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Recreational Fishing Damages Due to the *Cosco Busan* Oil Spill

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prepared for:

Cosco Busan Natural Resource Damage Assessment

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INTRODUCTION

On November 7, 2007, the *Cosco Busan* struck the Bay Bridge in San Francisco Bay, spilling approximately 58,000 gallons of intermediate fuel oil. Seven days later, on November 14, the State of California closed the commercial and recreational marine fisheries from Point Reyes to San Pedro Point, including San Francisco Bay and all areas within three nautical miles of the outer coast (Exhibit 1; CADFG, 2007). The closure was lifted on November 29, 2007, and the following advisory was issued: "It is possible that residual oil may remain on the water over the next several months. Recreational and commercial fishers should avoid exposure of their take to these residual pockets."

This report describes the calculation of economic losses to recreational anglers due to the *Cosco Busan* spill. The losses estimated in this report are based on the economic concept of consumer surplus (USDOI, 1987). An angler's consumer surplus from a fishing trip represents the difference between (1) the maximum amount that the angler would be willing to pay for the trip and (2) the amount that the angler actually paid for the trip (in gasoline, bait, etc.). Thus, consumer surplus is a measure of the net economic value of a fishing trip, after all expenses have been paid.

The analysis was conducted in two stages. First, publicly available data from the California Recreational Fisheries Survey are used to estimate the number of fishing days lost due to the spill. Second, a published study from the economics literature is used to estimate the value of a fishing day. Total damages are estimated by multiplying the number of lost fishing days by the value of a fishing day.

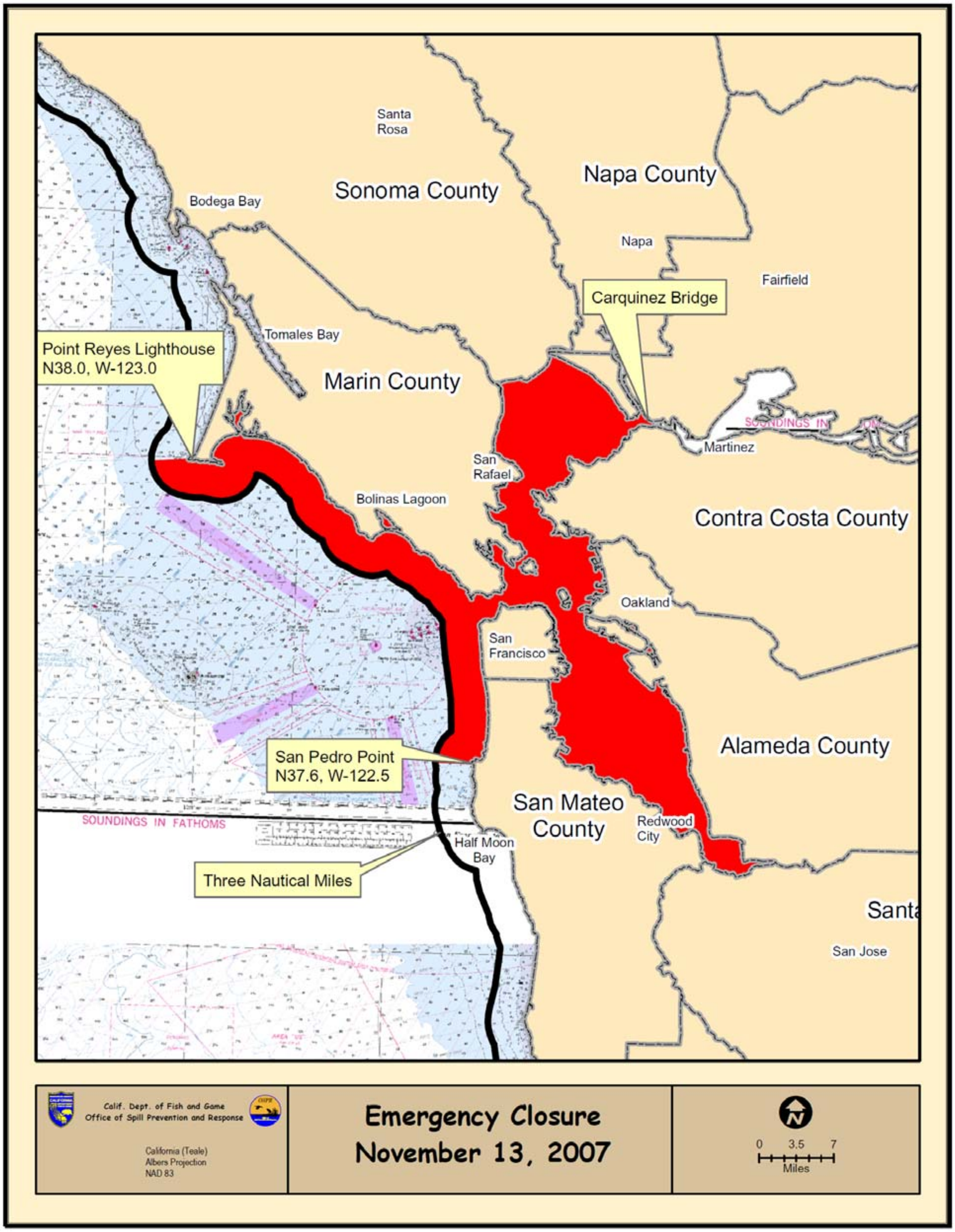
LOST FISHING DAYS

Fishing pressure estimates from the California Recreational Fisheries Survey (CRFS) are used to determine the number of lost fishing days.[1] The CRFS program uses a combination of access point surveys, telephone interviews with licensed anglers, and telephone interviews with licensed charter boat operators to develop monthly saltwater fishing pressure estimates for all coastal regions in California (PSMFC 2006). The CRFS estimates for the San Francisco Bay area are used in the current analysis. These estimates include all saltwater recreational angling within three miles of the coast from Sonoma County to San Mateo County, including all fishing within San Francisco Bay.

Lost fishing days are calculated by comparing fishing pressure in the San Francisco Bay area during the post-spill time period to fishing pressure during a reference period designated as "baseline." The post-spill time period is November 2007 to January 2008. This time period extends somewhat beyond the time period of the official closure because some anglers may have avoided the fishery even after the closure was lifted due to lingering concerns about spill-related impacts.

[1] CRFS estimates were obtained from http://www.recfin.org/forms/est2004.html.

EXHIBIT 1: RECREATIONAL FISHING CLOSURE AREA



The baseline time period was selected to reflect the level of fishing pressure that would have existed in the San Francisco Bay area if the spill had not occurred. Specifically, fishing pressure estimates from two years prior to the spill (November 2005 to January 2006), one year prior to the spill (November 2006 to January 2007), and one year after the spill (November 2008 to January 2009) were used to represent baseline conditions. Multiple years were used in the analysis to minimize the impact of anomalous fishing conditions during any particular year.[2] Pressure estimates from more than two years before the spill were not utilized because two changes in CRFS estimates occurred in 2005, making it difficult to compare pre-2005 estimates with estimates from 2005 and later: (1) the methodology used to develop fishing pressure estimates was modified and (2) the geographic region covered by the San Francisco Bay area estimates was changed.

The CRFS estimates of San Francisco Bay area fishing pressure for the post-spill and baseline time periods are summarized in Exhibit 2. Separate estimates are provided for boat fishing and shore fishing. Boat fishing is defined as fishing from private, rental, party, or charter boats. Boat fishing estimates were obtained by summing CRFS "private and rental" and "commercial passenger fishing vessel" estimates. Shore fishing is defined as fishing that occurs from the shore either on man-made structures such as piers and docks, or from natural areas such as beaches or banks. Shore fishing estimates were obtained by summing CRFS "man-made structures" and "beach and bank" estimates. Since the CRFS fishing pressure estimates for man-made structures only include fishing that occurs during daylight hours, the man-made structure estimates were adjusted to account for night fishing. The night fishing adjustment is derived from automated pedestrian counter data at Berkeley and Pacifica piers, which indicate that approximately 21 percent of visitation at these sites occurred between 5:30 p.m. and 7:00 a.m.

Estimates of lost fishing days are presented in Exhibit 2. For the November 2007 to January 2008 time period, there were an estimated 58,500 lost shore fishing days and 11,000 lost boat fishing days due to the spill. Fifty-four percent of the lost fishing days occurred in November 2007, 27 percent occurred in December 2007, and 19 percent occur in January 2008.

[2] Although weather conditions in January 2008 appeared to have been somewhat worse than average, a related analysis indicates that the adverse weather in January 2008 is unlikely to have had a significant impact on baseline fishing trips (see Attachment A).

EXHIBIT 2. SALTWATER RECREATIONAL FISHING DAYS IN SAN FRANCISCO AREA (THOUSANDS)

	BASELINE PERIOD				POST-SPILL PERIOD	LOST FISHING DAYS
	TWO YEARS PRE-SPILL	ONE YEAR PRE-SPILL	ONE YEAR POST-SPILL	AVERAGE		
Shore Fishing[a]						
November	37.8	35.2	66.0	46.3	16.0	30.3
December	27.9	20.7	40.8	29.8	13.2	16.6
January	26.0	29.3	21.5	25.6	13.9	11.6
TOTAL:						**58.5**
Boat Fishing[b]						
November	16.3	8.6	7.9	10.9	3.7	7.2
December	5.7	5.4	3.7	4.9	2.9	2.1
January	3.7	5.4	5.0	4.7	2.9	1.8
TOTAL:						**11.0**

Notes:
[a] – Shore fishing estimates calculated as sum of CRFS estimates for man-made structures and beach/bank, after dividing man-made structure estimates by 0.79 to account for night fishing (see text).
[b] – Boat fishing estimates calculated as sum of CRFS estimates for private/rental and commercial passenger fishing vessel modes.

VALUE PER FISHING DAY

The economic value of a fishing day is obtained from a study of saltwater fishing in Southern California by Kling and Thomson (1996). Kling and Thomson obtain data on saltwater fishing trips taken by randomly selected households in eight Southern California counties, and they estimate several different logit site choice models using various model specifications and nesting structures. Similar to CRFS data, all fishing trips in the Kling and Thomson dataset are categorized into one of four modes: beach, pier, charter boat, or private boat.

Our analysis uses welfare measures associated with the author-preferred model specification and the two nesting structures that group sites by fishing mode (i.e., Models A and B in Table 4 of Kling and Thomson). There are six separate welfare measures reported for each of these two nesting structures, one each for eliminating the fishing sites associated with the four fishing modes, one for eliminating all shore fishing sites, and one for eliminating all boat fishing sites. Our analysis focuses on the latter two welfare measures, as they more closely mimic the broad closure that was in place after the *Cosco Busan* spill.

The estimated loss associated with eliminating shore fishing sites ranges from $6.36 to $11.18 per choice occasion, while the estimated loss associated with eliminating boat fishing sites ranges from $24.19 to $43.02 per choice occasion. Converting to November 2009 dollars and averaging the results from the two nesting structures, this is equivalent to $15.30 per choice occasion for eliminating shore fishing sites and $58.62 per choice occasion for eliminating boat fishing sites.

Two additional adjustments were made to the value estimates from Kling and Thomson before using the estimates to evaluate losses due to the spill:

- **Fishing Day Value Adjustment:** As with many logit site choice models in the environmental economics literature, Kling and Thomson present loss estimates *per choice occasion*. Per choice occasion losses average losses across all fishing trips, including trips taken by anglers who do not visit the closed fishing site(s). When transferring the loss estimates to a new situation, these per choice occasion loss estimates must either be (1) applied to all fishing trips taken to the local area, including those taken to substitute sites (2) converted to trip values and applied only to "lost" trips, or trips diverted from the closed sites.

  As lost trip estimates have been developed for the current analysis, the Kling and Thomson loss estimates must be converted to trip values. The conversion is implemented by dividing each choice occasion loss estimate by the fraction of trips taken to the sites that were closed in the loss scenario (Attachment B). Twenty-six percent of the fishing trips in the Kling and Thomson dataset were taken to shore fishing sites, and the remaining 74 percent of the trips were taken to boat fishing sites (Kling, 2009). Thus, the choice occasion loss for shore fishing is divided by 0.26 and the choice occasion loss for boat fishing is divided by 0.74 to obtain fishing day values. The final values after the conversion are $58.84 per shore fishing day and $79.21 per boat fishing day.

- **Travel Cost Adjustment:** The costs associated with travel are directly related to the losses estimated by the Kling and Thompson model, as angler losses are related to the cost of traveling to an alternative fishing site when the closed site is unavailable. In determining travel costs, Kling and Thomson use 60 percent of each angler's wage rate as a proxy for the opportunity cost of travel time. This differs from the approach used in many travel cost studies in the literature, where one-third of the wage rate is applied. Thus, the fishing day values are adjusted to reflect the standard approach in the literature. The adjustment involves calculating the ratio of two per-mile travel costs: (1) average cost when one-third the wage rate is used as the opportunity cost of time ($0.46/mile) and (2) average cost when 60 percent of the wage rate is used as the opportunity cost of time ($0.72/mile). The final ratio (0.64 = $0.46 ÷ $0.72) is multiplied by the fishing day values to obtain the adjusted values. The adjusted fishing day values are $37.49 per day for shore fishing and $50.48 per day for boat fishing.

TOTAL ESTIMATED DAMAGES

Total damages are estimated by combining information on lost fishing days with information on the value of a fishing day. Shore fishing damages are calculated by multiplying estimated lost shore fishing days by the value of a shore fishing day, and boat fishing damages are calculated by multiplying estimated lost boat fishing days by the value of a boat fishing day. Both damage estimates are inflated using a 3% annual discount rate to reflect the two-year period between the spill and the calculation of damages. The final damage estimates are $2.3 million for shore fishing and $0.6 million for boat fishing, or a total of $2.9 million in recreational fishing damages (Exhibit 3).

EXHIBIT 3. SUMMARY OF RECREATIONAL FISHING DAMAGES

	LOST FISHING DAYS (THOUSANDS)	FISHING DAY VALUE (2009 DOLLARS)	TOTAL DAMAGES (MILLIONS)	TOTAL DAMAGES WITH INTEREST[A] (MILLIONS)
Shore Fishing	58.5	$37.49	$2.19	$2.33
Boat Fishing	11.0	$50.48	$0.56	$0.59
TOTAL:			$2.75	$2.92

Notes:

[a] – Reflects two years of interest (i.e., 2007 to 2009) at a 3% discount rate.

REFERENCES

California Department of Fish and Game (CADFG). 2007. DFG Defines San Francisco Bay Fishing Closure Zones. DFG News Release, November 14, 2007. www.dfg.ca.gov/news/fisheries-closure.pdf

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Pacific States Marine Fisheries Commission (PSMFC). 2006. California Recreational Fisheries Survey Methods. Revised 1 July 2006.

U.S. Department of the Interior (USDOI). 1987. *Type B Technical Information Document: Techniques to Measure Damages to Natural Resources*. Washington, D.C.

ATTACHMENT A:

ANALYSIS OF IMPACT OF ADVERSE WEATHER IN JANUARY 2008

Given the large amount of precipitation in January 2008, the possibility that the observed decline in fishing pressure during that month may have been weather related warrants consideration. First, however, one needs to establish that precipitation does in fact have a significant impact on saltwater fishing activity in the San Francisco Bay area. To investigate this issue, fishing trips (monthly CRFS estimates from January 2005 to February 2009) are regressed on precipitation (as measured at Oakland Airport), allowing for separate effects during the winter (December, January, and February) and non-winter months, and controlling for other factors that may potentially impact fishing pressure.

The form of the regression is as follows:

$$\ln(Trips_t) = \beta_0 + \beta_1 W_t * PPT_t + \beta_2(1 - W_t) * PPT_t + \beta_3 Temp_t + \beta_4 Trend_t + \sum_{i=1}^{11} \alpha_i Month_{it} + \delta_1 Nov07_t + \delta_2 Dec07_t + \delta_3 Jan08_t + \varepsilon_t$$

where:

$Trips_t$	=	Fishing trips (in thousands) to San Francisco Bay area in month *t* (sum across all modes)
W_t	=	Indicator (0/1) variable for winter months (December, January, February)
PPT_t	=	Total precipitation in month *t* as measured at the Oakland Airport
$Temp_t$	=	Average high temperature in month *t* as measured at the Oakland Airport
$Trend_t$	=	Number of months since January 2005
$Month_{it}$	=	Indicator (0/1) variable for each of the twelve months (January omitted)
$Nov07_t$	=	Indicator (0/1) variable for November 2007
$Dec07_t$	=	Indicator (0/1) variable for December 2007
$Jan08_t$	=	Indicator (0/1) variable for January 2008

As diagnostic tests indicated the potential presence of autocorrelation,[3] the Prais-Winsten generalized least squares estimation method was used, which assumes that the errors

[3] The Durbin-Watson test was inconclusive, while the Breusch-Godfrey test for first-order serial correlation was significant at the 5% level.

follow a first-order autoregressive process.[4] The estimation results are presented in Exhibit A-1. The results indicate that precipitation has a highly significant impact on fishing pressure during the summer months ($\hat{\beta}_2 = -0.092,$ t = -2.16) but the impact is near zero during the winter months ($\hat{\beta}_1 = -0.011,$ t = -0.34). Thus, it appears that a weather-related adjustment to January 2008 baseline fishing pressure is unnecessary.

EXHIBIT A-1: ESTIMATION RESULTS

VARIABLE	COEFFICIENT	T-STATISTIC
Winter x PPT	-0.01	-0.34
Non-Winter x PPT	-0.09	-2.16
Temp	-0.01	-0.69
Trend	-0.01	-2.15
FEB	0.37	2.43
MAR	0.84	3.14
APR	1.20	4.35
MAY	1.51	4.70
JUN	1.60	4.44
JUL	1.95	5.06
AUG	1.69	4.56
SEP	1.66	4.40
OCT	1.11	3.15
NOV	0.92	3.44
DEC	0.20	1.07
Nov 2007	-0.77	-2.91
Dec 2007	-0.40	-1.40
Jan 2008	-0.06	-0.17
Constant	4.40	3.60

ρ = 0.54
r^2 = 0.83
n = 50
Dependent variable = ln(*trips*)

[4] That is, we assume that $\varepsilon_t = \rho\varepsilon_{t-1} + u_t$.

This attachment summarizes the approach to transferring results from Kling and Thomson (1996) to estimate recreational fishing losses.

The analysis uses CRFS data to estimate the number of fishing trips displaced as a result of the closure (T). Recreational fishing losses (L) are calculated by multiplying the T displaced trips by an estimate of the loss per displaced trip (L_d):

$$L = T \ x \ L_d$$

The estimate of the loss per displaced trip is derived from Kling and Thomson (1996). Let T_1 represent the number of trips taken under baseline conditions to the closed sites in the Kling and Thomson model, and let T_2 represent the number of trips to all other sites in the model under baseline conditions. Thus, $T_1 + T_2$ represents the total number of "choice occasions" in the model. The loss estimates reported in the study (L_c) are equal to the total losses divided by the number of choice occasions:[5]

$$L_c = \frac{L}{T_1 + T_2}$$

$T_1 + T_2$ represents the total number of trips to all sites, so L_c is the loss per *choice occasion*. However, we are interested in an estimate of the loss per *displaced trip*:

$$L_d = \frac{L}{T_1}$$

To derive L_d, it is necessary to convert L_c from Kling and Thomson into an estimate for each displaced trip. This is done by dividing L_c by the fraction of trips to the closed sites:

$$L_d = \frac{L_c}{\left(\frac{T_1}{T_1 + T_2}\right)}$$

$$= \frac{\frac{L}{T_1 + T_2}}{\left(\frac{T_1}{T_1 + T_2}\right)}$$

$$= L/T_1$$

[5] Equation 6 on page 105 of Kling and Thomson is a per choice occasion measure of compensating variation, and the estimates presented in the tables are per choice occasion measures of welfare losses (see third sentence of third complete paragraph on page 107).