MEMORANDUM | September 1, 2015

TO Craig O'Connor, NOAA

FROM Eric English and Kenneth McConnell

SUBJECT A – Overview of Recreation Assessment

This memo describes the assessment of lost recreational use under the Oil Pollution Act of 1990 (OPA 90) in support of the Trustees' natural resource damage assessment for the Deepwater Horizon oil spill. Lost recreational use is one component of natural resource damages from the oil spill.

We calculate the interim lost-use value for coastal recreational activities that directly utilize or depend on Trustee resources adversely affected by the spill. The assessed activities include shoreline recreation, inland fishing and boating in the coastal areas of Louisiana, Mississippi, Alabama and the Gulf side of Florida, including the Florida Keys. Shoreline recreation refers to any recreational activities that take place along sandy beaches, such as swimming, sunbathing, and fishing. Inland fishing refers to fishing at saltwater locations not located on sandy beaches. These two shore-based categories were studied separately but are combined in the final assessment. Boating refers to fishing and pleasure boating on motorized boats or sailboats.

The spill began shortly after the explosion of the Deepwater Horizon drilling rig on April 20, 2010. Direct oiling, as well as the expectation and threat of oiling, led to public welfare losses to recreational users of beaches, coastal waters, and other coastal areas of the Gulf of Mexico. The magnitude and temporal extent of adverse effects depended on the activity and the region. The spill had a greater impact in the region designated in the assessment as the North Gulf, which extends from Louisiana-Texas border east through Gulf County, in the Florida panhandle. Impacts to shoreline activities in the North Gulf lasted from May 2010 through November 2011. In the Florida Peninsula, designated as the coastline from Franklin County, Florida to the Florida Keys, impacts to shoreline activities lasted from June 2010 through January 2011. Impacts to inland fishing lasted from May 2010 through March 2011, and were limited to the North Gulf. Boating damages occurred from May 2010 through August 2010 in the North Gulf only.

Damages are divided into Tier 1 and Tier 2 components. Tier 1 damages are based on extensive infield surveys of shoreline activities, inland fishing, and boating to estimate lost recreation days. The value of lost days was estimated using two valuation models, one for shoreline and inland fishing combined, and another for boating. Tier 2 damages are based on supplemental surveys and secondary data to estimate lost recreation days, combined with per-day values from the shoreline and boating valuation models.

The next section provides an overview of the assessment of lost recreational use. After that, there is a section describing Tier 1 damages, and a section describing Tier 2 damages. The final section describes methods used to determine the statistical precision of damage estimates.

OVERVIEW OF THE DAMAGE ASSESSMENT FOR LOST RECREATIONAL USE

The damage assessment combines lost recreation days, or "user days", estimated from infield surveys, and the value of lost days estimated from telephone surveys. The details of the many procedures and steps of the assessment are described in the full set of technical memos. The following paragraphs contain a brief summary.

Damages are calculated by multiplying the number of lost recreation user days attributed to the spill by the lost dollar value per lost user day. Each factor is derived from a separate set of surveys. The loss calculations are done on a monthly basis, so that damages can be expressed in present-value terms using monthly compounding and monthly inflation adjustments. Total losses are presented for mid-year 2015, using compounding and inflation adjustments through July 2015.

The infield data collection includes interviews and counts conducted on the ground and photographs from aerial overflights. Infield shoreline data was collected during the period June 2010 to May 2013. The inland fishing and boating components of the study began in June 2010 but ended in August 2012 and March 2013, respectively, based on the determination that recovery had occurred for these activities. The data provide the basis for estimates of user days while spill impacts were ongoing, as well as user days during the subsequent 12 months, representing baseline activity. Lost user days from the spill are estimated as the difference between user days during the spill period and baseline user days, adjusted for differences in weather. Technical Memo B1 – Estimation Procedures for Count Data provides details on the estimation of user days and lost user days.

Three recreation valuation surveys were conducted by telephone and covered recreation activity from April 2012 to June 2013, after the recovery of all activities to baseline levels. The local boating and local shoreline surveys covered activities by residents of the six-state area of Louisiana, Mississippi, Alabama, Florida, and parts of Texas and Georgia. This area is shown in Exhibit 1. These two surveys collected data on recreation trips to destinations anywhere along the coast of all six states. The national survey covered all types of shoreline recreational activity by residents of the contiguous United States outside the six-state area delineated in Exhibit 1. This includes 42 states plus areas of Georgia and Texas. The national survey included only trips of two nights or more and less than 30 days, while the local surveys included all trips less than 30 days. Together, the surveys were designed to sample all trips to the areas included in the infield counts, as well as most trips to adjacent areas where those affected by the spill could potentially relocate their recreation activity. These surveys are described in Technical Memos F1 – National Valuation Survey and G1 – Local Valuation Survey.

The three surveys provide the data for estimating two valuation models. Data from the local shoreline survey and the national survey are combined to develop the shoreline valuation model. This model evaluates both shoreline and fishing trips by residents of the contiguous 48 states to any of 83 shoreline sites from Texas to Georgia. Data from the boating survey are used to develop the boating valuation model, which evaluates boating trips by residents of the six-state area to any of 67 sites along the coast from Texas to Georgia. The structure of the models is presented in Technical Memo D1 – Model Structure.

EXHIBIT 1. THE SIX-STATE LOCAL SURVEY AREA

The two valuation models are used to simulate the decline in trips taken during the spill period by adjusting model coefficients. This process is described as "calibrating" the model to the estimate of lost trips from the infield surveys. In the calibration process, certain coefficients of the valuation models are adjusted so that the ratio of total user days during the spill period to total user days during the baseline period, as predicted by the model, equals the ratio of total user days during the spill period to total user days during the baseline period, as measured from the infield studies. The essence of the calibration is to use the count data from the infield surveys, carried out during spill and baseline periods, to adjust the valuation models, which were estimated using data on baseline activity only. The details of the calibration are described in Technical Memo D3 – Calibration Methods.

Valuing lost user days involves first calculating the economic value of all lost, substitute and diminished-value trips estimated by the calibrated valuation models. Next, the valuation models are used to predict the number of lost user days. The model's estimate of lost user days differs from the infield estimate of lost user days because the model was only calibrated to the percentage decline in days. Finally, the value of all lost, substitute and diminished-value trips is divided by the model's estimate of lost user days to calculate the value of losses from the spill per lost user day.

To estimate damages, the value per lost user day is multiplied by the estimate of lost user days from the infield surveys. This estimate of damages combines the reliability of the infield counts, involving onsite observation and aerial photographs of recreation activity, with the reliability of the valuation models, based on in-depth interviews and a general-population sample only possible using mail or telephone survey methods.

THE VALUATION MODEL

This section provides a summary[1] of the development of the valuation models and the calculation of per-day values. The models begin with defining individual i's utility on a given choice occasion as the maximum of

$U_i = V_{i0} + \varepsilon_{i0}$ for non-participation, and

$U_{ij} = V_{ij} + \varepsilon_{ij}$ for the utility of visiting site j

where $V_{i0} = \lambda Z_i$ and $V_{ij} = \alpha_j + \beta C_{ij}$. The term C_{ij} is the travel cost for individual i to reach site j, the term Z_i represents demographic characteristics, and the parameters λ, α_j and β are estimated.

With the estimated parameters,[2] the combined value of all lost, substitute and diminished-value trips can be computed. This is done with the standard log-sum formula, which also incorporates a scale parameter θ. The monetary measure of the loss from the spill for a given individual on a given choice occasion can be computed as

$$L_i = \frac{1}{\beta}\ln\left[\exp(V_{i0}) + \left(\sum_{j=all\ sites}\exp\left(\frac{V_{ij}}{\theta}\right)\right)^{\theta}\right] - \frac{1}{\beta}\ln\left[\exp(V_{i0}) + \left(\sum_{j=all\ sites}\exp\left(\frac{V_{ij}+\delta_j}{\theta}\right)\right)^{\theta}\right]$$

The δ_j are the calibrated parameters that, when added to the utility of the sites, make the proportional change in the valuation-model trips equal to the proportional change in counts.

There are two periods for the shoreline model. In period one, which is June 2010 through January 2011, the δ_j take three values: δ_j=0 for sites outside the spill area, δ_j=δ_{NG} for sites in the North Gulf region of the infield study, and $\delta_j = \delta_P$ for sites in the Florida Peninsula region of the infield study. The North Gulf region was impacted to a greater extent, and this is reflected in a different (more negative) parameter used in calibration. In period two, which is February 2011 through November 2011, the North Gulf calibration parameter is smaller than in period one. Since spill impacts in the Florida Peninsula have ended in period two, all calibration parameters outside the North Gulf are set to zero.

There is only one period for the boating model, which is June 2010 through August 2010. In this model the spill area is in the North Gulf only, so that $\delta_P = 0$ and $\delta_j = 0$ outside the North Gulf.

The model structure described above is known as a repeated nested logit model and includes a set of choice occasions, denoted T. Each randomly selected respondent contributes T outcomes for a given period of time. The lost value per choice occasion is

1 Full details are provided in Technical Memos D1 – Model Structure and D3 – Calibration Methods.
2 The estimated parameter values are given in Technical Memo D2 – Estimated Parameters.

the expression for L_i, above. For the sample of respondents, where each respondent's sample weight[3] is given by w_i, the total loss from the spill for a given period is

$$L = T \sum_i w_i L_i$$

The damage assessment employs a per-day value calculated as L divided by lost user days, both from the valuation model. Lost user days are calculated based on the decline in the probability of visiting sites under spill conditions. Specifically,

$$Lost\ user\ days = T \sum_i w_i \left[\sum_{j \in S} P_{ij}(\delta_j = 0) - \sum_{j \in S} P_{ij}(\delta_j)\right] \times ud$$

where ud is user-days per trip from the appropriate valuation survey and S is the set of all sites in the spill area. The term P_{ij} is the standard expression for a choice probability in a nested-logit model. The first sum inside the square brackets is the probability that individual i will visit any of the shoreline sites in the spill area under baseline conditions, and the second sum is the probability that individual i will visit any of the shoreline sites in the spill under spill conditions. A reduced probability to take a trip in the spill area means an increased probability to take no trip at all or to take a trip to a substitute site outside the spill area. Summed across choice occasions and weighted up to the population, this difference in probabilities becomes total lost trips as a consequence of the spill. Multiplying by user days per trip, ud, converts lost trips to lost user days.

The value of lost, substitute and diminished-value trips per lost user day from the valuation survey is

$$Value\ per\ lost\ user\ day = \sum_i w_i L_i / \left[\sum_i w_i \left(\sum_{j \in S} P_{ij}(\delta_j = 0) - \sum_{j \in S} P_{ij}(\delta_j)\right) \times ud\right].$$

This value is multiplied by the estimate of lost user days from the infield surveys for the appropriate activity, region and period.

TIER 1 DAMAGES

Tier 1 damages, reflecting lost user days from the infield surveys and user-day values from the valuation models, are presented in Exhibits 2 and 3. Lost user days for Tier 1 are shown in Exhibit 2. As described above, we calculate damages for shoreline recreation for two periods: June 2010 through January 2011 for the North Gulf and Peninsula, and February 2011 through November 2011 for the North Gulf only. Damages are calculated for inland fishing for the North Gulf only for the period June 2010 through March 2011. There is not a separate model for valuing inland fishing. Boating damages are calculated for the North Gulf only for June through August 2010. Baseline estimates of recreation activity for each of these periods are estimated using data from corresponding months following recovery, shown in the column titled "Baseline". The final column shows lost user days for each region and spill period. The weather adjustments and other

[3] See Technical Memos F3 – Weights for the National Valuation Survey, and G3 – Local Shoreline and Boating Valuation Weights.

components of the calculations of lost user days are explained in detail in Technical Memo B1 –Estimation Procedures for Count Data.

EXHIBIT 2: SPILL PERIOD, BASELINE PERIOD, AND TIER 1 LOST USER DAYS FOR THE THREE ACTIVITIES, BY REGION *

ACTIVITY	REGION	SPILL PERIOD	SPILL DURATION	BASELINE	LOST USER DAYS
Shoreline	North Gulf	1	June 2010-January 2011	June 2012 - January 2013	6,300,345
	Peninsula	1	June 2010-January 2011	June 2011-January 2012	3,870,176
	North Gulf	2	February 2011-November 2011	February 2013-May 2013; June 2012-November 2012	2,154,991
Inland Fishing	North Gulf		June 2010-March 2011	June 2011-March 2012	144,050
Boating	North Gulf		June-August 2010	June-August 2011	215,374

*Tier 1 only includes lost user days from the infield surveys, which were not completed for May 2010. Tier 2 estimates provide losses for May, 2010.

Exhibit 3 presents Tier 1 damages. In calculating damages, we account for past losses by compounding values on a monthly basis at the equivalent annual rate of three percent. The discount rate of three percent reflects a common practice applied in numerous previous damage assessments. All damages are compounded to July 1, 2015. Compounding methods increase the value of past losses in present-value terms. For example, a one dollar loss incurred five years ago would be compensated at the compounded value of $1.16 today.

The initial price level for the damages is determined by data used in the travel cost model. This includes price-levels from 2011 (household income and hence the value of time), as well as 2012 and 2013 (other travel costs, including gasoline costs and airline fares). On this basis, it is conservative to adjust for inflation using a starting point of January 2013. We convert to July 2015 prices by multiplying all damages by 1.0288 to account for the inflation rate between January 2013 and July 2015.

Combining calculations for compounding and inflation, total damages for a given activity are computed as $1.0288 \times \sum_{m=1}^{M} D_m(1 + r_m)^{T-m}$. The factor 1.0288 is the adjustment for inflation to July 2015 prices. The term D_m is the monthly damage estimate. The final month of damages M varies by activity, period and region. Specifically, M = 18 for North Gulf shoreline, 10 for inland fishing, and 3 for boating.[4]. For Peninsula shoreline, M=8. In all cases, T = 61, which brings the compounding on a monthly basis up to July 2015.[5] Finally, r_m is the monthly equivalent to an annual discount rate of three percent. The compounded damages amount to $523.8 million for Tier 1..

4This assumes that damages are compounded on the first day of the month following the month in which they were incurred.
5 This holds for Tier 1 damages. Tier 2, discussed below, includes May 2010, which would require T= 62.

EXHIBIT 3: TIER 1 DAMAGES, COMPOUNDED TO JULY 1, 2015, IN JULY 2015 PRICES

	NORTH GULF	PENINSULA
Shoreline Losses		
June 2010 -January 2011		
Lost user days	6.3 million	3.87 million
Lost value per lost user day	$35.80	$35.80
Total losses in for period 1	$260,372,843*	$159,325,505*
February 2011-November 2011		
Lost user days	2.15 million	
Lost value per lost user day	$38.86	
Total losses for period 2	$94,116,953*	
Boating Losses		
Lost value per lost user day	$16.20	
Lost user days	215,374	
Total losses	$4,039,766*	
Inland Fishing Losses		
Lost user days	144,050	
Lost value per lost user day	$35.80/$38.86	
Total losses	$5,993,239*	
Total Tier-1 damages	**$523,848,306**	

*Because the damages are compounded by month, they do not equal the product of lost user days and the value per lost user day.

TIER 2 DAMAGES

The losses for the shoreline valuation model and the boating valuation model are considered Tier 1 damages because they derive from the extensive infield data collection. However, the coverage of the infield studies omits some losses that are incorporated using other sources of information. The additional losses are denoted as Tier 2 losses. The additional losses include:

- The early data collection, used to estimate lost user days during May 2010, before the full infield studies began in June 2010 (Technical Memo BC-1 – Early Data Collection).
- The supplemental shoreline study, providing an estimate of the proportion of shoreline activity that takes place before 10 AM, when the main shoreline sampling day began (Technical Memo BC-2 – Supplemental Shoreline Adjustment).
- The backyard boating survey, providing an estimate of lost boating trips launched from private waterfront residences and marinas rather than public access points

(Technical Memos C1 – Backyard Boating Survey and C2 – Backyard Boating Methods).

- An estimate of the fishing that took place outside the main fishing sampling times, which began at 630 AM and ended at 730 PM (Technical Memo I5 – Adjustment for Undercoverage of Nighttime Fishing).
- An estimate of lost user days from the for-hire sector of recreational fishing (Technical Memo I6 – Lost User Days in For-Hire Boat Fishing).
- Analysis of the fixed costs of boating, used to adjust the value of a boating trip to include costs lost to boaters in the short run (Technical Memo I7 – Fixed Costs and Boating Losses).
- An estimate of losses at certain Federal lands excluded from the infield survey, including Ship Island and Fort Barrancas/Advanced Redoubt, all of which are part of Gulf Islands National Seashore (Technical Memo I9 – Lost Recreation Visits at Ship Island and Fort Barrancas).

Second tier damages are computed by multiplying monthly lost user days by the appropriate value per lost user day and then converting to July 2015 prices. The resultant monthly lost value is compounded to July 1, 2015. Results are shown in Exhibit 4.

EXHIBIT 4: TIER 2 LOSSES COMPOUNDED TO JULY 1, 2015, IN JULY 2015 PRICES

CATEGORY	SOURCE	LOST USER DAYS	COMPOUNDED LOSSES IN 2015 PRICES
Early data collection	Lost user days in May 2010 for shoreline, inland fishing and boating	1,645,716*	$66,810,561
Supplemental shoreline study	Shoreline activity before regular sampling hours	1,234,821	$51,191,963
Backyard boating	Boating lost user days launched from private residences	22,895	$429,994
Night fishing	Fishing user days estimated outside sample period	152,517	$6,357,177
For-hire fishing	Lost user days as measured through MRIP for hire survey	216,089	$9,003,910
Fixed costs of boating	Underestimate of value due to fixed costs incurred: incremental addition to the value per lost boating trip	N/A	$2,848,632
Federal lands outside sample area	Lost user days as measured using National Seashore visitation data	23,276	$952,371
Total Tier-2 damages			**$137,594,608**

*The lost user days by activity are 1,550,137 for shoreline, 22,708 for inland fishing and 72,871 for boating.

In summary, the recreational damages are

- Tier 1: $523,848,306
- Tier 2: $137,594,608
- Tier 1 + Tier 2: $661,442,914

The average lost value per lost user day is $36.02 for Tier 1 and Tier 2 damages.6

Additional categories of recreation loss were investigated, but were not included in the assessment:

- Hunting trips with commercially operated guides. Discussions by phone with commercial hunting guides suggested some losses may have occurred, but this category of loss was not assessed.
- Diving trips on commercially operated dive boats. Discussions by phone with commercial dive operators suggested that some losses may have occurred, but this category of loss was not assessed.

6 The average lost value per lost user day for shoreline and inland fishing damages is $36.25 and the average value for boating damages is $24.10 (or $16.20 without the additional fixed cost adjustment, which has a value of $7.90).

- Shoreline use other than fishing that takes place at night. Cameras mounted at several locations throughout the Gulf Coast indicated that some beach visits occur after dark, but this category of loss was not assessed.
- Lost user days that occurred at recreational sites in Texas are not part of the Tier 1 or Tier 2 assessment, and are not included in this memorandum.

PRECISION

The damage estimates exhibit statistical uncertainty due to sampling error from the count surveys and the valuation surveys, as well as the imputation of income. The resulting uncertainty in the estimation of damages is explained in detail in Technical Memo D4 – Precision Estimation. This memo explains the calculation of measures of precision for damages for shoreline recreation and boating. Formal analysis of the precision of estimates applies only to the Tier 1 damages. For purposes of understanding the dispersion of the damage estimate, we focus first on the estimate of the uncompounded damages in 2013 prices and its standard error. In the case of shoreline recreation, the damage estimate is computed as the product of lost value per lost user day and lost user days, for period 1 and period 2, North Gulf and Peninsula. As the exhibit in Technical Memo D4 – Precision Estimation shows, the estimate of uncompounded damages in 2013 prices is $440.4 million, with a standard error of 70.14, so that an approximate 95% confidence interval would be $440 million plus or minus 2*70.14million, which is $300.12 million to $580.68 million. The uncompounded boating damages in 2013 prices are $3.39 million with a standard error of 1.27 million, yielding a 95% confidence interval of $0.85 million to $5.93 million.

The estimates of Tier 1 damages put forth in this memo are compounded by month, converted to 2015 prices and summed. The compounded shoreline damages, including inland fishing, equal $519.81 million. The essential difference between the totals in Technical Memo D4 – Precision Estimation and the damages in Exhibit 2 is the multiplication of the monthly losses by the compounding factor and the correction to July 2015 price levels, which when combined range between 1.1 and 1.2, approximately. If this factor were constant then we could multiply the standard error from the precision estimate by the ratio of the compounded to the uncompounded damages to get the appropriate standard error for the compounded damages. Given the modest range of the compound factor, we calculate an approximate standard error in a similar way: we multiply the standard error from the precision memo by the ratio of compounded to uncompounded damages for each component. For Tier 1 shoreline damages, which have a compounded value of $519.81 million, this yields a standard error of 82.79 million and a 95% confidence interval of $354.23 million to $685.38 million. Similar analysis for boating, which has a compounded value in July 2015 price levels of $4.04 million, yields a 95% confidence interval for the compounded Tier 1 boating losses of $1.01 million to $7.06 million.

The compounded shoreline and boating damages are statistically independent so the variance of their sum is the sum of their variances. The estimate of this sum in the uncompounded case, from Technical Memo D4 – Precision Estimation, is $443.79 million and the standard error, calculated as the square root of the sum of the variances of

the two components, is 70.15 million. The estimate for all Tier 1 damages in the compounded case is $523.8 million. The approximate standard error for the compounded damage estimate equals the ratio of the compounded to uncompounded damages times the standard error of 70.15 million. An approximate 95% confidence interval for the Tier 1 damages is $523.8 million +/- 2*82.81 million: $358.24 million to $689.46 million, which includes shoreline, inland fishing and boating.

Treating the Tier 2 damage estimates as a constant and adding to the confidence intervals for shoreline gives an approximate 95% confidence interval for the sum of the damages for the two tiers.

EXHIBIT 5: APPROXIMATE 95% CONFIDENCE INTERVALS FOR COMPOUNDED DAMAGES IN JULY 2015 PRICES

DAMAGE	LOWER LIMIT	POINT ESTIMATE	UPPER LIMIT
Shoreline	$354.23 million	$519.81 million	$685.38 million
Boating	$1.01 million	$4.04 million	$7.06 million
Tier 1 damages	$358.24	$523.85	$689.46
All damages*	$495.83 million	$661.44 million	$827.06 million

*Treating Tier 2 components as non-random, this is the confidence interval for the total Tier 1 damages, shifted higher by adding Tier 2 damages of $137.59 million.