	*tmax*	0.0419*** (0.000488)
September	-1.499*** (0.00989)	*preciptotal*	-0.705*** (0.00834)
October	-1.529*** (0.0189)	*watertemp_max*	0.0286*** (0.000458)
		Constant	1.088*** (0.0330)
		Observations	1,476

7.4.3 Seawolf Park Cars

Seawolf Cars Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
visits	2402	141.2624	105.6863	1	633.5
Year	2402	2011.704	1.986055	2008	2015
Month	2402	6.5	3.467977	1	12
Dow	2402	3.006245	2.003423	0	6
BeachHoliday	2402	0.1457119	0.718356	0	5
tmax	2295	77.64009	12.4594	36	100
preciptotal	2333	0.0975804	0.3500266	0	4.31
watertemp_max	2352	72.09506	12.73179	41.1	93.4

Seawolf Cars Poisson Regression

Standard errors in parentheses		*** p<0.01, ** p<0.05, * p<0.1	
2009	1.129*** (0.0551)	*December*	0.680*** (0.0131)
2010	1.087*** (0.0551)	*Monday*	-0.664*** (0.00675)
2011	1.006*** (0.0551)	*Tuesday*	-0.700*** (0.00702)
2012	1.190*** (0.0550)	*Wednesday*	-0.732*** (0.00701)
2013	1.222*** (0.0550)	*Thursday*	-0.668*** (0.00687)
2014	1.349*** (0.0550)	*Friday*	-0.298*** (0.00602)
2015	1.386*** (0.0552)	*Saturday*	0.260*** (0.00525)
February	-0.0416*** (0.0148)	*Easter*	0.497*** (0.0134)
March	0.784*** (0.0128)	*Memorial*	0.600*** (0.0137)
April	0.639*** (0.0146)	*Independence*	0.163*** (0.0131)
May	0.754*** (0.0160)	*Labor*	0.475*** (0.0128)
June	0.933*** (0.0172)	*Columbus*	-0.134*** (0.0155)
July	1.009*** (0.0181)	*tmax*	0.0153*** (0.000446)
August	0.793*** (0.0185)	*preciptotal*	-0.377*** (0.00730)
September	0.735*** (0.0173)	*watertemp_max*	0.00165*** (0.000528)
October	1.265*** (0.0146)	*Constant*	1.970*** (0.0619)
November	1.111*** (0.0125)	Observations	2,250

7.4.4 Seawolf Park Buses

Seawolf Buses Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
visits	2179	0.4151505	0.9070105	0	16.5
Year	2179	2011.469	1.937333	2008	2015
Month	2179	6.265259	3.492264	1	12
Dow	2179	3.006425	2.003889	0	6
BeachHoliday	2179	0.1363011	0.6918516	0	5
tmax	2074	77.22903	12.54145	36	100
preciptotal	2112	0.0952225	0.3474756	0	4.31
watertemp_max	2129	71.43248	12.72167	41.1	93.4

Seawolf Buses Poisson Regression

Standard errors in parentheses		*** p<0.01, ** p<0.05, * p<0.1	
2009	-1.247*** (0.453)	*December*	0.182 (0.222)
2010	-0.306 (0.443)	*Monday*	-0.784*** (0.136)
2011	-0.444 (0.444)	*Tuesday*	-0.560*** (0.128)
2012	-0.533 (0.443)	*Wednesday*	-0.697*** (0.133)
2013	-0.583 (0.445)	*Thursday*	-0.595*** (0.128)
2014	-0.489 (0.485)	*Friday*	-0.370*** (0.120)
2015	-0.726 (0.454)	*Saturday*	0.237** (0.102)
February	0.0957 (0.210)	*Easter*	0.0206 (0.253)
March	0.513** (0.203)	*Memorial*	-0.0138 (0.314)
April	0.685*** (0.230)	*Independence*	0.350 (0.302)
May	0.906*** (0.262)	*Labor*	0.375 (0.381)
June	0.658** (0.307)	*Columbus*	-1.015** (0.504)
July	0.348 (0.323)	*tmax*	0.0222*** (0.00810)
August	-0.124 (0.347)	*preciptotal*	-0.435*** (0.155)
September	-0.188 (0.325)	*watertemp_max*	-0.0124 (0.0106)
October	0.716*** (0.247)	*Constant*	-1.229* (0.683)
November	1.133*** (0.193)	Observations	2,029

7.4.5 Pocket Park 1

Pocket Park 1 Summary Statistics

Variable	Obs	Mean	Std. Dev	Min	Max
visits	1025	89.69598	99.11822	0	668
Year	1025	2011.7	2.177533	2008	2015
Month	1025	6.24878	1.666994	3	9
Dow	1025	3.057561	2.224597	0	6
BeachHoliday	1025	0.2370732	0.8181243	0	4
tmax	1008	87.04464	6.918234	56	100
preciptotal	1013	0.0488963	0.1862188	0	2.14
watertemp_max	994	82.38947	8.049423	52.7	93.4

Pocket Park 1 Poisson Regression

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

2009	1.135*** (0.0181)	*Monday*	-0.994*** (0.0127)
2010	0.986*** (0.0185)	*Tuesday*	-1.720*** (0.0195)
2011	1.050*** (0.0173)	*Wednesday*	-1.529*** (0.0184)
2012	1.145*** (0.0175)	*Thursday*	-1.361*** (0.0162)
2013	1.365*** (0.0190)	*Friday*	-1.156*** (0.0126)
2014	1.039*** (0.0181)	*Saturday*	-0.0192** (0.00816)
2015	1.163*** (0.0193)	*Easter*	0.769*** (0.0176)
April	-0.436*** (0.0168)	*Memorial*	0.899*** (0.0163)
May	-0.517*** (0.0204)	*Independence*	0.784*** (0.0159)
June	-0.920*** (0.0256)	*Labor*	0.948*** (0.0213)
July	-1.108*** (0.0277)	*tmax*	0.0271*** (0.00152)
August	-1.419*** (0.0289)	*preciptotal*	-1.334*** (0.0317)
September	-1.668*** (0.0298)	*watertemp_max*	0.0429*** (0.00133)
		Constant	-1.043*** (0.0996)
		Observations	979

7.4.6 Pocket Park 2

Pocket Park 2 Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
visits	1009	34.71692	34.51775	1	229
Year	1009	2011.451	2.30291	2008	2015
Month	1009	6.200198	1.668321	3	9
Dow	1009	3.03667	2.203812	0	6
BeachHoliday	1009	0.2249752	0.8005025	0	4
tmax	991	86.94551	6.991991	56	100
preciptotal	997	0.0466138	0.1873659	0	2.14
watertemp_max	978	82.3087	8.194328	49.3	93.4

Pocket Park 2 Poisson Regression

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Variable	Coefficient	Variable	Coefficient
2009	-0.241*** (0.0224)	*Monday*	-0.976*** (0.0216)
2010	-0.155*** (0.0228)	*Tuesday*	-1.411*** (0.0282)
2011	-0.184*** (0.0196)	*Wednesday*	-1.295*** (0.0272)
2012	-0.0937*** (0.0205)	*Thursday*	-1.010*** (0.0244)
2013	0.00440 (0.0247)	*Friday*	-0.714*** (0.0190)
2014	-0.458*** (0.0227)	*Saturday*	0.152*** (0.0138)
2015	0.00184 (0.0245)	*Easter*	0.785*** (0.0353)
April	-0.492*** (0.0321)	*Memorial*	0.812*** (0.0293)
May	-0.128*** (0.0358)	*Independence*	0.536*** (0.0253)
June	-0.366*** (0.0447)	*Labor*	0.592*** (0.0331)
July	-0.338*** (0.0480)	*tmax*	0.0112*** (0.00255)
August	-0.641*** (0.0498)	*preciptotal*	-1.038*** (0.0474)
September	-0.879*** (0.0503)	*watertemp_max*	0.0473*** (0.00234)
		Constant	-0.451*** (0.167)
		Observations	962

7.4.7 Dellanera Park

Dellenera Park Summary Statistics

Variable	Obs	Mean	Std. Dev	Min	Max
visits	1413	10.5088	12.30103	0	82
Year	1413	2012.14	2.30504	2007	2015
Month	1413	6.579618	2.927874	1	12
Day of Week	1413	3.122435	2.093058	0	6
Holiday	1413	0.2024062	0.8382295	0	5
tmax	1405	81.33879	10.72688	41	100
preciptotal	1409	0.0865905	0.3129665	0	3.75
watertemp_max	1368	75.59222	11.719	44.1	93.4

Dellenera Park Poisson Regression

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Variable	Coefficient	Variable	Coefficient
2009	-0.157 (0.169)	*Monday*	-0.792*** (0.0333)
2011	-0.0434 (0.0342)	*Tuesday*	-1.044*** (0.0388)
2012	0.164*** (0.0295)	*Wednesday*	-1.019*** (0.0377)
2013	0.325*** (0.0335)	*Thursday*	-0.867*** (0.0351)
2014	-0.0122 (0.0306)	*Friday*	-0.267*** (0.0270)
2015	0.204*** (0.0339)	*Saturday*	0.414*** (0.0229)
February	0.196 (0.122)	*Easter*	0.711*** (0.0604)
March	1.188*** (0.103)	*Memorial*	0.930*** (0.0464)
April	0.999*** (0.108)	*Independence*	0.469*** (0.0416)
May	1.227*** (0.113)	*Labor*	0.432*** (0.0526)
June	1.374*** (0.123)	*Columbus*	-0.145 (0.136)
July	1.498*** (0.126)	*tmax*	0.0186*** (0.00317)
August	1.238*** (0.128)	*preciptotal*	-0.514*** (0.0429)
September	0.613*** (0.124)	*watertemp_max*	0.0177*** (0.00312)
October	0.268** (0.121)	*Constant*	-1.512*** (0.213)
November	0.246** (0.117)	Observations	1,360
December	-0.0485 (0.145)		

7.4.8 Galveston Island State Park

Galveston Island State Park Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
DayVisits	983	317.2696	302.1841	0	2119
Year	983	2012.849	1.371709	2011	2015
Month	983	5.90234	1.947013	3	9
Dow	983	3.004069	2.004573	0	6
BeachHoliday	983	0.162767	0.6754023	0	4
tmax	976	84.1752	8.41848	41	100
preciptotal	981	0.0995668	0.3366605	0	3.73
watertemp_max	975	78.65671	9.149435	47.7	93.4

Galveston Island State Park Poisson Regression

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

2012	0.174*** (0.00593)	*Wednesday*	-1.147*** (0.00769)
2013	0.248*** (0.00715)	*Thursday*	-0.937*** (0.00710)
2014	0.178*** (0.00631)	*Friday*	-0.761*** (0.00634)
2015	0.206*** (0.00724)	*Saturday*	0.190*** (0.00488)
April	-0.140*** (0.00880)	*Easter*	0.610*** (0.0107)
May	-0.0200* (0.0103)	*Memorial*	0.831*** (0.00956)
June	-0.0358*** (0.0132)	*Independence*	0.529*** (0.00948)
July	-0.0646*** (0.0143)	*Labor*	0.805*** (0.0115)
August	-0.468*** (0.0152)	*tmax*	0.0265*** (0.000715)
September	-0.820*** (0.0138)	*preciptotal*	-0.674*** (0.00994)
Monday	-0.978*** (0.00695)	*watertemp_max*	0.0134*** (0.000663)
Tuesday	-1.137*** (0.00767)	*Constant*	2.947*** (0.0467)
		Observations	970

7.4.9 Seawall Parking

Seawall Parking Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Visits	631	289.5087	271.196	1	1380
Year	631	2013.916	0.6767667	2013	2015
Month	631	6.744849	3.632726	1	12
Dow	631	3.017433	2.003492	0	6
BeachHoliday	631	0.1648177	0.783621	0	5
tmax	628	75.1035	13.54267	37	97
preciptotal	628	0.1121783	0.3815774	0	3.73
watertemp_max	631	69.28842	13.54383	41.9	92.8

Seawall Parking Poisson Regression

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

2014	0.230***
	(0.00808)
2015	0.308***
	(0.0124)
February	-0.126***
	(0.0149)
March	0.664***
	(0.0133)
April	0.133***
	(0.0182)
May	0.0629***
	(0.0218)
June	-0.116***
	(0.0236)
July	-0.363***
	(0.0278)
August	-0.324***
	(0.0275)
September	-0.618***
	(0.0262)
October	-0.469***
	(0.0232)
November	-0.342***
	(0.0185)
December	-0.353***
	(0.0180)
Monday	-0.928***
	(0.00877)
Tuesday	-1.107***
	(0.00948)
Wednesday	-1.124***
	(0.00967)
Thursday	-1.032***
	(0.00939)
Friday	-0.634***
	(0.00804)
Saturday	0.0624***
	(0.00654)
Easter	0.498***
	(0.0167)
Memorial	0.184***
	(0.0201)
Independence	-0.327***
	(0.0219)
Labor	0.386***
	(0.0151)
Columbus	-0.139***
	(0.0227)
tmax	0.0326***
	(0.000617)
preciptotal	-0.625***
	(0.0117)
watertemp_max	0.0148***
	(0.000758)
Constant	2.624***
	(0.0378)
Observations	628

7.4.10 **Boat Ramps**

Boat Ramp Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
COUNT	264	6.57197	11.85986	0	101
SITE	264	67.80682	52.1764	14	183
YEAR	264	2011.447	2.296681	2008	2015
MONTH	264	3.856061	0.7812691	3	5
Dow	264	3.015152	2.228351	0	6
TOD	264	8.890152	1.035151	8	11
tmax	253	75.44664	6.256593	58	85
preciptotal	264	0.0164773	0.0485984	0	0.2
watertemp_max	253	70.11897	5.731584	58.8	80.4

Boat Ramp Poisson Regression

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

15.SITE	-0.712***	*2009*	-0.812***	*Wednesday*	-1.655***
	(0.147)		(0.170)		(0.142)
24.SITE	-0.291*	*2010*	0.423***	*Thursday*	-0.547***
	(0.159)		(0.122)		(0.180)
26.SITE	-0.938***	*2011*	-0.923***	*Friday*	-2.172***
	(0.199)		(0.225)		(0.418)
27.SITE	-0.823***	*2012*	-1.499***	*Saturday*	-0.580***
	(0.191)		(0.194)		(0.119)
29.SITE	1.694***	*2013*	-1.007***	*9am -10am*	0.317***
	(0.107)		(0.202)		(0.0906)
78.SITE	0.139	*2014*	-1.333***	*10am -11am*	0.342***
	(0.111)		(0.245)		(0.0962)
83.SITE	0.823***	*2015*	-1.094***	*11am - 12pm*	0.0825
	(0.0993)		(0.257)		(0.150)
84.SITE	-0.359***	*April*	0.788***	*tmax*	0.0598***
	(0.137)		(0.185)		(0.0162)
113.SITE	-2.100***	*May*	2.162***	*preciptotal*	2.378
	(0.260)		(0.426)		(1.761)
176.SITE	-1.035***	*Monday*	-4.098***	*watertemp_max*	-0.0996***
	(0.181)		(0.595)		(0.0260)
183.SITE	-2.022***	*Tuesday*	-2.702***	*Constant*	4.572**
	(0.460)		(0.203)		(2.037)
				Observations	253

7.4.11 Mustang Island State Park

Mustang Island State Park Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
DayVisits	847	352.9563	353.1973	13	2002
Year	847	2012.484	1.113815	2011	2014
Month	847	6.01889	1.996953	3	9
Dow	847	3.008264	2.003821	0	6
BeachHoliday	847	0.1652893	0.6917784	0	4
tmax	847	90.28099	8.222031	44	107
preciptotal	847	0.061843	0.2637095	0	3.27

Mustang Island State Park Poisson Regression

Standard errors in parentheses   *** p<0.01, ** p<0.05, * p<0.1

2012	0.0823*** (0.00529)	*Wednesday*	-0.924*** (0.00775)
2013	0.110*** (0.00521)	*Thursday*	-0.846*** (0.00757)
2014	0.106*** (0.00543)	*Friday*	-0.490*** (0.00641)
April	-0.486*** (0.00930)	*Saturday*	0.436*** (0.00511)
May	-0.371*** (0.00968)	*Easter*	0.351*** (0.0133)
June	0.158*** (0.0101)	*Memorial*	1.128*** (0.0119)
July	0.498*** (0.0102)	*Independence*	0.489*** (0.00915)
August	0.0946*** (0.0110)	*Labor*	0.750*** (0.0106)
September	-0.849*** (0.0116)	*tmax*	0.0256*** (0.000468)
Monday	-0.822*** (0.00730)	*preciptotal*	-0.283*** (0.00903)
Tuesday	-0.920*** (0.00776)	*Constant*	3.796*** (0.0384)
		Observations	847

7.4.12 **Income Prediction**

```
Truncated regression
Limit:  lower =      0            Number of obs   =    561
     upper =    +inf             Wald chi2(7)    =   71.32
Log likelihood = -2615.7985            Prob > chi2    =   0.0000

------------------------------------------------------------------------------
  reincome |   Coef.  Std. Err.   z  P>|z|   [95% Conf. Interval]
-------------+----------------------------------------------------------------
    lgag |  28.87769  5.616161   5.14  0.000   17.87021  39.88516
  1.spanish | -46.89886  11.14806  -4.21  0.000  -68.74865  -25.04906
  1.college |  16.27969  3.925905   4.15  0.000   8.585061  23.97433
 1.fulltime |  9.892599  3.897415   2.54  0.011   2.253806  17.53139
  1.female |  .8931754  3.819158   0.23  0.815  -6.592236  8.378587
  1.ownpool |  11.94846  4.559426   2.62  0.009   3.012147  20.88477
 1.ownsfcst |  2.299161  3.656583   0.63  0.529   -4.86761  9.465932
    _cons | -79.52072  22.05565  -3.61  0.000   -122.749  -36.29245
-------------+----------------------------------------------------------------
   /sigma |  34.75331  1.682136  20.66  0.000   31.45639  38.05024
------------------------------------------------------------------------------
```

7.4.13 **Nested Logit Regression**

```
Nested Logit Output:

RUM-consistent nested logit regression     Number of obs    =   111289
Case variable: caseid             Number of cases  =    1978

Alternative variable: siteid          Alts per case: min =     28
Cluster variable: id                     avg =    56.3
                              max =     65

                         Wald chi2(74)  =  4873.44
Log pseudolikelihood = -19653.252         Prob > chi2   =   0.0000

                  (Std. Err. adjusted for 884 clusters in id)
------------------------------------------------------------------------------
       |        Robust
  selected |   Coef.  Std. Err.   z  P>|z|   [95% Conf. Interval]
-------------+----------------------------------------------------------------
siteid    |
   ntcost2 | -.0350055  .0050019  -7.00  0.000   -.044809  -.0252019
    ASC1 | -2.018041  .5324363  -3.79  0.000  -3.061597  -.9744855
    ASC2 | -.8928866  .2386339  -3.74  0.000   -1.3606  -.4251729
    ASC3 |  -.625681  .2614269  -2.39  0.017  -1.138068  -.1132937
    ASC4 | -1.056607  .3186706  -3.32  0.001   -1.68119  -.4320237
    ASC5 | -.4654415  .2766647  -1.68  0.093  -1.007694  .0768115
    ASC6 | -1.951906  .5471818  -3.57  0.000  -3.024363  -.8794496
    ASC7 |  .2232867  .1375249   1.62  0.104  -.0462571  .4928306
    ASC8 | -.5140716  .2076235  -2.48  0.013  -.9210062  -.107137
    ASC9 | -1.428204  .3387716  -4.22  0.000  -2.092184  -.7642235
    ASC10 |  .3594204  .1744913   2.06  0.039   .0174237  .7014171
    ASC11 | -.2350484  .1476239  -1.59  0.111  -.5243859  .0542891
    ASC12 | -1.284935  .2794686  -4.60  0.000  -1.832683  -.7371863
    ASC13 | -.3953621  .1778267  -2.22  0.026  -.7438962  -.0468281
    ASC14 | -.7090987  .1906702  -3.72  0.000  -1.082805  -.3353921
    ASC15 |  .1412759  .1855531   0.76  0.446  -.2224015  .5049532
    ASC16 | -.7195577  .2044064  -3.52  0.000  -1.120187  -.3189284
    ASC17 | -1.079398  .2621836  -4.12  0.000  -1.593269  -.5655278
    ASC18 | -.5483334  .3226804  -1.70  0.089  -1.180775  .0841085
    ASC19 | -1.792867  .4263427  -4.21  0.000  -2.628483  -.9572503
    ASC20 | -1.190636  .3678317  -3.24  0.001  -1.911573  -.4696989
    ASC21 | -.6664744  .4611205  -1.45  0.148  -1.570254  .2373051
    ASC22 | -.2051797  .1605645  -1.28  0.201  -.5198803  .1095208
    ASC23 | -.7612153  .2345506  -3.25  0.001  -1.220926  -.3015045
    ASC24 |  -1.37593  .3834051  -3.59  0.000   -2.12739  -.6244696
    ASC25 | -1.150908  .3294662  -3.49  0.000   -1.79665  -.5051664
    ASC26 | -.7619853  .2700598  -2.82  0.005  -1.291293  -.2326778
    ASC27 | -.8953846  .4024748  -2.22  0.026  -1.684221  -.1065485
    ASC28 | -.8523668  .2633154  -3.24  0.001  -1.368455  -.3362782
    ASC30 | -1.377794  .3984149  -3.46  0.001  -2.158673  -.5969152
    ASC31 | -.6584899  .3277568  -2.01  0.045  -1.300881  -.0160984
    ASC32 | -1.991449  .5559284  -3.58  0.000  -3.081049  -.9018494
    ASC33 | -.8933522  .3504255  -2.55  0.011  -1.580174  -.2065308
    ASC34 | -1.172454  .3186544  -3.68  0.000  -1.797005  -.5479027
    ASC35 | -1.888465  .4556167  -4.14  0.000  -2.781457  -.9954726
    ASC36 | -2.192746  .5720534  -3.83  0.000   -3.31395  -1.071542
    ASC37 | -1.512469  .4484252  -3.37  0.001  -2.391366  -.6335719
    ASC38 | -.0270986  .1359685  -0.20  0.842  -.2935919  .2393947
    ASC39 | -.2430481  .1593799  -1.52  0.127   -.555427  .0693308
    ASC40 | -.0395716  .1534943  -0.26  0.797  -.3404149  .2612718
    ASC41 | -.2956741  .2119297  -1.40  0.163  -.7110487  .1197005
    ASC42 | -1.026093  .2511475  -4.09  0.000  -1.518333  -.5338524
```

```
    ASC43 | -.6569746  .2176068  -3.02  0.003  -1.083476  -.2304732
    ASC44 | -.3201675  .1676752  -1.91  0.056  -.6488049    .00847
    ASC45 |  .0350198  .1588483   0.22  0.826  -.2763172  .3463567
    ASC46 | -1.748469  .3584942  -4.88  0.000  -2.451105  -1.045833
    ASC47 | -.9541311  .2856645  -3.34  0.001  -1.514023  -.3942391
    ASC48 | -.5685381  .2184853  -2.60  0.009  -.9967615  -.1403148
    ASC49 | -.7241468  .2600532  -2.78  0.005  -1.233842  -.2144518
    ASC50 |  .1674437  .1169351   1.43  0.152   -.061745  .3966324
    ASC51 | -.3565622  .1863271  -1.91  0.056  -.7217566  .0086322
    ASC52 | -.6254475  .2277038  -2.75  0.006  -1.071739  -.1791562
    ASC53 | -1.444695  .3526164  -4.10  0.000   -2.13581  -.7535792
    ASC54 |  -1.28942  .3494019  -3.69  0.000  -1.974235  -.604605
    ASC55 | -.9934676  .3201779  -3.10  0.002  -1.621005  -.3659304
    ASC56 | -1.832547  .4423177  -4.14  0.000  -2.699473  -.9656197
    ASC57 | -1.828753  .4325912  -4.23  0.000  -2.676616  -.9808899
    ASC58 | -1.676394  .5546569  -3.02  0.003  -2.763502  -.5892868
    ASC59 |  .0318012  .1653046   0.19  0.847  -.2921899  .3557923
    ASC60 | -.5476288  .2727022  -2.01  0.045  -1.082115  -.0131422
    ASC61 |  .0652255  .3198444   0.20  0.838   -.561658   .692109
    ASC63 | -.6406341  .2528448  -2.53  0.011  -1.136201  -.1450674
    ASC64 | -.4203653  .2670193  -1.57  0.115  -.9437135  .1029829
    ASC65 | -1.375246  .3379098  -4.07  0.000  -2.037537  -.7129545
------------------------------------------------------------------------------
participation equations
------------------------------------------------------------------------------
notrip    |
   childdm |  .0467635  .137705   0.34  0.734  -.2231332  .3166603
     lgag |  1.093569  .0668339  16.36  0.000   .9625765  1.224561
   spanish | -.0447271  .3545281  -0.13  0.900  -.7395895  .6501352
   college | -.5483983  .1596942  -3.43  0.001  -.8613931  -.2354034
   gradsch | -.4682672  .266903  -1.75  0.079  -.9913876  .0548531
  fulltime |  .0695921  .1492668   0.47  0.641  -.2229654  .3621496
    female |  .2857338  .1462603   1.95  0.051  -.0009312  .5723987
  property | -.4279615  .1681308  -2.55  0.011  -.7574918  -.0984312
   ownpool |  .0335151  .1618647   0.21  0.836  -.2837339  .3507641
  ownsfcst |  -.060702  .1346151  -0.45  0.652  -.3245427  .2031388
-------------+----------------------------------------------------------------
taketrip  |
   childdm |     0  (base)
     lgag |     0  (base)
   spanish |     0  (base)
   college |     0  (base)
   gradsch |     0  (base)
  fulltime |     0  (base)
    female |     0  (base)
  property |     0  (base)
   ownpool |     0  (base)
  ownsfcst |     0  (base)
------------------------------------------------------------------------------
dissimilarity parameters
------------------------------------------------------------------------------
participat~n |
 /notrip_tau |      1  5.304288          -9.396214  11.39621
/taketrip_~u |  .4747003  .0522372           .3723172  .5770833
------------------------------------------------------------------------------
```