DATA PROCESSING SUMMARY: *COSCO BUSAN* SHORELINE AND EELGRASS HABITATS

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ACCESS AND GIS DATABASE REVIEWS AND CHANGES

Introduction

The data recorded onto the Shoreline Cleanup and Assessment Team (SCAT) datasheets during the field surveys were entered into an Access database by the Environmental Unit during the spill response. A maximum oiling shapefile was also created from the SCAT datasheets so that varying oiling degrees along the shoreline could be viewed spatially. The goal of the review process of the *Cosco Busan* SCAT data was to:

1) Assess the quality and consistency of the data entry in the SCAT database ("database") in relation to the SCAT datasheets used in the shoreline surveys;

2) Assess the quality and consistency of the maximum oiling shapefile ("shapefile") presenting the maximum oiling for the segments of shoreline surveyed during the field efforts; and

3) Ensure that the structure of the database and the shapefile could be used to support injury assessment for various workgroups.

Manual and automated reviews were made by comparing the SCAT datasheets to the database and the shapefile. The Natural Resource Damage Assessment (NRDA) cooperative workgroup then reviewed the data for completeness.

Manual Review

An initial inspection of the data was completed in early March 2008. Five percent of the segments listed in the database, equivalent to 22 segments, were chosen using a random number generator to select the records from Phase I and Phase II surveys (i.e., surveys that ended in the first week of December 2007) from the Segment table in the database. The selected segments were manually checked by comparing the SCAT datasheets to the information entered into the database and the shapefile, focusing on errors that would affect the shoreline oiling assignments. Minor discrepancies were found between the SCAT datasheets and the database (e.g., using the high or low value of a given range instead of an average, typographical errors). An on-screen assessment was then completed to review the geographical and oiling accuracy between the shapefile and the SCAT datasheets and between the shapefile and the database. Inconsistencies noted between the shapefile and SCAT datasheets included issues such as:

a) Differences in measurements (e.g., length of oiling, using the high or low value of a given range instead of an average),

b) Small differences in habitat type (e.g., seawalls versus riprap), and

c) Segments with “no oiling observed” were not entered into the shapefile.

Larger inconsistencies were found when comparing the shapefile to the database but this was mainly due to the development and structure of the shapefile, discussed under the *Automated Review* section below. One of the problems found when comparing the database and the shapefile was the treatment of information on the presence of tarballs. Tarball data were recorded in various places (i.e., SCAT datasheet, Shoreline Treatment Recommendation Transmittal form {STRT}, Shoreline Oiling Summary {SOS} form, Post Operations Memo {POM} form, and their associated tables within the database) that made it challenging to track back to the shapefile.

Automated Review

Additional automated queries were developed and run to check the logical consistency of the data in the database and the shapefile. An automated script was written to determine the oiling degree based on the oiling measurements in the database and the matrices (Table 1) that were used to assign oiling degrees during the spill response. The automated oiling degree was then compared to the oiling classification assigned to each record in the database, noting where differences occurred. The same script was applied to the shapefile to compare the oiling classification assignments. The automated oiling degree was also checked against the shapefile to ensure that the appropriate maximum oiling degree was transferred to the shapefile. A new field, "RPI_Oil" was created to store the new maximum oiling within the shapefile. Any discrepancies between the automated oiling degree and the oiling listed in the shapefile were noted.

Table 1. Shoreline oiling categories based on the oiled band width, percent oil distribution, and oil thickness in the oiled band. Both matrices were used to determine final oiling categories.

		WIDTH OF OILED AREAS			
		Wide (> 6 m)	**Medium (> 3-6 m)**	**Narrow (> 0.5-3 m)**	**Very Narrow (< 0.5 m)**
OIL DISTRIBUTION	**Continuous (91-100%)**	Heavy	Heavy	Moderate	Light
	Broken (51-90%)	Heavy	Heavy	Moderate	Light
	Patchy (11-50%)	Moderate	Moderate	Light	Very Light
	Sporadic (1-10%)	Light	Light	Very Light	Very Light

Table 1 (cont.). Shoreline oiling categories based on the oiled band width, percent oil distribution, and oil thickness in the oiled band. Both matrices were used to determine final oiling categories.

		INITIAL CATEGORIZATION OF SURFACE OIL			
		Heavy	**Moderate**	**Light**	**Very Light**
AVERAGE THICKNESS	**Thick or Pooled (> 1 cm)**	Heavy	Heavy	Moderate	Light
	Cover (> 0.1-1.0 cm)	Heavy	Heavy	Moderate	Light
	Coat (> 0.01-0.1 cm)	Moderate	Moderate	Light	Very Light
	Stain/Film (< 0.01 cm)	Light	Light	Very Light	Very Light

Findings

During the review, it was noted that the database and shapefile were developed separately even though both sources used the information recorded on the hardcopy SCAT datasheets. This development process led to small differences in data structure and formatting of segment identifiers, making it difficult to relate the two products. It was recommended that the format of segment identifiers in the database and shapefile be corrected in order to appropriately link between the two products and allow for a more thorough assessment of the data. Once the database and shapefile were related, each record in the database was cross-referenced to the corresponding record in the shapefile to see where differences occurred. At this point in the review process, the shapefile contained 817 individual oil zones. Of these:

- 479 shapefile records matched records in the Zone Table of the database,
- 167 shapefile records matched records in the Zone Table of the database, but had some data discrepancies,
- 47 shapefile records were missing from the Zone Table of the database but added to the shapefile (typically tarball data found in SCAT datasheets, STRT, POM, or SOS within database but not in Zone Table), and
- 124 shapefile records where no oiling was observed were added from the database to the shapefile.

Where records between the database and shapefile matched but discrepancies were found, edits were made when appropriate. Discrepancies and revisions were recorded in the "STREATMENT" field of the shapefile. Inconsistencies found in the manual and automated reviews were also corrected in both the shapefile and the database when appropriate.

A second automated review and analysis was completed to ensure consistency and accuracy between the shapefile and the database after they were linked. RPI recalculated the oiling degrees based on the measurements in the shapefile and matrices and updated the "RPI_OIL" field. This field was then compared to the oiling degrees already listed in the shapefile under the "RECOILATE" field. There were nine segments where the "RPI_OIL" field and the "RECOILATE" field did not match. These segments were discussed with the workgroup during the review process and were edited. Any changes made to the shapefile after the database and shapefile were linked were recorded in the "RPIComment" field.

It was determined during the review that the "Length" field in the shapefile should be considered as the official length of the shoreline oiling. This was due to the fact that the database captured only the start and stop points of the shoreline segments but not the start and stop points of the oiled zones within each segment. However, the shapefile contained the geographical locations of the oiled zones and their corresponding length, allowing the lengths to be adjusted appropriately during the review process.

NRDA Cooperative Review

The edited shapefile was incorporated into a Google Earth project and sent to the Trustee members of the shoreline habitat workgroups to review for completeness based on their notes from field surveys. Proposed edits by the Trustee members were sent to RPI to be incorporated into the shapefile. Each edit was then evaluated by the joint Trustee/RP workgroups based on the evidence provided by the Trustees. Table 2 provides a list of the edits proposed for the maximum degree of oiling, and Table 3 provides a list of the edits proposed for the shoreline habitat classification. Some maximum oiling edits were not made as there was not enough information to make a revision. Edits were finalized, and the RPI_OIL and RPIComment field values were updated based on the revisions.

Table 2. Trustees' proposed edits to the maximum degree of oiling associated with the SCAT survey data.

Name of Edits	Sub-segment	Common name of location	Specifics of location	GPS coordinates (if available)	Current oiling category	Proposed oiling category	SCAT Edits as of 10/08
Marin Edits (by Toby McBride)	MRN006	Tennessee Beach		37.84N 122.555W	No Oil Observed	Very Light	Changed to Very Light
	MRP005	Fort Baker	Adjacent to GG Bridge	37.827N 122.477W	No Oil Observed	Very Light	Incomplete information; No edit was made
	MRS003B	Paradise Beach		37.89431N 122.45806W	No Oil Observed	Very Light	Incomplete information; No edit was made
	ALF001	Roberts Landing		37 40' 21.95" N, 122 09' 56.19" W to 37 40' 09.27 N, 122 09' 53.10" W	No SCAT	Moderate	Incomplete information; No edit was made
	ALA004	Albany Beach		entire segment of ALA004 Zone A	Light	Moderate	Changed to Moderate
	ALD003	Crown Beach		entire segment of ALD003	No Oil Observed	Very Light	Changed to Very Light
Alameda Edits (by Michael Anderson)	ALD 001	Alameda	Encinal Boat Launch	37.7676N 122.29337W	No SCAT	Very Light	Incomplete information; No edit was made
	ALD 002	Alameda	Alameda Beach	37.76343N 122.27325W	No Oil Observed	Very Light	Changed exposed portions to Very Light per 25-Sep-08 Meeting
Bolinas Edits (by Steve Hampton)			Arroyo Hondo to Abalone Point, Marin County		No Oil Observed / Light	Leave Light as is, add Very Light to rest of area	Light oiling remained as is; Added Very Light to rest of area
			Arroyo Hondo to Bolinas Point		No Oil Observed / Very Light / No SCAT	Very Light everywhere except at RCA Trailhead and at Bolinas Point which should be Light	Added Very Light everywhere except at RCA Trailhead (already listed as Light) and at Bolinas Point (also Light)

			Bolinas Point South To Agate Beach		Very Light / No SCAT	Very Light	Changed to Very Light
			Bolinas Beach from Wharf Road north to south Duxbury Reef		No Oil Observed / No SCAT	Very Light	Changed to Very Light
Richardson Bay and Horseshoe Cove (by Natalie Manning)	MRP004	Horseshoe Cove	No Oil Observed on retaining wall-along parking lot (north side) and on the No Oil Observed segment along West rip rap wall		No Oil Observed	Moderate	Changed to Moderate
	MRQ002 and MRQ003	Richardson Bay			No Oil Observed	Light	Changed to Light
East Bay (by Toby McBride)	ALA017Fa	Emeryville Crescent	N marsh edge from Powell St to N channel	37.83665N 122.29818W to 37.83434N 122.29689W	No Oil Observed	Very Light	Changed remaining unoiled portion of ALA107F to Very Light
	ALA017Fb	Emeryville Crescent	S edge of N channel to N edge of S channel	37.832883N 122.296661W to 37.83020N 122.29634W	No Oil Observed	Very Light	Changed remaining unoiled portion of ALA107F to Very Light
	ALA017Fc	Emeryville Crescent	SE corner of Crescent	37.82836N 122.29822W to 37.82804N 122.29897W	No Oil Observed	Very Light	Changed remaining unoiled portion of ALA107F to Very Light
	ALA017G	Emeryville Crescent	Info showed SCAT from just N of N channel across to just S of same		No Information	Moderate	Changed to Very Light as discussed in 25-Sep-08 NRDA meeting
	CCZ017a	Stege Marsh	SE edge of W Marsh	37.907790N 122.335043W to 37.909005N 122.335070W	No Information	Very Light	Changed to Very Light

	CCZ018a	Stege Marsh	NE edge of W Marsh	37.909622N 122.335647W to 37.910070N 122.334582W	No Information	Light	Changed to Light
	CCZ019a	Battery Cove	Far NE corner of E Marsh	37.908112N 122.326731W to 37.907967N 122.326810W	No Information	Moderate	Changed to Moderate
	CCZ020a	Stege Marsh	SW edge of E Marsh	37.907781N 122.332182W to 37.908514N 122.331197W to 37.908368N 122.330551W	No Information	Light	Changed to Light
	CCY005a	Cypress Point/Kellers Beach	Entire length of subsegment based on matching mussel samples		No Oil Observed	Very Light	Changed to Very Light
	CCZ017	Meeker Slough		??	No Information	??	Incomplete Information; No edit was made
Edits by Jan Roletto	MRO002	Rodeo Lagoon	shoreline adjacent to sandy beach	37°49'51.53"N, 122°32'9.62"W to 37°49'45.16"N, 122°32'3.37"W	No Oil Observed	Very Light	Changed to Very Light
	MRN004	Muir Beach	segment west of segment MRN004 Zone A1A	37°51'34.32"N, 122°34'40.32"W to 37°51'33.85"N, 122°34'49.83"W	No Oil Observed	Very Light	Changed to Very Light
	MRM003	Bolinas Lagoon	Zone B53 and Zone B33		No Oil Observed	Very Light	Changed to Very Light
	SML003/SML004/SML005	Fitzgerald Marine Reserve			No Oil Observed/Very Light		Incomplete information; No edit was made
Edits by Kristin Ward	SFH-10	Crissy Field Tidal Marsh	Eastern portion of marsh close to tidal inlet; following shoreline	see google earth edits	No Oil Observed	Very Light	Changed to Very Light

	SFH-10	Crissy Field	Entire segment	see google earth edits	No Oil Observed	Very Light	Changed to Very Light
	MRM-03	Bolinas Lagoon	Southern area of cordgrass-picklweed marsh	see google earth edits	No Oil Observed	Very Light	Changed to Very Light
Rocky Intertidal Edits (by Darren Fong)	ALA019 (currently labeled ALA11C)	Berkeley marina		37.8629, -122.3139 to 37.86083, -122.31556	Light	Change eastern portion of segment to Moderate	Changed eastern portion to Moderate
	MRO004	Bonita Cove		37.82066, -122.52833 to 37.81855, -122.52924	No Oil Observed	Very Light	Changed to Very Light
	MRR008	China Cove		37.87064, -122.4254 to 37.87112, -122.42804	No Oil Observed - Light	Moderate (see SCAT sheet)	Changed to Light per 25-Sep-08 meeting
	MRL003/MRM001	Duxbury		37.89984, -122.712600 to 37.89462, -122. 70505	No SCAT	Very Light	Changed to Very Light
	SFH010	Marina Green (East)		37.806056, -122.468678 to 37.80688, -122.44854	No Oil Observed	Very Light	Changed to Very Light
	MRN002	Slide Ranch South		37.87043, -122.596460 to 37.86582, -122.59183	No SCAT	Light (see SCAT sheet)	Changed to Light
	MRP003 and MRP002	Yellow Bluff		37.83571, -122.472050 to 37.84311, -122.47695	No Oil Observed / Very Light	Light (see SCAT sheet)	Changed to Light
	SMK007	Pedro Point		37.5985590935398, -122.515871 to 37.5960309813369, -122. 525901	No Data (Adjacent to No Oil Observed)	No Oil Observed	Changed to No Oil Observed

	CCY005	Keller Beach and Cypress Point		37.92119, -122.921190 to 37.92117, -122.38736	No Oil Observed	Very Light	Changed to Very Light
	CCY005	Keller Beach and Cypress Point		37.92258, -122.389140 to 37.92267, -122.38987	No Oil Observed	Very Light	Changed to Very Light
	SFI001	North Baker Beach		37.80447, -122.480750 to 37.994500, -122.481090	No Oil Observed	Very Light (<1%)	Changed to Very Light
	MRK001 and MRJ001	Santa Maria Creek		38.01664, -122.856460 to 38.01211, -122.848300	No SCAT / No Oil Observed	Very Light (<1%)	Changed to Very Light
	MRL002	Bolinas Point		37.90617, -122.727870 to 37.90368, -122.728070	No SCAT	Very Light (<1%)	Changed to Very Light
	MRN004	Muir Beach		37.859751, -122.578024 to 37.859557089, -122.579287	Data Mixed (adj to Light and NOO). Segment marked NOO had oil in eastern edge rock	Light (1-10%)	Changed to Light
	MRO004B	Bonita Cove		37.819108, -122.529355 to 37.8194, -122.52914	No Oil Observed	Very Light	Changed to Very Light
	MRN005B	Tennessee Cove		37.595285, -122.522055 to ?	No Oil Observed	Very Light	Changed to Light; refer to printed map
	MRN005B	Tennessee Cove		37.8417, -122.552400 to 37.8407, -122.591300	No Oil Observed	Very Light	Changed to Light; refer to printed map
	MRL003	Duxbury Reef		37.897717, -122.711783 to ?	No SCAT	Very Light	Changed to Very Light

	SMK007	Shelter Cove (Adjacent to Pedro Point)		37.598555, -122.515124 to 37.594902, -122.518559	No Oil Observed	Very Light	Changed to Very Light
	SMK006B	Linda Mar Beach		37.597, -122.510700 to 37.598400, -122.514000	No SCAT	Very Light	Changed to Very Light
	MRN004	Redwood Creek/Big Lagoon		37.86013, -122.577700 to 37.86025, -122.576200	No SCAT	Very Light	Changed to Very Light
	MRN004	Redwood Creek Tidal Outlet		37.859797, -122.577980 to 37.86013, -122.577700	No SCAT	Very Light	Changed to Very Light
	SFJ003	Fort Funston		37.7148, -122.504650 to 37.724, -122. 507000	No Oil Observed (Zones a22 and a42)	Very Light	Changed to Very Light
	MRM005	Red Rock		37.888248, -122.632514 to ?	No SCAT	No Oil Observed	Incomplete information; No edit was made
	MRO001-MRO002	Rodeo Beach North		37.831960, -122.540060 to 37.831700, -122.540760	No SCAT	Moderate	Moderate and Sand Cove north of Rodeo Beach becomes Light
Edits Discussed at 25-Sept-08 Mtg	ALA017F Zone A 11/13/07	Emeryville Crescent		37°49'35.09"N, 122°18'33.15"W to 37°49'34.58"N, 122°18'31.70"W	Light	Moderate	Expanded and changed to Moderate per 25-Sep-08 meeting
	CCZ001	Brooks Island			Very Light	Light	Changed to Light
	CCZ026				Very Light	Light or Moderate	Incomplete information; No edit was made

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Table 3. Trustees' proposed edits to the habitat classification associated with the SCAT survey data.

Segment	Survey Date	Zones	Edit
ALA003	Nov. 9, 2007	B and C	Both zones listed as seawall in shapefile but recorded as riprap on SCAT forms. Removed both zones since a riprap segment was already present in area with a higher degree of oiling.
ALA009A	Nov. 19, 2007	A2	Zone listed as seawall in shapefile but recorded as riprap on SCAT forms. Changed habitat to rip-rap and removed segment already present in area with a lower degree of oiling.
ALA009B	Nov. 19, 2007	A1	Zone listed as cobble-pebble in shapefile but recorded as sandy gravel on SCAT forms. Removed zone since a sandy gravel segment was already present in area with a higher degree of oiling.
ALA011B	Nov. 19, 2007	A	Zone listed as seawall in shapefile but recorded as riprap on SCAT forms. Changed habitat to riprap and removed riprap segments already present in area with same or lower degree of oiling.
ALA011C	Nov. 19, 2007	A	Zone removed since another segment was already present in area with same habitat and higher degree of oiling.
ALA011D	Nov. 19, 2007	A1	Zone listed as mud in shapefile but recorded as riprap on SCAT forms. Removed zone since riprap segments were already present in area with the same or higher degree of oiling.
ALA011G	Nov. 17, 2007	A	Zone listed as cobble-pebble but recorded as sand on SCAT forms. Removed segment since a sand segment was already present in area with a higher degree of oiling.
ALB004	Nov. 14, 2007	B	Zone listed as seawall in shapefile but recorded as sandy gravel on SCAT forms. Changed habitat to sandy gravel and removed the sandy gravel segment already present in area with a lower degree of oiling.
ALB004	Dec. 2, 2007	A2	Zone listed as seawall in shapefile but recorded as riprap on SCAT forms. Removed zone since a riprap segment was already present in area with a higher degree of oiling.
MRP004	Nov. 12, 2007	C	Zone listed as boulder in shapefile but recorded as riprap on SCAT forms. Changed habitat riprap and removed riprap segment already present in area with a lower degree of oiling.

DATA ANALYSIS AND AREA CALCULATIONS: *COSCO BUSAN* SHORELINE HABITATS AND EELGRASS WORKGROUPS

Data Used by the NRDA Cooperative Workgroup

Data from the SCAT surveys collected during the response and cleanup efforts were used to determine the geographic extent of shoreline oiling. Multi-agency teams collected data on the degree of oiling and the habitat type during these surveys. The shoreline was divided into segments. For each segment, field observations were recorded including width of the oiled band, percent oil coverage in the band, oil thickness, and shoreline type. The SCAT data were entered into an Access™ database daily by the Environmental Unit (EU). An ArcInfo™ shapefile was also created by the Environmental Unit to store the maximum oiling data so that the data could be viewed spatially.

Twelve shoreline types were recorded on the SCAT datasheets (Table 4).

Table 4. Shoreline types recorded on SCAT datasheets.

Shoreline Types
bedrock
boulder
cobble/pebble
coarse gravel
seawall
riprap
sand beach
mixed sand and gravel
marsh
vegetation
mud
peat-soil

During the review of the SCAT data, four additional habitat types were added to the maximum oiling shapefile:

1) Marsh and Tidal Flat Polygons: The marsh and tidal flat polygons are a union of three data sources: 1) digital data downloaded from the San Francisco Estuary Institute (SFEI) website (published 2001); 2) the San Francisco Bay Environmental Sensitivity Index (ESI) (published 1998); and 3) the Central California ESI (published 2006/2007) for the outer coast.

2) Eelgrass: Polygonal data provided by Merkel & Associates (2004).

3) Hotsie-treated Segments: The NRDA workgroup provided a Google Earth file depicting the shoreline segments where hot-water washing took place. These SCAT segments were reclassified as "Hotsie" habitats in the shapefile in order to provide the group with separate area information on these locations.

4) Rock Replacement: The NRDA workgroup provided a Google Earth file depicting the cobble-pebble shoreline segments where rock replacement activities took place. These SCAT segments were reclassified as "Rock Replacement" in the maximum oiling shapefile in order to provide separate area information on these locations.

To assist the NRDA cooperative workgroup in identifying data gaps, determining the degree of exposure, and estimating potential service losses, other sources of data were identified and reviewed. These included:

1) Tarballs: Tarball data that came from the Access database via the SCAT, STRT, SOS, and POM datasheets were classified as oiling degrees in the shapefile. A tarball evaluation matrix was used to assign the oiling (Table 5). Other tarball data, recorded by the Response Planning Unit's Maintenance and Monitoring Team (MMT) and the GFNMS BeachWatch surveys (BeachWatch) were used to QA/QC the data that were already present in the shapefile. These data were plotted and incorporated into a Google Earth project to show the number of tarballs on specific beach segments over time. Tarballs were monitored by the MMT from January 2008 to August 2008 and by the BeachWatch surveys from November 2007 to July 2008.

2) Tissue Samples: Fingerprint analysis of tissue samples was provided by NOAA and California OSPR to the NRDA cooperative workgroup on August 11, 2008. Tissue samples from various species (e.g., *Cryptomya*, *Mytilus*, *Venerupis*, *Gammarids*, *and Emerita*) were plotted and linked to Google Earth to reflect sample locations, analytical results (PAH), and whether or not it was determined to be a match to the *Cosco Busan* oil.

3) Wrack data: Algae and wood wrack counts were provided by GFNMS BeachWatch surveys. The data were plotted and linked to Google Earth as counts observed along specific shoreline segments over time. The counts of wrack were recorded from October through July.

Table 5. Tarball oiling category evaluation matrix

		Average Diameter		
		<1cm	>1 to <=10cm	>10cm
Density	<1m^2	Very Light	Very Light	Very Light
	1 to <10m^2	Very Light	Very Light	Light
	>=10m^2	Light	Light	Light

Area Calculations and Oiling Classifications

The following paragraphs describe how the oiled areas (Table 10, summary at the end of the document) were calculated for each habitat type both in the bay and along the outer coast.

In Bay

The NRDA shoreline habitat workgroups assigned two oiling zones to the shoreline, depending on the habitat type: Oiled intertidal zone (Oiled ITZ) and lower intertidal zone (LITZ). The Oiled ITZ is the entire area from the low tide line to the high tide line for a particular habitat (determined from the length of the segment multiplied by the average ITZ width) or the area of the oiled footprint (determined from the length of the segment multiplied by the oil band width recorded on the SCAT datasheet). The LITZ is the area calculated for some habitats that does not include the oiled band recorded on the SCAT datasheet.

Table 6 lists the intertidal zone widths that were used for some of the in bay habitats. The ITZ widths were provided either by averaging actual field measurements (sand beaches, bedrock), estimating and averaging measurements using high-resolution aerial photographs or Google Earth (bedrock, sand beaches, gravel beaches), using the tidal range (seawalls), or using the typical slope of the habitat and tidal range to determine the width (riprap).

Table 6. Average intertidal zone widths for in bay habitats.

Habitat	ITZ width (ft)
Sand Beaches	50
Bedrock (wave cut platforms, rocky shores, boulders)	73.8
Gravel Beaches (cobble/pebble, coarse gravel)	55.8
Riprap	18.2
Seawall	9.1

a) Riprap and Sand Beaches: The average ITZ width was used to calculate the Oiled ITZ for both riprap and sand beaches assuming that the oiling would have affected the entire shoreline from the low tide line to the high tide line. The entire ITZ was considered as one impacted area, not differentiating between the oil footprint and the remainder of the ITZ as the ecological services would likely be impacted equally in each zone for these two habitat types. Therefore, no LITZ was calculated and the area of the Oiled ITZ was calculated by multiplying the average width (Table 6) for each habitat by the length of the segment. The shoreline area was assigned an oiling degree based on the measurements from the SCAT datasheets and the oiling matrices used during the response.

b) "Rocky" Habitats (bedrock, boulder, cobble/pebble, coarse gravel) and Seawalls: These habitats were assigned impacts that varied by ITZ zone; therefore, area calculations were completed separately. The Oiled ITZ was calculated by multiplying the length of the segment by the actual oiled band width recorded in the SCAT data. The LITZ was calculated by multiplying the length of the segment by the average width of the ITZ (Table 6), minus the recorded oiled band width from the SCAT data. Both the Oiled ITZ and the LITZ areas were assigned an oiling degree based on the measurements from the SCAT datasheets and the oiling matrices used during the response. There were some exceptions for nine seawall segments: 1) Seven seawalls had a recorded oiled band width on the SCAT survey that was greater than the average intertidal zone width found in Table 6 (estimated from the tidal range during the spill). When this occurred, the recorded oiled band width measurement from the SCAT data was used as the entire intertidal zone width; 2) There were two oiled seawall segments that had an oiled band width of 20 m (65 ft) that, after inquiry, were determined to be oiled pilings beneath piers. In order to correct for this situation, the recorded width (20 m) was multiplied by the oiled band width of adjacent seawalls (0.3 m) to produce a more reasonable oiled band width of 6 m (19.7 ft) for these two particular cases.

c) Marsh, Vegetation, Mud, and Peat-Soil: The Oiled ITZ was calculated using the actual oiled band width recorded in the SCAT data multiplied by the length of the shoreline segment. For a few of the marsh, vegetation, or mud segments where the oiling was changed due to edits agreed to during the review process, an oiled band width associated with the segment may not have been available. The width for these segments was determined by the oiled band width of an adjacent segment of the same habitat type. LITZ areas were not calculated for these habitats as they are typically fronted by tidal flats that are already represented as polygons in the maximum oiling shapefile and have their own oiling classifications.

d) Mud and Sand Flats: Flats within 200 meters of the shoreline were separated into mud and sand habitat categories, and the area of the polygon was calculated within the GIS software. Flat polygons were assigned an oiling based on the degree of oiling of the nearest shoreline segments.

e) Eelgrass: Eelgrass polygons were divided into intertidal (<4 ft deep) and subtidal areas (> 4 ft deep) and the area of the polygons (Table 7) were calculated within the GIS software. Intertidal areas were assigned the same oiling degree as the adjacent shoreline segments. The subtidal areas were assigned one oiling degree less than the adjacent shoreline segments.

Table 7. Eelgrass area calculations.

Area of Eelgrass by Oiling Category (acres)					
	Adjacent to Heavy	***Adjacent to Moderate***	***Adjacent to Light***	***Adjacent to Very Light***	***Total***
< 4 feet	17.6	11.4	118.8	771.4	919.2
> 4 feet	0.0	2.9	0.2	17.7	20.8
Totals	**17.6**	**14.3**	**119.0**	**789.1**	**940.0**

f) Hotsie: The average ITZ width for riprap was used to calculate the Oiled ITZ for the hot-water washed segments assuming that the flushing would have affected the entire shoreline from the low tide line to the high tide line. The entire ITZ was considered as one impacted area, not differentiating between the oil footprint and the remainder of the ITZ. Therefore, no LITZ was calculated, and the area of the Oiled ITZ was calculated by multiplying the average width (Table 6) of riprap by the length of the segment.

g) Rock Replacement: The rock replacement segments were assumed to have varying impacts to both ITZ zones; therefore area calculations were completed separately. The Oiled ITZ was calculated by multiplying the length of the segment by the actual oiled band width recorded in the SCAT data. The LITZ was calculated by multiplying the length of the segment by the average width of the ITZ (Table 6), minus the recorded oiled band width from the SCAT data.

Outer Coast

The outer coast habitats were treated similarly to the in bay habitats in that the “rocky” and seawall habitats were divided into Oiled ITZ and LITZ areas while the areas for riprap, sand beach, and marsh habitats were calculated using the entire intertidal zone width to obtain only

the Oiled ITZ. However, the width calculations for each habitat present on the outer coast were based on the Coastal Biophysical Inventory (CBI) data for the Point Reyes National Seashore and Golden Gate National Recreational Area from the Pacific Coast Science & Learning Center.

The CBI shore width is measured along a transect perpendicular from the waterline (near low tide) to a cliff base, the end of the intertidal zone, or the end of another transect. This transect length is shown as T in Figure 1. The transect may be divided into two sections, referred to as lower and upper zones (LL and UL, respectively, in Fig. 1) based on significant change in the substrate or slope. The slope of each zone and the cliff (CL in Fig. 1) are also recorded.

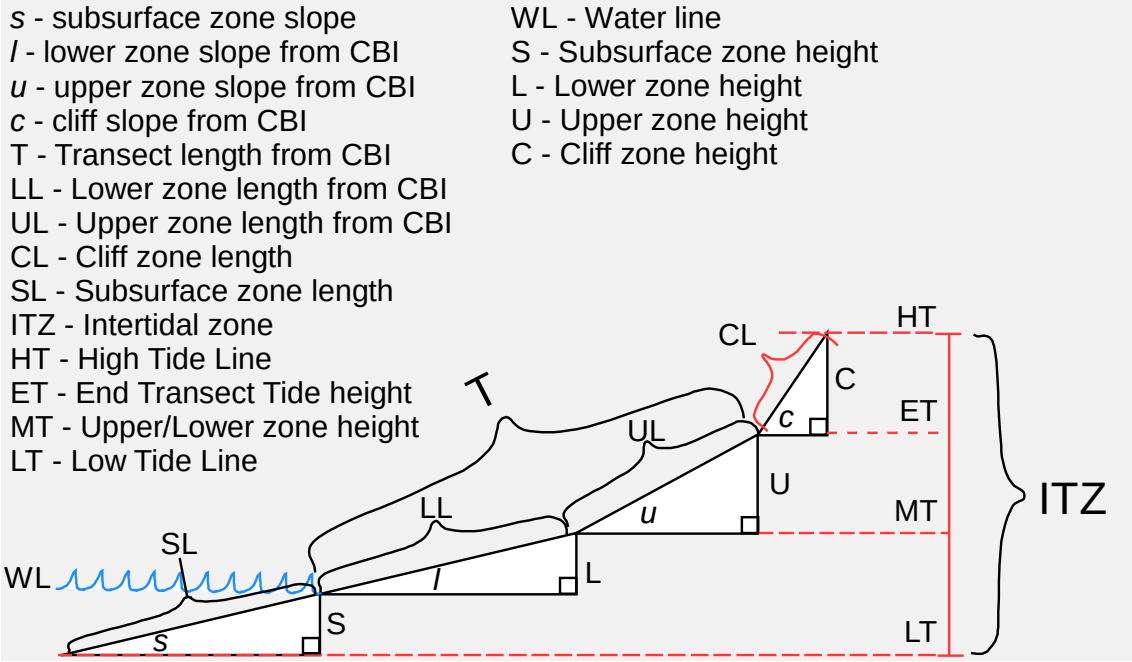

Figure 1. Schematic of the beach showing the different segments and variables used to calculate the zone widths.

Based on the information available in the CBI the shore was divided into four zones.

1) Subsurface zone (SL): Distance from the waterline at the time of the survey to the low tide line used for the purposes of this project.
2) Lower zone (LL): Identified by CBI as the waterline to the beginning of the upper zone. If there is no upper zone, the lower zone is considered the entire width of the beach or to the base of a cliff.
3) Upper zone (UL): Identified by CBI as the end of the lower zone to the true terrestrial area or the base of a cliff.

4) Cliff zone (CL): Begins at the end of the upper zone. If there is no upper zone, the cliff zone starts at the end of the lower zone.

The widths of each of these zones was extracted directly from the CBI data or calculated based on CBI's slope of the segment and the range of the intertidal zone. The range of the intertidal zone was determined from the tidal range of the nearest station to shoreline segment. The high and low tide limits were based on the highest high and lowest low tide for the time period from November 7, 2007 to December 7, 2007. To calculate the area for outer coast habitats, the length of each of the individual zones were totaled to produce an intertidal zone width. The intertidal zone width and the length of the segment were then used to calculate the area as was done for the in bay habitats. The following sections describe the formulas used.

Individual Zone Widths

The widths of the individual zones were calculated based on zone type:

a) Subsurface zone – The waterline of the CBI survey is given as the tide stage at the time of the survey. It was assumed that the slope of the subsurface zone of the beach was the same as the slope of the lower zone of the beach. The subsurface zone length is calculated from the waterline to the low tide limit using the formula SL = S/sin(*s*) (Fig. 1) where:

SL = Subsurface length

S = Difference between water level and low tide

s = Slope of the lower zone of the beach.

Exceptions – If there was a slope of 0 for the lower zone of the beach then the subsurface length was not calculated.

b) Lower zone – If there was an upper zone, the length of the lower zone was calculated from the water line to the mark of the beginning of the upper zone, as recorded in the CBI data. If there was no upper zone, then the length of the lower zone was calculated from the water line to the end of the transect (Fig. 1).

Exceptions – If there was an upper zone and no measurement indicating the beginning of the upper zone, then the length of the lower zone was calculated as the entire length of the transect. If the calculated tide level for the end of the lower zone was higher than the high tide level, the length of the lower zone was calculated using the formula LL=(HT-WL)/sin(*l*) where:

LL = Lower zone length

HT = High tide line

WL =Waterline

l = Slope of lower zone

c) Upper zone – When there was an upper zone, the length of the upper zone was calculated as the distance from the upper zone mark to the end of the transect (Fig. 1).

Exceptions – If there was no measurement indicating the beginning of the upper zone, then no calculations were possible, and the entire transect was assumed to be the lower zone. If the start of the upper zone was above the high tide line as determined in the lower zone calculations, then the upper zone was assigned a length of 0. If the end of the upper zone was above the high tide line, then the length of the upper zone was calculated using the formula UL=(HT-MT)/sin(*u*) where:

UL = Upper zone length
HT = High tide line
MT = Height at mark between upper zone and lower zone
u = Slope of upper zone

d) Cliff zone – The length of the cliff zone within the intertidal zone was calculated using the formula CL = (HT-ET)/sin(*c*) (Fig. 1) where:

CL = Cliff zone length
HT = High tide line
ET = Height at end of CBI Transect
c = Slope of the cliff

Exceptions – The length of the cliff zone was not calculated if the end height of either the lower zone or upper zone was higher than the high tide line. And the length of the cliff zone was not calculated if the slope of the cliff was 0.

Total Intertidal Zone Width

The total width of the intertidal zone was calculated as the sum of each of the above zones lengths.

Exceptions – If there was no perpendicular transect length, the width of the intertidal zone was set to the median of all the shoreline sections that had the same primary lower zone habitat. If there was no primary lower zone habitat then the median width for the matching SCAT shoreline habitat was used.

Area Calculations

The Oiled ITZ area was calculated by one of two methods depending on the habitat: 1) for sand beaches and riprap, the area was calculated from the length of the segment multiplied by the total intertidal zone width for the particular segment; 2) for all other habitats, the area was calculated as the length times width of the oil band from the SCAT data. The LITZ area was calculated by multiplying the length of the shoreline segment by the calculated lower intertidal zone width (calculated from subtracting the recorded oiled band from the SCAT data from the entire intertidal zone width, i.e., the sum of each of the zone lengths). Both the Oiled ITZ and the LITZ were assigned an oiling degree based on the measurements from the SCAT datasheets and the oiling matrices used during the response.

Outer Coast Golden Gate National Recreational Area: *Un-Surveyed Segments*

A significant portion of Golden Gate National Recreational Area (GGNRA) shoreline from the Golden Gate Bridge north to Stinson Beach was not surveyed by the SCAT teams because the area is predominantly inaccessible headlands. These un-surveyed segments were selected from the CBI dataset, assigned a very light degree of oiling, and area calculations were computed based on the same methodologies described above. It is important to note that SCAT shoreline habitat classification and oiled band width information were not available for these segments. Therefore the shoreline habitat classification was based on the habitat classification from the CBI dataset, and an oiled band width of 5 meters for cove-like segments and 3-meters for exposed segments were assumed in determining the area calculations (Table 8).

Table 8. Area calculations for un-surveyed segments in the GGNRA.

Habitat	Segment Type	Oiled ITZ (acres)	LITZ (acres)
Bedrock	Cove	1.29	8.79
Bedrock	Exposed	4.99	52.83
Boulders	Exposed	2.31	12.28
Coarse Sand	Cove	0.28	0.00
Coarse Sand	Exposed	0.89	0.00
Cobbles	Exposed	0.05	0.40
Fine Sand	Cove	7.18	0.00
Fine Sand	Exposed	0.31	0.00
Granules	Cove	0.06	0.32
Pebbles	Cove	0.04	0.13
Pebbles	Exposed	0.04	0.18
Totals		**17.43**	**74.94**

Golden Gate Bridge and Half Moon Bay: *No Oil Observed Segments*

Forty-two segments surveyed from December 30, 2007 and January 10, 2008 were surveyed by airboat with no oiling observed. However, these inaccessible areas were between beaches that did have oil in November. Therefore, these segments were assigned an oiling degree of very light. An average oiled band width of 3.1 meters for boulder segments and 3.0 meters for cobble/pebble segments was assumed for these segments; and the area calculations were based on the same methodologies mentioned above.

Table 9. Area calculations for no oil observed segments between Golden Gate Bridge and Half Moon Bay.

Habitat	Oiled ITZ (acres)	LITZ (acres)
Boulder	5.72	34.52
Cobble-Pebble	1.21	6.91
Sand	22.88	0.00
Totals	**29.81**	**41.43**

Table 10. Total area calculations by substrate type, location, and oiling category.

Substrate Type	Area of shoreline by Oiling Category (acres)									
	Heavy		Moderate		Light		Very Light		Total	
In Bay	***Oiled ITZ***	***LITZ***	***Oiled ITZ***	***LITZ***	***Oiled ITZ***	***LITZ***	***Oiled ITZ***	***LITZ***	***Oiled ITZ***	***LITZ***
Bedrock	0.27	0.33	0.09	0.76	0.92	14.10	1.11	12.65	2.39	27.83
Boulder	0.07	0.27	0.15	0.70	0.08	1.30	0.05	0.80	0.35	3.06
Coarse Gravel	0.00	0.00	0.00	0.00	1.13	7.64	0.29	1.62	1.42	9.26
Cobble-Pebble	0.10	0.46	0.52	3.08	0.69	4.60	0.89	8.97	2.19	17.10
Seawall	0.04	0.00	0.03	0.17	1.63	1.73	0.86	6.61	2.56	8.51
Rip-Rap	0.93	0.00	5.76	0.00	21.32	0.00	49.57	0.00	77.58	0.00
Hotsie	N/A								4.83	0.00
Rock Replacement	N/A								0.18	0.82
Sand	0.00	0.00	2.38	1.48	1.97	12.51	4.11	23.27	8.46	37.26
Sandy Gravel	0.27	0.76	0.09	0.54	0.59	6.51	0.57	6.29	1.51	14.10
Marsh/ Vegetation/ Peat Soil	0.14	0.00	0.03	0.00	4.27	0.00	12.35	0.00	16.78	0.00
Mud	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total In Bay	**1.81**	**1.81**	**9.05**	**6.72**	**32.59**	**48.38**	**69.80**	**60.21**	**118.24**	**117.95**
Outer Coast										
Bedrock	0.50	0.25	0.02	0.21	0.08	1.17	6.92	82.52	7.53	84.15
Boulder	0.02	0.06	0.62	2.59	1.76	5.80	9.21	52.26	11.62	60.70
Coarse Gravel	0.00	0.00	0.00	0.00	0.10	1.53	0.52	16.95	0.62	18.48
Cobble-Pebble	0.05	0.34	0.22	0.95	0.45	28.68	1.68	10.75	2.41	40.72
Seawall	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.02
Rip-Rap	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sand	1.03	1.12	0.19	0.76	5.63	111.79	58.41	393.89	65.25	507.55
Sandy Gravel	0.78	0.31	0.00	0.00	0.58	7.63	0.13	4.64	1.48	12.58
Marsh/ Vegetation/ Peat Soil	0	0	0.55	0.00	0.74	0.00	0.01	0.00	1.30	0.00
Total Outer Coast	**2.38**	**2.08**	**1.60**	**4.50**	**9.33**	**156.59**	**76.89**	**561.02**	**90.21**	**724.19**
Flats (200 m)		**Adjacent to Heavy**		**Adjacent to Moderate**		**Adjacent to Light**		**Adjacent to Very Light**		
Mud Flats		4.18		239.41		227.43		868.38		1,339.40
Sand Flats								37.52		37.52
Grand Totals (200 m)	**4.19**	**8.08**	**10.65**	**250.63**	**41.92**	**432.40**	**146.68**	**1,527.13**	**208.45**	**2,219.06**