STRATEGIC PLANNING METHODOLOGY TO EVALUATE LOW PROBABILITY/HIGH CONSEQUENCE TANKER OIL SPILLS, USING THE GULF OF MEXICO AS A TEST AREA

Volume II

A Dissertation

by

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TABLE OF CONTENTS

Volume I

TABLE OF CONTENTS, Continued

TABLE OF CONTENTS, Continued

Volume II

TABLE OF CONTENTS, Continued

TABLE OF CONTENTS, Continued

TABLE OF CONTENTS, Continued

LIST OF TABLES

Volume I

LIST OF TABLES, Continued

LIST OF TABLES, Continued

LIST OF FIGURES

Volume I

Volume II

CHAPTER IX

ESTIMATING SPILL FREQUENCY AND VOLUME IN THE GULF OF MEXICO

Introduction

This Chapter focuses on the following variables from the Chapter II methodology:

- V(i), the volume of oil spilled for a catastrophic spill (V(1)) and for a significant spill (V(2));

- SPILL(i), the frequency of spills of size range (i) occurring in the region;

- ACTIVITY, the level of the company's oil shipment activity in the region as a fraction of the area total oil shipments; and

- FACTOR, a representation of steps which a company may undertake to either lower or raise the company's likelihood of experiencing a major spill event. The Chapter discusses of how these variables can be selected, and focuses in particular on the Gulf of Mexico test area.

Estimating Values for V(i)

V(1) and V(2), volumes representing a catastrophic spill and a significant spill respectively, require a company to make its first judgmental selection in approaching the Chapter II methodology. As noted above, because the present knowledge concerning oil spills does not permit every volume to be considered (due to lack of information about spill frequency and probability for every volume), a company attempting to estimate its exposure must select what for it would be a catastrophic and a significant spill event. There are a number of alternative approaches to making these estimates:

- Determine the designated geographic region's average shipment volume, and use this volume for a catastrophic spill and 50-66% for a significant spill;

- Determine the designated geographic region's largest single shipment, and use this volume for a catastrophic spill and use 50-66% for a significant spill;

- Determine the company's average shipment volume, and use this volume for a catastrophic spill and use 50-66% of this volume for a significant spill;

- Determine the company's largest single shipment, and use this volume for a catastrophic spill and use 50-66% for a significant spill; or

- Some combination of the above alternatives.

Benefits and drawbacks exist for each alternative. Use of the geographic region's average shipment has the important limitation of possibly not being consistent with the particular company's scale of activity. As an example, the Gulf of Mexico average shipment volume for 1982 is approximately 50,000 tons (see Appendix J); examining two companies operating in the Gulf for this same time period, Charter Oil's company average shipment is approximately 53,537 tons, while another company, Mobil Oil, has an average shipment of 80,169 tons. While use of a Gulfwide average would be a suitable representation for Charter during this period, it would clearly understate Mobil's scale of operations.

The second alternative, use of an individual company average shipment volume, also contains a potential limitation. Use of an average, even if it is an individualized company average, may seriously understate the company's true exposure to a "catastrophic" spill event. Again referring to Charter and Mobil in the Gulf, consider the variations between average volume and largest company vessel for these companies:

Company	Lowest Shipment	Highest Shipment	Average Shipment
Mobil Oil	18,471 tons	280,432 tons	80,169 tons
Charter Oil (See Appendix J)	27,618 tons	77,041 tons	53,538 tons

If Mobil Oil in particular were to use as its definition of "catastrophic" the company average shipment of 80,169 tons, the company has ignored all potential spills of 80,170 - 280,432 tons, which could occur if its largest shipment experienced a spill. Mobil's true "catastrophic" spill is three times its company average shipment level.

Considering the third alternative, use of a company's largest shipment volume and 50-66% of this volume as an estimate of "catastrophic" and "significant" has the reverse problem of alternative two. Again referring to the table above, if Mobil were to use 280,432 for V(1) and also were to use 185,085 tons (66% of 280,432 tons) for V(2), then Mobil will have probably overestimated its "significant" spill potential. Note that while a company such as Mobil makes shipments in the +250,000 ton range, it also makes extremely small shipments, in the +18,000 range. To assign a value to V(2) that focuses only on the company's largest spill may generate too great an estimate of NET EXP.

The recommended solution to selecting values for V(1) and V(2) is that a blending of company average shipment and company largest single shipment be used. In order to avoid the potential underestimation of a company's exposure to a truly catastrophic spill event, V(1) will be assigned the value of the company's largest shipment. (A variation would be to examine the company's top two or three shipments, and take this "top shipment" average). In order to avoid the other problem of potentially overestimating the value of a "significant" spill event, V(2) will be assigned the value of the company's average shipment. Selection of the average shipment may understate the exposure for large individual shipments and overstate the exposure for small shipments, but it should act to give the company a representative scale of exposure.

Therefore, the two example companies above would assign the following values to V(1) and V(2):

Mobil: V(1)= 280,432 tons; V(2)= 80,169 tons.

Charter: V(1)= 77,041 tons; V(2)= 53,538 tons.

Estimating Values for SPILLS(i)

As discussed in Chapter II, the variable SPILLS(i) represents the number of major oil spills of volume (i) in the described geographic area per year. Because the frequency of large volume oil spills is low, it is not feasible to determine a frequency for every (i) volume. Therefore, two states of (i) are used, where SPILLS(1) reflects a significant spill volume, and SPILLS(2) a catastrophic spill event.

A question similar to that raised in the discussion of variable V(i) also exists in estimating SPILLS(i): how should spill volume ranges be determined in order to generate a frequency value? Even if a fixed proxy value for V(1) and V(2) were used (ex. - use of a fixed value of 250,000 tons for V(1) and 50,000 tons for V(2) regardless of the company involved), it would still be necessary for the variable SPILLS(i) to include as data spills above and below the stated volumes. The list below reflects the relatively few unintentional tanker spills which fall into these ranges, even over a five year period of 1976-1980:

Volume Range	Spills, 1976-1980	Annual Average
+ 3.4 tons (+1,000 gallons)	53	10.6
+ 143 tons (+42,000 gallons)	12	2.4
+ 340 tons (+100,000 gallons)	10	2.0
+1,701 tons (+500,000 gallons)	8	1.6
+3,401 tons (+1,000,000 gallons)	6	1.2
+20,408 tons(+6,000,000 gallons)	4	0.8
+34,014 tons(+9,999,999 gallons)	3	0.6

(1)

The problem is made still more complex by the proposed valuation for V(i) discussed above making use of a volume for V(1) and V(2) that varies for each company in the Gulf.

Recognizing both the need for frequencies for SPILLS(i) and also the limitations imposed by the low number of large spill occurrences, the following approach is applied to estimating SPILLS(i):

- 1. Obtain tanker unintentional spill data for the designated geographic region for a substantial time period; data for a period of at least 3-5 years would appear to be advisable, in order to avoid basing an estimate of annual spill frequency on a single year which may be unusually high or unusually low in terms of significant volume spills;

- 2. As part of estimating SPILLS(1) for a significant spill, generate two types of information about shipments in the area:
  - the geographic area's average shipment volume; and
  - the range of company average shipment volumes in the area;

- 3. Determine a frequency SPILLS(1) for the geographic area for spills in the range represented by the company and geographic area average shipment volumes;

- 4. As part of estimating SPILLS(2) for a catastrophic spill, determine the range of company "largest" shipments, and determine a frequency SPILLS(2) for spills falling within this range;

- 5. Validation of both frequencies should focus on whether the "correct" spills have been selected, that is, spills which, even if they are at the low end of the volume range, could have been larger volume spills;

- 6. If either SPILLS(1) or SPILLS(2) cannot be determined due to lack of spill occurrences in the necessary volume range, use a proxy value by:
    - reference to catastrophic spill data from other locations; and/or
    - projections of catastrophic spill frequency as a fraction of significant spill frequency.

- 7. Finally, attempt to validate frequencies by reference to worldwide or other regional spill occurrence information.

Step 1, data on unintentional tanker spills for the Gulf of Mexico, is presented for years 1976-1980 (2) at Table 20, at page 241. Note that insignificant spills of below 3.4 tons (less than 1,000 gallons) have been excluded.

Step 2, determination of the Gulf of Mexico average shipment volume and determination of company average shipment volumes, is reflected in Table 21, at page 243. The high end for this average is 111,739 tons (Marathon), and the low end is 23,735 tons (Mobile Bay Refinery). The distribution of company average shipments is found in Table 22 at page 245. Note that the Gulfwide average of 48,216 tons falls within the heaviest concentration of company average shipments, the 35,000-75,000 ton range.

Estimating SPILLS(2), A Significant Spill Frequency

Examining the major Gulf spill occurrences during 1976-1980, there are four spills which fall within the range of 20,000 tons and +34,000 tons (the Coast Guard's spill recording system does not record spill volumes beyond 9,999,999 gallons, or 34,000 tons, and so the precise volume for these upper limit spills is not

TABLE 20

GULF OF MEXICO UNINTENTIONAL TANKER SPILLS, 1976-1980, OF 3.4 TONS (= 1,000 GALLONS) AND ABOVE

Tanker Operation - "Underway", "Unknown Operation", or "No Operation Reported"

Volume (tons)	Cause	Tanker (thousand tons)	Operation	Location: (lat/long/)
1976:				
3.4	Corrosion	T(.15-.3)	Underway	2928/8913(off New Orleans LA)
714.3	Unknown	T(10-20)	Underway	2930/9453(Galveston Bay,TX)
14.3	Unknown	T(10-20)	Underway	2936/9423(Galveston/Pt. Arthur,TX)
21,428.6	PE-Hose Twist	T(10-20)	Underway	2750/8234(Tampa Bay,FL)
1977:				
None				
1978:				
228.6	Collision	T(0-.15)	Underway	2943/9352(Pt. Arthur,TX)
8,571.4	Grounding	T(20-35)	Underway	2855/9517(off coast Freeport,TX)
34,014(*)	Grounding	T(20-35)	Underway	2922/9448(Galveston Bay,TX)
5,128.6	PE-Unknown	T(35-50	Underway	2929/9346(off Pt. Arthur,TX)
1979:				
7.8	Grounding	T(1-10)	Underway	2751/9704(Corpus Christi,TX)
34,014(*)	Grounding	T(50-100)	Underway	2920/9440(off Pt. Arthur,TX)
57.8	Grounding	T(.5-1)	Underway	3017/8826(off Mobile,AL)
40.8	Grounding	T(10-20)	Underway	3018/8814(off Mobile,AL)
2,857.1	Unknown	T(35-50)	None	2944/9508(Galveston/Houston,TX)
884.4	Unknown	T(1-10)	Underway	3000/9359(Beaumont,TX)
4.3	Unknown	T(10-20)	None	2958/9353(Beaumont,TX)
1980:				
3,054.4	Collision	T(1-10)	None	3016/8915(Gulfport,LA)
34,014(*)	Grounding	T(50-100)	Underway	2937/9246(LA coast, between Pt. Arthur,TX and Lafayette,LA)

(*) The PIRS reporting system does not have storage capability for digits in excess of 9,999,999 gallons (= 34,014 tons). Spills designated by (*) have probably exceeded the level shown.

TABLE 20, Continued

Tanker Operation - "All Other Operations"

Volume (tons)	Cause	Tanker (thousand tons)	Operation	Location (lat/long/)
1976:				
3.4	Collision	T(10-20)	Moored	3004/9405(Pt. Arthur/Beaumont,TX)
3,6	PE-Inattent.	T(35-50)	Unloading	3000/9359(Pt. Arthur,TX)
17,3	PE-Valve Op.	T(10-20)	Unloading	2737/8234(Tampa Bay,FL)
3.6	PE-Valve Op.	T(35-50)	Ballast	3000/9359(Pt. Arthur,TX)
3.4	PE-Valve Op.	T(35-50)	Unloading	3000/9350(Pt. Arthur,TX)
29.6	PE-Pipe Cut	T(35-50)	Unloading	2749/9726(Corpus Christi,TX)
4.3	PE-Valve Fail	T(1-10)	Loading	2750/9704(Corpus Christi,TX)
4.3	PE-Loading	T(10-20	Loading	2950/9357(Pt. Arthur/Beaumont,TX)
10.7	PE-Overfill	T(20-35)	Loading	2749/9726(Corpus Christi,TX)
27.2	PE-Unknown	T(20-35)	Loading	2943/9508(Houston Channel,TX)
1977:				
87.1	PE-Pressurize	T(20-35)	Loading	2749/9726(Corpus Christi,TX)
3.4	PE-Loading	T(10-20)	Loading	3004/9404(Beaumont,TX)
129.3	PE-Unknown	T(20-35)	Unloading	2943/9512(Houston Channel,TX)
1978:				
5.7	Unknown	T(20-35)	Unloading	2922/9453(Galveston,TX)
5.7	PE-Inattent.	T(35-50)	Other Op.	2749/9726(Corpus Christi,TX)
4.3	PE-Valve Op.	T(1-10)	Loading	2943/9512(Galveston/Houston,TX)
14.3	PE-Valve Op.	T(10-20)	Ballast	3005/9401(Pt. Arthur/Beaumont,TX)
5.7	PE-Valve Op.	T(10-20)	Loading	2951/9358(Pt. Arthur/Beaumont,TX)
5.7	PE-Valve Fail	T(35-50)	Ballast	2922/9453(Galveston,TX)
3.4	PE-Overfill	T(50-100)	Fueling	2740/9726(Corpus Christi,TX)
1979:				
162.9	Collision	T(35-50)	Departing	2922/9453(Galveston, TX)
14.3	Collision	T(.5-1)	Moored	2943/9514(Galveston/Houston,TX)
5.7	Weather/Seas	T(50-100)	Moored	3000/9359(Pt. Arthur/Beaumont,TX)
3.4	Unknown	T(1-10)	Loading	2943/9507(Houston/Baytown,TX)
4.3	Unknown	T(10-20)	Ballast	2959/9357(Beaumont,TX)
7.1	PE-Inattent.	T(20-35)	Loading	2943/9501(Galveston,TX)
7.3	PE-Valve Op.	T(1-10)	Loading	2950/9357(Pt. Arthur/Beaumont,TX)
89.1	PE-Valve Op.	T(50-100)	Ballast	3010/9315(Lake Charles,LA)
8.1	PE-Overfill	T(0-.15)	Fueling	2922/9453(Galveston,TX)
7.1	PE-Overfill	T(20-35)	Unloading	3000/9405(Beaumont,TX)
1980:				
34.0	Oth. Casualty	T(.5-1)	Load	2908/9513(Galveston,TX)
3.6	Unknown	T(20-35)	Ballast	2856/9520(Galveston,TX)
5.1	PE-Valve Op.	T(10-20)	Loading	2748/9727(Corpus Christi,TX)
32.3	PE-Hose Cut	T(35-50)	Unloading	2943/9507(Houston Channel,TX)
6.8	PE-Sounding	T(10-20)	Fueling	2944/9517(Houston Channel,TX)
10.2	PE-Sounding	T(10-20)	Fueling	2943/9507(Houston Channel,TX)

Source: U.S. Coast Guard PIRS computer data base, 1982.

TABLE 21

AVERAGE SHIPMENT AND "LARGEST" SHIPMENT VOLUMES
FOR COMPANIES IMPORTING OIL INTO THE GULF OF MEXICO,
JAN-OCT 1982

Company	Volume (tons)	Number of Shipments	Average Shipment (tons)	Largest Shipment (tons)
Amoco Oil Co.	9,339,292	176	53,065	129,311
Ashland Oil Co.	3,493,746	78	44,792	142,857
Atlantic Richfield Co.	2,889,338	49	58,966	107,000
Champlin Petroleum Co.	1,750,068	30	58,336	107,141
Charter Oil Co.	428,302	8	53,538	77,041
Chevron, USA	4,144,747	107	38,736	71,065
Cities Services Oil Co.	1,857,933	44	42,226	73,236
Clark Oil and Ref. Co.	2,612,480	51	51,225	85,101
Coastal Corp.	2,534,987	50	50,700	90,593
Conoco, Inc.	523,570	7	74,796	159,332
Coral Petroleum, Inc.	425,862	8	53,233	66,571
Continental Petroleum	336	2	168(*)	223(*)
Crown Central Pet. Corp.	1,445,071	26	55,580	89,230
Delta Refining Co.	1,004,429	16	62,777	83,804
Exxon Corp.	4,699,632	132	35,603	79,580
GHR Energy Corp.	1,395,744	33	42,295	150,157
Gulf Oil Corp.	3,010,028	70	43,000	90,129
Gulf States Oil and Ref.	749,074	14	53,505	85,399
Horizon Petroleum Co.	438,108	6	73,018	71,558
Houston Oil and Ref.	216,028	4	54,007	64,719
Hunt Oil Co.	240,498	9	26,722	32,101
Intercoastal Petroleum	1,496	5	299(*)	275(*)
International Processors	316,301	6	52,717	69,918
Kerr-McGee	1,633,843	29	56,339	84,331
Koch Industries, Inc.	140,717	3	46,906	57,213
LaGloria Oil and Gas	589,881	12	49,157	74,761
Marathon Oil Corp.	7,263,039	65	111,739	432,347
Mobil Oil Co.	3,369,083	42	80,216	280,432
Mobile Bay Ref. Co.	142,409	6	23,735	35,639
Murphy Oil Corp.	729,879	12	60,823	80,218

(*) Companies which have probably had oil shipped as part of another company's shipment. These partial shipments will not be included in estimates of the "low end" of Gulf of Mexico shipments.

TABLE 21, Continued

Company	Volume (tons)	Number of Shipments	Average Shipment (tons)	Largest Shipment (tons)
Nat'l Coop. Refy. Assoc.	43,247	1	43,247	43,247
Phillips Petroleum Co.	1,605,222	37	43,384	55,434
Placid Ref. Co.	143,789	3	47,930	74,860
P&O Falco, Inc.	71,605	1	71,605	71,605
Sea Horse Marine, Inc.	12,679	75	169(*)	986(*)
Sentry Ref.	277,072	10	27,707	50,393
Shell Oil Co.	9,483,704	180	52,687	270,582
Sigmore Corp.	484,691	7	69,242	74,372
Std. Oil - Ohio	1,574,663	34	46,314	82,836
Sohio Supply Co.	1,334,089	30	44,470	83,552
Strategic Petroleum Res.	7,282,197	185	39,363	266,101
Sun Company, Inc.	207,956	4	51,989	72,657
Tenneco, Inc.	304,351	6	50,725	71,401
Texaco, Inc.	6,660,026	145	45,931	283,803
Texas City Ref. Inc.	2,972,783	44	67,563	89,916
Tosco Corp.	424,336	9	47,148	77,802
Total Petroleum, Inc.	399,979	6	66,663	85,062
Union Oil Co. - USA	1,077,659	16	67,354	200,016
Vulcan Asphalt and Ref.	107,320	4	26,830	28,408
Gulf of Mexico Total:	91,863,289	1,897	48,426	

(*) Companies which have probably had oil shipped as part of another company's shipment. These partial shipments will not be included in estimates of the "low end" of Gulf of Mexico shipments.

Source: American Petroleum Institute, Imported Crude Oil and Petroleum Products (Washington: API, 1982).

TABLE 22

DISTRIBUTION OF COMPANY AVERAGE OIL SHIPMENTS
AND COMPANY LARGEST SHIPMENTS
IN THE GULF OF MEXICO, JAN-OCT 1982

Range(thous-and tons)	Average Shipment		Largest Single Shipment	
	Number of Companies	Comments	Number of Companies	Comments
below 20	3		3	
20-30	4		1	
30-40	3		2	
40-50	13	Gulf of Mexico average	1	
50-60	15		3	
60-70	6		3	
70-80	3	Conoco,Horizon,P&O Falco	12	
80-90	1	Mobil	10	
90-100	--		2	Coastal,Gulf
100-110	--		2	Arco, Champlin
110-120	1	Marathon	--	
120-130	--		1	Amoco
130-140	--		--	
140-150	--		1	Ashland
150-160	--		2	Conoco, GHR Energy
.				
200-210	--		1	Union Oil
.				
260-270	--		1	Strategic Pet. Res.
270-280	--		1	Shell
280-290	--		2	Mobil, Texaco
.				
430-440	--		1	Marathon

Source: American Petroleum Institute, Imported Crude Oil and Petroleum Products (Washington: API, 1982). For full details of companies, see Table 21, at page 243.

known). (3)

It would be preferable for the occurrences constituting the SPILLS(2) significant spill value to range over the full breadth of company average shipment volumes (i.e.- 35,000-75,000 tons). Because of the data collection limitations noted in the Coast Guard PIRS system, it is not fully clear whether the 9,999,999 gallon spills reflect lower range values (such as 35,000 tons) or higher range values (in excess of 35,000 tons). Use of these four occurrences to constitute the variable SPILLS(2), the annualized frequency for a significant spill, generates a value of 4 occurrences/5 years, or 0.8.

A related question which arises is whether any additional spill occurrences should be added to SPILLS(2). These potential additions are spills which, while not reaching the volume level to clearly constitute the "significant" spill range, are occurrences which could have resulted in significant volume spills. To answer this question, the Gulf tanker spills for the 1976-1980 period are analyzed below.

The first division in the historical spill occurrences of interest is the spill data element "vessel operation". Examining Table 20, at page 241, the spills for the 1976-1980 period have been separated into two broad categories: Part A, which contains spills where vessel operation is "vessel underway", "unknown operation", or "no operation reported"; and Part B, which contains spills where vessel operation is "all other operations". The Part A category is primarily composed of the operation "vessel underway". The Part B listing for "all other operations" is composed primarily of operations that are port loading/unloading, ballasting, and fueling activities.

Of greatest interest in this division is the discovery that no spills of greater than 163 tons are found in the "all other operations" category of spills. In fact, 31 of the 36 spills in Part B are below 34 tons (10,000 gallons) in volume.

In contrast, all four of the "significant" spills identified, of 21,429 tons and three spills of +34,014 tons, are found in Part A, and all four of these spills are vessel operation "vessel underway". Further, 13 of the 17 spills in Part A are above 34 tons (10,000 gallons).

Conclusions that may be drawn from these findings include:

- Vessel operations that are port oriented activities, (particularly loading/unloading) are likely to generate small rather than significant or large spills; and

- The vessel operation that is clearly identifiable with significant (and potentially catastrophic) spills is operation "vessel underway".

Further consideration of tanker spills during this period, and especially Part A vessel operation spills, reveals information about the spill element "cause of incident". Consider Parts A and B separated into "cause of incident", in Table 23, at page 248. The cause that is most closely associated with both number of significant spills and also spill volume is "grounding". It should also be noted that "grounding" only appears as a cause in the Part A vessel operation category. Other causes of large volume spills are "personnel error" and "collisions".

Conversely, for Part B "other operations", the overwhelming cause of incident is "personnel error", accounting for 27 out of 36 "other operations" spills.

The final selection of a value for SPILLS(2) is therefore uncertain depending upon the number of spills which by "vessel operation" and "cause of incident" are to be characterized as "potential" significant spills.

TABLE 23

ANALYSIS OF GULF TANKER SPILLS, 1976-1980, BY CAUSE OF INCIDENT
(spills of 3.4 tons = 1,000 gallons and above)

Tanker Operation - "Underway", "Unknown Operation" or "No Operation Reported"

Cause of Incident	Volume in Tons: 0-1,701	1,701-3,401	3,401-17,007	17,007-34,014	34,014+	Total
Collision	1	1				2
Corrosion	1					1
Grounding	3		1		3	7
Personnel Error			1	1		2
Unknown	4	1				5

Tanker Operation - "All Other Operations"

Cause of Incident	Volume in Tons: 0-1,701	1,701-3,401	3,401-17,007	17,007-34,014	34,014+	Total
Collision	3					3
Other Casualty	1					1
Personnel Error	27					27
Unknown	4					4
Weather/Seas	1					1

Source: U.S. Coast Guard PIRS computer data base, 1982. For full information about spills represented in this Table, refer to Table 20, at page 241.

For the Gulf during the 1976-1980 period, there are several alternative values for SPILLS(2):

- 0.8 = 4 spills of +20,000 tons/5 years;

- 1.6 = 4 spills of +20,000 tons, plus 4 additional smaller spills where operation="underway", and cause="grounding"/5 years;

- 2.0 = 4 spills of +20,000 tons, plus 6 additional smaller spills where operation="underway", and cause="grounding or collision"/5 years;

- 3.2 = 4 spills of +20,000 tons, plus 12 additional smaller spills where operation="underway", and cause="grounding, collision, unknown, or personnel error unknown"/5 years;

- Other values, which add to the 0.8 value a fraction of the smaller, "potential" spill events that have occurred (i.e.- while recognizing the need to add "potential" spills, a recognition that not every "potential" spill should be counted as a "significant" spill).

The approach of adding "potential" spills to a frequency has been endorsed and used by the U.S. Coast Guard in its 1979 report "Deployment Requirements for U.S. Coast Guard Pollution Response Equipment", in which the Coast Guard observed:

> For the purpose of (Coast Guard) data gathering, an historic massive spill is taken to be any harbor, coastal or open sea incident in which over 3,000 tons of petroleum or its products was actually spilled. This lower limit is set at only 3% of the nominal for a massive spill (i.e. - estimating a massive spill at 100,000 tons) so that a larger number of incidents will be eligible for study. The assumption is that many of these smaller incidents had the potential for a much larger spill and hence can contribute to our knowledge of possible future massive spills of the 100,000 ton variety. (4)

The 0.8 value, which makes use of only spills actually within the range of company average shipments, is a valid frequency, but may understate the real frequency for significant volume spills. Selective inclusion of other "potentially significant" spills in the 1.6 and 2.0 frequencies is an effort to acknowledge that any or all of the smaller spills where the vessel was "underway" and the cause was identified as "grounding" or "collision" might have been significant spills.

The value 3.2 continues this addition process for "potentially significant" spills, but raises the corollary question: does the frequency overstate the occurrence of significant spills by inclusion of spills that are not really "potentially significant" occurrences?

A value for SPILLS(2) that includes "potentially significant" spills can only be fully reliable where all information about these "potentially significant" events is known. Was a major spill averted only because the wind and water currents permitted efficient cleanup? Was the spill never really likely to become a major event? Did the spill take place fortuitously near lightering and cleanup resources?

For the purpose of operationalizing the Chapter II methodology, the frequency to be used for SPILLS(2) should fall somewhere between 0.8 and 3.2, recognizing the need to add "potential" spills from appropriate causes. An intuitive review of causes of incidents results in the conclusion that any collision or grounding is a potentially serious event, and so it is appropriate to include many of those groundings and collisions which a vessel experiences while "underway" into SPILLS(2). If the "potential" spills from groundings and collisions are added to the four known spills in the "significant" range, SPILLS(2) = 6 potential spills, plus 4 identified "significant spills / 5 years = 2.0.

Estimating SPILLS(1), A Catastrophic Spill Frequency

SPILLS(1), the frequency for a catastrophic spill event, is linked to V(1) which has been hypothesized for each company operating in the region to be the company's largest single shipment volume. An important limitation prevents arriving at a value for SPILLS(1) in the manner applied for SPILLS(2). For the volumes associated with catastrophic spills, there is no way through the PIRS data base to determine how many, if any, of the spills identified as +9,999,999 gallons were on the scale of "catastrophic" occurrences.

The difficulty of generating a reliable SPILLS(1) value exists even if one of these occurrences were to be identified as a "catastrophic" volume spill. An annualized frequency is composed of two parts: the numerator of the fraction, which represents the number of incidents during a time period; and the denominator, which is the number of years in the time period. The unresolved question for almost any effort to reach a SPILL(1) value is whether the time period used is of sufficient length. Note that this was not as serious a problem in calculating SPILLS(2), because for "significant" spills there were more than one occurrence during a multi-year period. For SPILLS(1), on the other hand, it is not clear whether the one major spill should be viewed as 1 spill in 5 years; 1 spill in 6 years; etc. The extreme infrequency of spills of "catastrophic" volume undermines the reliability of a SPILLS(1) estimate. This limitation has been recognized by the OECD in its analyses of worldwide spill occurrences. (5)

It is proposed that a value for SPILLS(1) might be estimated based on the estimates for spills of "significant" volume, SPILLS(2). The frequency of "significant" spills is likely to be more reliable than a SPILLS(1) estimate, because of the higher level of occurrence of "significant" events. Estimating the fraction or percentage of significant spills that would constitute the expected frequency of a "catastrophic" spill would then permit a hypothetical value for SPILLS(1) to be generated.

In an effort to relate the frequency of "catastrophic" volume spill events to the frequency of "significant" spill events (which occur far more often than do "catastrophic" level events), a methodology suggested for a different region is of some value. This approach is the result of analyses conducted for the Gulf of Alaska outer continental shelf area by consultants with Booz, Allen and Hamilton, and Applied Management Science. Among their assumptions, the authors grouped tanker spills in the Gulf of Alaska caused by collision and rammings and spills from other causes. The study hypothesized:

> When a ramming or collision does occur, about 10 percent of the accidents result in a major oil spill. Ten percent of the rammings and collisions leading to a major spill result in a total loss of the vessel, and the entire contents are presumed lost. For the remaining 90 percent of the accidents, a spill is assumed to be 6/10 the vessel's capacity. (6)

The approach to estimating spills from collisions and rammings is therefore that out of 100 spills from these causes, 9 are likely to be 66% cargo losses, and 1 is likely to be a 100% loss. The assumptions in this study have been cited with approval as part of a 1978 Exxon Special Report. (7)

While it is not appropriate to apply this theory directly to the Gulf of Mexico, some use can be made of the concept of an assumption about the relationship between the frequency of "significant" spills and the percentage of these spills as being "catastrophic" events (in the study, a total cargo loss). The difficulty with applying the theory directly to the Gulf of Mexico is that the Gulf of Mexico, being a shallow water area, has "groundings" as its principal cause of major spills. See Table 23, at page 248. Thus, the Gulf of Alaska's major spill causes are "rammings" and "collisions", while the Gulf of Mexico is principally concerned with "groundings", "collisions" and "personnel error".

It would seem to be a reasonable method for estimating SPILLS(1) to assume that the frequency of catastrophic spills is a small fraction of the frequency of "significant" spills. In considering a value for this "fraction", application of the Gulf of Alaska's 10% of the number of spills which generate a 6/10 cargo loss is used. For the Gulf of Mexico, SPILLS(2) is defined as the frequency of a significant spill (i.e.- a spill which is equivalent to a company's average shipment volume). A "significant" spill may be analogized to the Gulf of Alaska's definition of a serious spill (6/10 cargo loss). Therefore, if SPILLS(2) is estimated as 1.6 (see earlier discussion), use of the approach from the Gulf of Alaska study, applying a slightly more conservative value of 8%, yields an estimated SPILLS(1) frequency of 0.16 spills/year, or 1 catastrophic volume spill in 6-7 years.

The consideration in relating SPILLS(1) frequency to SPILLS(2) frequency that must be evaluated carefully is the percentage value used. As more information is obtained about the Gulf, and as additional "significant" and "catastrophic" spills are recorded and added to a data base, a more precise empirical relationship between the two frequencies will become available.

Validating Gulf of Mexico Tanker Spill Data

In order to establish that the data dealing with Gulf of Mexico tanker spills, assumptions made about "potential spills" and causes, and the derived estimates of spill frequencies SPILLS(1) and SPILLS(2) are fair estimates, the results of other studies and information sources will be briefly reviewed. This section is divided into Gulf of Mexico validating data and worldwide validating data.

Gulf of Mexico Validating Data

Other data which relate to the Gulf of Mexico and oil spill risks are drawn from two sources:

- Data from the Coast Guard PIRS data base dealing with unintentional barge oil spills in the Gulf of Mexico; and

- Coast Guard hypothesized future spill frequencies for key Gulf of Mexico ports, generated as part of the Coast Guard Deployment Report.

Gulf of Mexico Barge Spills: Spills by barges have been excluded from the discussion until this point in order to focus on tanker spills and frequencies. There are many differences between spills by tankers and barges: tankers are self propelling and navigating, while barges must be towed or pushed by tugs; tankers are typically in the 50,000-100,000 DWT range, while barges are most frequently 1,000-10,000 DWT; many large tankers cannot enter Gulf shallow water ports, while most barges can enter such ports; and many other operational differences. (8)

There are, however, important parallels between tanker and barge spill experiences which can be used to support some of the assumptions made in reaching estimates for tanker spill frequencies. The Gulf of

Mexico barge spills for 1976-1980 are set forth in Appendix K.

Of importance is the analogous relationship of vessel operations and large spill occurrences, and also of causes of spills. For barge operations, out of 38 spills occurring during "other vessel operations" (particularly port loading and unloading operations), only 2 spills are within the 50-500 ton range. The remaining 36 spills are of minor levels of damage, below 50 tons. See Appendix K, Part 2.

In contrast, in the category of barge operations "underway", "unknown operation" and "no operation reported", there are 24 spills, in which 12 are above 500 tons, with 8 more in the 50-500 ton range. Thus, the assumption that operations "underway", "unknown" and "no operation reported" are the appropriate points of attention for tankers is reinforced by the findings for barge operations.

The second aspect of barge findings which confirms assumptions made concerning tankers is in the area of causes of incidents. See Table 24, at page 256, which compares tanker and barge spills when grouped by cause of incident. As in the case of tankers, barge spills occurring while "underway", "unknown" or "no operation reported" are overwhelmingly caused by either collisions or groundings. Groundings constitute 14 spills and collisions 10 spills out of the 30 spills in this operation category.

In the "other operations" category, the overwhelming single cause of barge spills is "personnel error", the same finding as in the case of tanker "other operations" spills.

A third point of interest is to examine barge spill locations by ports and to compare these locations with tanker spills. See Table 25, at page 257.

TABLE 24

COMPARISON OF GULF TANKER AND BARGE SPILLS, 1976-1980, BY CAUSE OF INCIDENT

(spills of 3.4 tons = 1,000 gallons and above)

Vessel Operation - "Underway,", "Unknown Operation, or "No Operation Reported"

Cause of Incident	Tankers Number	Tankers Percent	Barges Number	Barges Percent
Corrosion	1	5.9%	--	--
Collision	2	11.8%	10	33.3%
Grounding	7	41.2%	14	46.7%
Personnel Error	2	11.8%	2	6.7%
Sinking	--	--	1	3.3%
Unknown	5	29.4%	3	10.0%
Total	17	100.0%	30	100.0%

Vessel Operation - "All Other Operations"

Cause of Incident	Tankers Number	Tankers Percent	Barges Number	Barges Percent
Collision	3	8.3%	4	10.5%
Corrosion	--	--	2	5.3%
Fire/Expl.	--	--	1	2.6%
Grounding	--	--	1	2.6%
Material Fault	--	--	1	2.6%
Minor Damage	--	--	2	5.3%
Other Casualty	1	2.8%	--	--
Personnel Error	27	75.0%	25	65.8%
Unknown	4	11.1%	2	5.3%
Weather/Seas	1	2.8%	--	--
Total	36	100.0%	38	100.0%

Source: U.S. Coast Guard PIRS computer data base, 1982. For full information about spills represented in this Table, refer to Table 20, at page 241, for data on tanker spills, and Appendix K for data on barge spills.

TABLE 25

COMPARISON OF GULF TANKER AND BARGE SPILLS, 1976-1980, BY LOCATION OF INCIDENT

(spills of 3.4 tons = 1,000 gallons and above)

Location of Incident	Number of Tanker Spills	Number of Barge Spills
Beaumont/Pt. Arthur, TX	18	8
Corpus Christi, TX	7	14
Freeport, TX	1	--
Galveston/Houston, TX	18	31
Gramercy, LA	--	1
Gulfport, MS	1	3
Lafayette, LA	--	2
Lake Charles, LA	1	2
Mobile, AL	2	--
New Orleans, LA	1	4
Tampa Bay, FL	2	3

Source: U.S. Coast Guard PIRS computer data base, 1982. For full information on tanker spills, see Table 20, at page 241, and Appendix K for data on barge spills.

As with tanker spills, Galveston, TX is identified as the location with the greatest number of barge spills, and Beaumont/Pt. Arthur and Corpus Christi follow.

The conclusion is that, while recognizing that differences in tanker and barge operations and problems do exist, that the proportions for vessel activities, causes, and regional locations of both tanker and barge spills are virtually identical.

Projected Spill Frequency for Key Gulf of Mexico Ports: As part of its 1979 Deployment Report, the Coast Guard projected expected spill frequencies for major ports in the U.S., including the following Gulf of Mexico port areas: Tampa, FL; Lake Pascagoula, MS; Baton Rouge, LA; New Orleans, LA; Lake Charles, LA; Pt. Arthur, TX; Texas City, TX; and Corpus Christi, TX. See Appendix L for the component locations included in each port region, and the projected spill frequency for each port.

These projections were based upon 1974-1977 spill figures, including only spills larger than 50,000 gallons (170 tons), and were adjusted to a hypothetical 1985 level. The resulting frequency for the Gulf of Mexico is estimated at 8.043 spills of +170 tons per year.

The Coast Guard's projections are for all vessel spill events over 170 tons, and so both tanker and barge spills are included:

Year	Tanker Spills	Barge Spills	Total
1976	2	1	3
1977	0	2	2
1978	4	3	7
1979	3	7	10
1980	2	5	7
Total	11	18	29

Note that the Gulf spills in this category have increased from years 1976-1977 to years 1978-1980, reaching approximately the Coast Guard projections of 8 spills of +170 tons per year. This increasing trend is also found in worldwide spills, with the OECD reporting that the incidence of large spills (in the 10,000-25,000 ton range and above) sharply increased in the 1976-1979 period over the prior 1965-1975 period. (9) The important conclusion, however, is that the relative order of magnitude of spill frequency based on both the data directly obtained in this dissertation and the data used by the Coast Guard in its Deployment report are comparable.

Worldwide Validating Data

Estimated Worldwide Spills/Barrels Transported: The use of worldwide spill data is of limited use for direct comparisons with smaller geographic regions, unless number of spills can be related to some generally applicable value. A study by Stewart performed for the Department of Interior in 1976 generated a rate for tanker spills divided by barrels of oil shipped of 3.87 spills of +1,000 barrels per 1 billion barrels transported. (10) This ratio has been directly adopted by the U.S. Geological Survey in its 1982 environmental impact statement of oil spill risks for the Gulf of Mexico Outer Continental Shelf area. (11)

Translating this ratio into tons of oil, an estimated frequency of 3.87 tanker spills of +143 tons is hypothesized for every 142,857,143 tons shipped.

The level of Gulf shipments for the most recent recorded period, January-October, 1982, is 91,863,289 tons. Annualizing this yields 110,235,947 tons. Applying the Stewart ratio results in a hypothesized 2.99 spills of 143+ tons.

Examining the reported tanker spills during 1976-1980, there were 12 tanker spills of 143+ tons. See Table 20, at page 241. This annualizes to a rate of 2.4

spills per year.

As with other validating data discussed, the purpose of discussing the Stewart estimate is to show that the actual findings for the Gulf during 1976-1980 are basically in accord with other spill data in terms of relative order of magnitude.

U.S. Coast Guard Analysis of Worldwide Tanker Spills: As part of its study of location of pollution prevention equipment in the United States, the Coast Guard's 1979 study analyzed 68 worldwide tanker spills of over 3,000 tons for cause of incident and relative water location (i.e.- harbor, open ocean, etc.). The findings of this analysis are found in Table 26, at page 261. Two results are of interest:

First, the majority of spills occurred within 50 miles of the coast (62.9%). In the Gulf, virtually all spills of this size during the 1976-1980 period occurred within this same region. The relatively high percentage of worldwide spills beyond 50 miles may not be appropriate to compare against the Gulf of Mexico, because the worldwide spills include open ocean locations (such as the North Atlantic Sea) which, having far more severe weather than the open Gulf of Mexico, can be expected to produce more open ocean spills.

The second result is the distribution of causes of incidents. For these worldwide figures, "grounding", "structural failure" and "collision" account for 89.8% of the spills studied. The "groundings" and "collisions" are consistant with the Gulf tanker statistics for 1976-1980. The "structural failure" figures are quite different, with the Gulf showing no major spills having been assigned this cause. It is not clear why this difference exists; however, one possibility may be the existence of more stringent U.S. vessel standards for vessel operations in U.S. waters, which has the effect

TABLE 26

WORLDWIDE TANKER SPILLS, 1967-1978,
BY CAUSE OF INCIDENT AND WATER LOCATION

(68 spills analyzed, 3,000 tons or greater)

Cause of Incident	Harbor Interior	Harbor Entrance	Coastal Area	50+ NM at Sea	Total
Breakdown	0.0%	1.5%	0.0%	0.0%	1.5%
Collision	0.0%	1.5%	10.3%	0.0%	11.8%
Explosion	0.0%	0.0%	0.0%	2.9%	2.9%
Fire	0.0%	0.0%	1.5%	1.5%	3.0%
Grounding(*)	2.9%	10.3%	27.9%	0.0%	41.1%
Ramming	0.0%	0.0%	0.0%	0.0%	0.0%
Struct. Failure(**)	0.4%	0.4%	6.3%	29.8%	36.9%
Other	0.0%	0.0%	0.0%	2.9%	2.9%
Total	3.3%	13.6%	46.0%	37.1%	100.0%

(*) "Groundings" include both actual groundings and also strandings.

(**) "Structural Failures" include actual structural failures, flooding, and sinking.

Source: A. O. Brien, et. al., Deployment Requirements for U.S. Coast Guard Pollution Response Equipment, Vol. 1 (Washington: U.S. Department of Transportation, 1979).

of separating out substandard vessels (which may continue to operate in other world waters).

Estimating Company Activity (ACTIVITY)

The variable ACTIVITY included in Chapter II reflects the level of company participation in the total activity of the designated geographic region. This level of activity is of importance to a company planning its exposure to oil spills, because a company with a high share of the region's activity can expect overall to have a higher exposure to the possibility of a spill event.

The ACTIVITY variable can be viewed from two perspectives: a company's share of the number of vessel shipments in the region; and/or a company's share of the total oil cargo volume moved in the region. See Table 27, at page 263, which lists the Gulf of Mexico importing companies and their share of both Gulf shipments and Gulf volume shipped for January-October 1982.

Which proportion should be used to define ACTIVITY is somewhat uncertain because the degree of exposure to a spill event is based on both the number of shipments and also the volume shipped. Each additional shipment is an additional vessel movement which could result in a spill. Similarly, the larger the volume of each shipment, the greater a "catastrophic" spill event will be for the company. Therefore, increasing the number of vessel shipments or increasing the volume per shipment, will each increase a company's "share" of the chance that a major spill will be from that company's vessel. (12) See the discussion following dealing with vessel size and pollution-causing incidents.

TABLE 27

LEVEL OF ACTIVITY OF COMPANIES
IMPORTING OIL INTO THE GULF OF MEXICO,
JAN-OCT 1982

Company	Volume (tons)	Percent of Total Volume	Shipments	Percent of Total Shipments
Amoco Oil Co.	9,339,292	10.13	176	9.28
Ashland Oil Co.	3,493,746	3.79	78	4.11
Atlantic Richfield Co.	2,889,338	3.13	49	2.58
Champlin Petroleum Co.	1,750,068	1.90	30	1.58
Charter Oil Co.	428,302	0.46	8	0.42
Chevron, USA	4,144,747	4.49	107	5.64
Cities Services Oil Co.	1,857,933	2.01	44	2.32
Clark Oil and Ref. Co.	2,612,480	2,83	51	2.69
Coastal Corp.	2,534,987	2.75	50	2.64
Conoco, Inc.	523,570	0.56	7	0.37
Coral Petroleum, Inc.	425,862	0.46	8	0.42
Continental Petroleum	336	0.00	2	0.11
Crown Central Pet. Corp.	1,445,071	1.57	26	1.37
Delta Refining Co.	1,004,429	1.09	16	0.84
Exxon Corp.	4,699,632	5.10	132	6.96
GHR Energy Corp.	1,395,744	1.51	33	1.74
Gulf Oil Corp.	3,010,028	3.26	70	3.69
Gulf States Oil and Ref.	749,074	0.81	14	0.74
Horizon Petroleum Co.	438,108	0.48	6	0.32
Houston Oil and Ref.	216,028	0.23	4	0.21
Hunt Oil Co.	240,498	0.26	9	0.47
Intercoastal Petroleum	1,496	0.00	5	0.26
International Processors	316,301	0.34	6	0.32
Kerr-McGee	1,633,843	1.77	29	1.53
Koch Industries, Inc.	140,717	0.15	3	0.16
LaGloria Oil and Gas	589,881	0.64	12	0.63
Marathon Oil Corp.	7,263,039	7.87	65	3.43
Mobil Oil Co.	3,369,083	3.61	42	2.21
Mobile Bay Ref. Co.	142,409	0.15	6	0.32
Murphy Oil Corp.	729,879	0.79	12	0.63

TABLE 27, Continued

Company	Volume (tons)	Percent of Total Volume	Shipments	Percent of Total Shipments
Nat'l Coop. Refy. Assoc.	43,247	0.05	1	0.05
Phillips Petroleum Co.	1,605,222	1.74	37	1.95
Placid Ref. Co.	143,789	0.16	3	0.16
P&O Falco, Inc.	71,605	0.08	1	0.05
Sea Horse Marine, Inc.	12,679	0.01	75	3.95
Sentry Ref.	277,072	0.30	10	0.53
Shell Oil Co.	9,483,704	10.28	180	9.49
Sigmoor Corp.	484,691	0.53	7	0.37
Std. Oil - Ohio	1,574,663	1.71	34	1.79
Sohio Supply Co.	1,334,089	1.45	30	1.58
Strategic Petroleum Res.	7,282,197	7.89	185	9.75
Sun Company, Inc.	207,956	0.23	4	0.21
Tenneco, Inc.	304,351	0.33	6	0.32
Texaco, Inc.	6,660,026	7.22	145	7.64
Texas City Ref. Inc.	2,972,783	3.22	44	2.32
Tosco Corp.	424,336	0.46	9	0.47
Total Petroleum, Inc.	399,979	0.43	6	0.32
Union Oil Co. - USA	1,077,659	1.17	16	0.84
Vulcan Asphalt and Ref.	107,320	0.12	4	0.21
Gulf of Mexico Total:	91,863,289		1,897	

Source: American Petroleum Institute, Imported Crude Oil and Petroleum Products (Washington: API, 1982).

Estimating Values for FACTOR

The variable FACTOR is a collection of elements which are within a company's decisionmaking control. These elements have been identified by earlier research efforts as increasing or decreasing the company's likelihood of being involved in a spill event. FACTORS is included in the Chapter II methodology to note that there are such aggravating and mitigating elements which a company can control through decisionmaking, but as noted in Chapter II, this particular variable cannot presently be operationalized. This limitation stems from two sources: first, some of the elements in FACTOR are at best hypothesized aggravating or mitigating variables, where no hard data on performance based on the presence or absence of the variable has yet been obtained. For example, while a factor such as crew training is postulated by the industry as being likely to enhance crew performance and therefore lower the likelihood of an accident, no certainty about the degree of improvement exists. (13)

The second limitation in quantifying some FACTOR variables is that elements have been identified as being correlated with spill accidents, but the weight that should be given to the element cannot presently be determined. Using another example, differences in vessel size, vessel flag, and vessel crew have been correlated against vessel accidents, permitting assumptions about preferable crew and vessel flag nationalities. However, there is no real sense at the present of how significantly these factors will bear on overall exposure to a spill. Knowing that vessels registered under a Greek flag experience higher rates and quantities of spills per tonnage carried (14) is insufficient to lead to a statement that selection of a Greek vessel increases the likelihood of a spill by a stated percentage.

This section will briefly discuss some of the presently identified elements which may contribute to the likelihood of a spill event. For the purposes of the Chapter II model, FACTOR must at present not be included in the equations, because of the danger of overstating or understating the importance of these contributing elements.

Tanker Size

The statistics for pollution-causing incidents (worldwide) as a function of tanker size are set forth in Table 28, at page 267. Of interest is that the highest frequency of accidents per port call occurs in the 100,000-200,000 ton tanker category, with the 200,000 and above category closely following.

If spills per ton delivered is examined, the reverse situation holds, with the 6,0000-10,000 range having the highest statistic and the 100,000-200,000 and 200,000+ categories being lowest.

These two sets of statistics generate an interesting conclusion: the large range tankers experience the greatest frequency of pollution causing incidents; however, because each large vessel transports more oil than does a small tanker, the incidence per ton delivered is low for the heavy tankers.

As with other elements of FACTOR, it is not clear what is actually represented by this distribution. The conclusions of the joint Office of Ocean Resources Coordination and Assessment and Engineering Computer Optecnomics study is set forth below. The researchers in this study were not in a position to establish the tradeoffs between size of vessel, exposure, and benefit

TABLE 28

WORLDWIDE TANKER POLLUTION CAUSING INCIDENTS, 1969-1978
BY TANKER SIZE (DEADWEIGHT TONS)

Tanker Size (DWT) Delivered	Casualties per Port Call (1/10,000)	Casualties per Long Ton (1/100,000,000)
6,000-19,000	5.8	8.5
20,000-49,999	6.0	2.6
50,000-99,999	7.5	2.2
100,000-199,999	11.8	1.8
200,000 and over	10.5	0.7

Source: Norman Meade, et. al., "An Analysis of Tanker Casualties for the Ten Year Period 1969-1978", presented at the 1981 Oil Spill Conference, March 2-5, 1981, Atlanta Georgia, Figure 6 and Figure 8.

to the company:

> As a hypothetical example, suppose that a shipper has 80,000 tons of crude oil to be delivered, and has the option of using a 20,000 DWT or an 80,000 DWT tanker to transport the cargo. The 20,000 DWT tanker has a lower rate of accident and PCI's (pollution causing incidents) per port call, but would necessitate making four round trips to deliver the entire amount. The 80,000 DWT tanker has a higher rate of accidents and PCI's per port call, but in making only one trip its total exposure to risk is lower. For tankers greater than 80,000 DWT such comparisons cannot be made. Many of the tankers this size and larger utilize the offshore deepwater terminals, thus reducing the risk associated with the port call. A comparison of rates of accidents per port call for smaller carriers making conventional port calls versus a Very Large Crude Carrier (VLCC) discharging or loading at a deepwater terminal compares two tankers with unequal exposures to risk. (15)

Flag of Registry

The study conducted by the Office of Ocean Resources and Coordination and Assessment and Engineering Computer Optechomics analyzed worldwide tanker casualties. The ORCA study examined spills by flag of registry. The study found that:

- Greek and Liberian tankers typically have the poorest records;

- Panamanian, United States and United Kingdom tankers have the second poorest record; and

- Japanese, French and Italian tankers have the best record (16).

An OECD study of oil spills during the period 1965 to 1979 also draws conclusions concerning principal world tanker fleets. From this study rates for the eight principal tanker fleets have been prepared in Table 29, at page 269. From these rates a more refined set of conclusions can be drawn:

TABLE 29

SPILL ACCIDENTS BY LEADING WORLD FLEETS, 1965-1979

Percentages of DWT Shipped, Accidents, and Quantity Spilled Among Leading World Fleets

Major Oil Fleets by Country	Percentage of DWT Shipped	Percentage of Accidents	Percentage of Quantity Spilled
France	7%	4%	2%
Greece	8%	17%	23%
Italy	4%	4%	2%
Japan	13%	7%	5%
Liberia	46%	35%	51%
Panama	4%	8%	6%
United Kingdom	13%	10%	7%
United States	6%	15%	4%

Number of Accidents and Quantity Spilled per DWT Shipped

Major Oil Fleets by Country	Accidents per DWT (thousands)	Rank	Quantity per DWT (thousands)	Rank
France	0.60	7	3,593	8
Greece	3.83	1	38,056	1
Italy	1.55	3	7,822	5
Japan	0.59	8	5,434	7
Liberia	1.14	5	14,738	3
Panama	2.10	2	17,520	2
United Kingdom	1.03	6	7,090	6
United States	1.42	4	9,236	4

Source: Organization of Economic Cooperation and Development, Combatting Oil Spills: Some Economic Aspects (Paris: OECD, 1982), 69.

Liberia experiences the greatest number of accidents, and also the greatest quantity spilled. However, Liberia carried 46% of the tonnage during this time period, over three times the volume of the United Kingdom and Japan. Thus, the number of accidents and volume spilled do not alone suggest that Liberia is the most hazardous flag of registry.

Extracting the relative rankings from Table 29:

Rank	Accidents/DWT Shipped	Quantity Spilled/DWT Shipped
1 (worst)	Greece	Greece
2	Panama	Panama
3	Italy	Liberia
4	U.S.	U.S.
5	Liberia	Italy
6	U.K.	U.K.
7	France	Japan
8 (best)	Japan	France

From the OECD data, the following further conclusions emerge:

- Greece and Panama clearly emerge as flags with the worst performance per DWT shipped both in terms of number of accidents and also quantity spilled. It can be seen that Greece is the country whose fleet experiences the highest number of accidents per DWT shipped and also experiences the largest volume spilled per DWT shipped.

- Liberia, the United States and Italy are identified as "average" flags. Liberia remains a less desirable flag, although this is due to the volume of oil spilled per DWT shipped rather than to the number of accidents sustained per DWT. Italy, although fairly undesirable in terms of number of accidents per DWT, has not experienced a particularly high quantity/DWT rate. The U.S. appears to experience a substantial share of both numbers and volume spilled.

- The most desirable flags are clearly seen to be the U.K., Japan and France, occupying the 6-8 ranking for both accidents and volume per DWT.

An additional study of spills from 1964-1976 performed by the Tanker Advisory Center found similar results. (17). This study also reached some important conclusions on tankers and the relationship between accidents and changes of ownerships:

- Tankers that change ownership several times have poor casualty records;
- Serious casualties usually occur shortly after tankers change owners;
- Significant differences exist in casualty rates by owners; and
- The average tanker sustains a reported casualty about once every four years; (18)

Even with the above conceptual understanding of flag of registry performance, this knowledge cannot presently be directly translated into a quantitative planning tool. The conclusions from the ORCA-Engineering Computer Opteconomics support this conclusion:

> The analysis of tanker casualties by flag indicates that a simple bivariate analysis may obscure relationships that would be of interest to the policy analyst. The analysis of flag showed that certain vessels had better safety records than others. To what extent this is attributable to the other characteristics of that particular fleet (e.g., bigger vessels, voyages in safer waters, or newer vessels with more modern equipment) cannot be determined from a bivariate analysis. Likewise, the fact that tankers of certain flags had relatively poor records may be due as much to age, size, or locale of use as it is to the nation itself. (19)

Crew Training

Crew training programs to train vessel crews in accident prevention and spill handling techniques are being offered by a number of organizations. Training in the U.S. includes a program in petroleum tanker safety at the Maine Maritime Academy; a program on oil spill prevention and control offered by the National Spill Control School, Corpus Christi, TX; a program on petroleum tankship operations offered by the World Trade Institute in New York; and a course in oil and hazardous material control at Texas A&M University. See Appendix M for details about these programs.

This training is typically offered to the captain and mates of a vessel, who in turn pass their knowledge along to the crews. Length of programs vary, averaging five days, and program costs per person can range from $575-$1,000 and above. There are also programs offered in Switzerland dealing with navigation of VLCC's (very large crude carriers) and also programs in England and Scotland.

The degree of benefit achieved from such training is, however, uncertain. Representatives of training programs have indicated that while some improvement is to be expected, the level of improvement is unknown. (20) This uncertainty is due to variations in crew background and nationality, and is also due to the fact that even crew training cannot avoid some types of accidents. In addition, no formal studies have been performed of trained versus untrained crews.

Ports and Vessel Approaches

For the Gulf of Mexico in the 1976-1980 period under examination, it is clear that three ports and off-port areas, Galveston, TX, Beaumont, TX, and Corpus Christi, TX, experienced the greatest number of spills. See Table 25, at page 257.

The level of spill incidents in a port area is a function of the overall level of activity in the port, and also the level of tanker/oil activity in the same port. However, from the individual company perspective, use of a port such as Galveston or Beaumont/Pt. Arthur rather than Corpus Christi or New Orleans places the company's shipment in a higher risk environment. Of course such knowledge may not be of use to a company which has no choice but to use a particular port (due to refinery or delivery constraints).

Conclusion

This Chapter has selected values and has made estimates where required for the variables V(i), SPILLS(i), ACTIVITY, and FACTOR. These values will be applied in Chapter XII when the Chapter II methodology is operationalized to the degree possible given the present state of knowledge about oil spill events.

NOTES

1. U.S. Coast Guard Pollution Incident Reporting System computer data base, 1982.

2. The PIRS data base contains spill data for a larger period, 1974-1982. However, from discussions with U.S. Coast Guard personnel and from direct examination of reported data, it is evident that only data from 1976-1980 is likely to be valid. For the period 1974-1975 , data may be unreliable because of sporadic entries (as the system was being started up) and errors in data entry. For the 1981-1982 period, data is unreliable because the PIRS system is 10 years old and in serious need of software redesign. Data loss and derogation in program performance has been noted by the Coast Guard, and budget plans for system upgrading are in progress.

3. Interview, U.S. Coast Guard PIRS personnel.

4. A. O. Brien, et. al., Deployment Requirements for U.S. Coast Guard Pollution Response Equipment, Volume I: Analysis, Report No. CG-0-D-14-79 (U.S. Department of Transportation, 1979), 74.

5. Organization for Economic Cooperation and Development, The Cost of Oil Spills (Paris, 1982), 21-22.

6. L. J. Donovan and J. J. Owen III, "A Method to Estimate the Pollution Risk and Cost of OCS Oil Transportation", Journal of Petroleum Technology (June, 1977), 642.

7. R. B. Wheeler, "The Fate of Petroleum in the Marine Environment", Exxon Product Research Company Special Report, August, 1978 (1978), 31.

8. See generally, M. M'Gonigle and M. Zacher, Pollution, Politics and International Law: Tankers at Sea (Berkeley, CA: University of California Press, 1979).

9. OECD, The Cost of Oil Spills, 29.

10. R. J. Stewart, A Survey and Critical Review of U.S. Oil Spill Data Resources with Application to the Tanker/Pipeline Controversy (Cambridge, MA: Martingale, Inc., 1976). Report to the U.S. Department of the Interior.

11. Robert P. LaBelle, "An Oilspill Risk Analysis for the Gulf of Mexico Outer Continental Shelf Lease Area Regional Enviromental Impact Statement", Executive Summary of U.S. Geological Survey Open File Report 82-238, April, 1982, 9.

12. Norman Meade, et. al., "An Analysis of Tanker Casualties for the Ten Year Period 1969-1978", presented at the 1981 Oil Spill Conference, March 2-5, 1981, Atlanta Georgia, 13. The research conducted was part of a National Oceanic and Atmospheric Administration and Engineering Computer Optecnomics joint research effort.

13. Interview with representative of the National Spill Control School, Corpus Christi, TX.

14. Meade, "An Analysis of Tanker Casualties", 13.

15. Ibid., 12.

16. Ibid., 10.

17. U.S. Congress, House Committee on Government Operations, Hearings of March, 1977 on Coast Guard Efforts to Prevent Oil Pollution Caused by Tanker Accidents, 95th Cong., 1st Sess., 1977, 57-58. Statement of Arthur McKenzie, Director, Tanker Advisory Center.

18. U.S. Congress, House Committee on Government Operations, Hearings of March, 1977, 57. Statement of Arthur McKenzie, Director, Tanker Advisory Center.

19. Meade, "An Analysis of Tanker Casualties", 13.

20. Interview with representative of the National Spill Control School, Corpus Christi, TX.

CHAPTER X

GULF OF MEXICO CLEANUP CAPABILITY

Introduction

The company responsible for a spill is liable for cleanup costs and specific damages associated with the spill under the Clean Water Act. (1) There may be other additional cleanup responsibilities applicable at both the state and federal level dependent upon the natural and historic resources affected by a spill event. (2) This assignment of liability for cleanup and damage costs has added greatly to the cost consequences of a spill to the company whose traditional costs were previously only those associated with cargo loss, vessel loss or damage, and crew injury. The high costs associated with cleanup and damages have made it very important for the organization to attempt to control these costs. As damage costs can be reduced by reducing the spill itself, the cleanup activity plays a very important part in controlling costs.

Cleanup costs can be expected to be related to the potential severity of damage costs: larger spills or spills in sensitive areas will likely require greater cleanup effort and therefore will generate greater costs. (3) This relationship is contained in equation 3 in Chapter II at page 39.

All companies involved in the transportation of oil invest some funds (Y) in preparation for future cleanup actions (F(k) costs). Investment options range from use of insurance to cover damage and cleanup costs; retaining outside firms to handle all the phases of cleanup; or maintaining a total in-house capability for spill cleanup. Because no single alternative is likely to produce the most cost effective solution, company cleanup strategies usually involve a combination of company cleanup capacity, contractor support and insurance. Company resources, liability limits, availability of outside resources, risk averseness of management, public opinion, and financial exposure (based on volume of oil transported and rate of spill) are major factors that are used to determine cleanup investment. Higher end liability limits will require far more complex and costly solutions to adequately protect the company.

Several distinct groups which possess cleanup resources and capabilities can become involved in a cleanup operation:

- Government, both federal and state;
- Contractors;
- Cooperatives;
- Private organizations; and
- The company itself.

Most companies rely upon some combination from among these groups to supply their cleanup needs. (4) The company can choose the amount of involvement of contractors, cooperatives, some private organizations and, of course, itself. The company cannot, however, directly control the degree of involvement and costs incurred by government groups such as the U.S. Coast Guard Gulf Strike Force or regional response team. However, the need for these groups to become involved (and therefore the degree of additional costs generated by the groups) is likely to be related to how well the company itself manages the cleanup operation. (5)

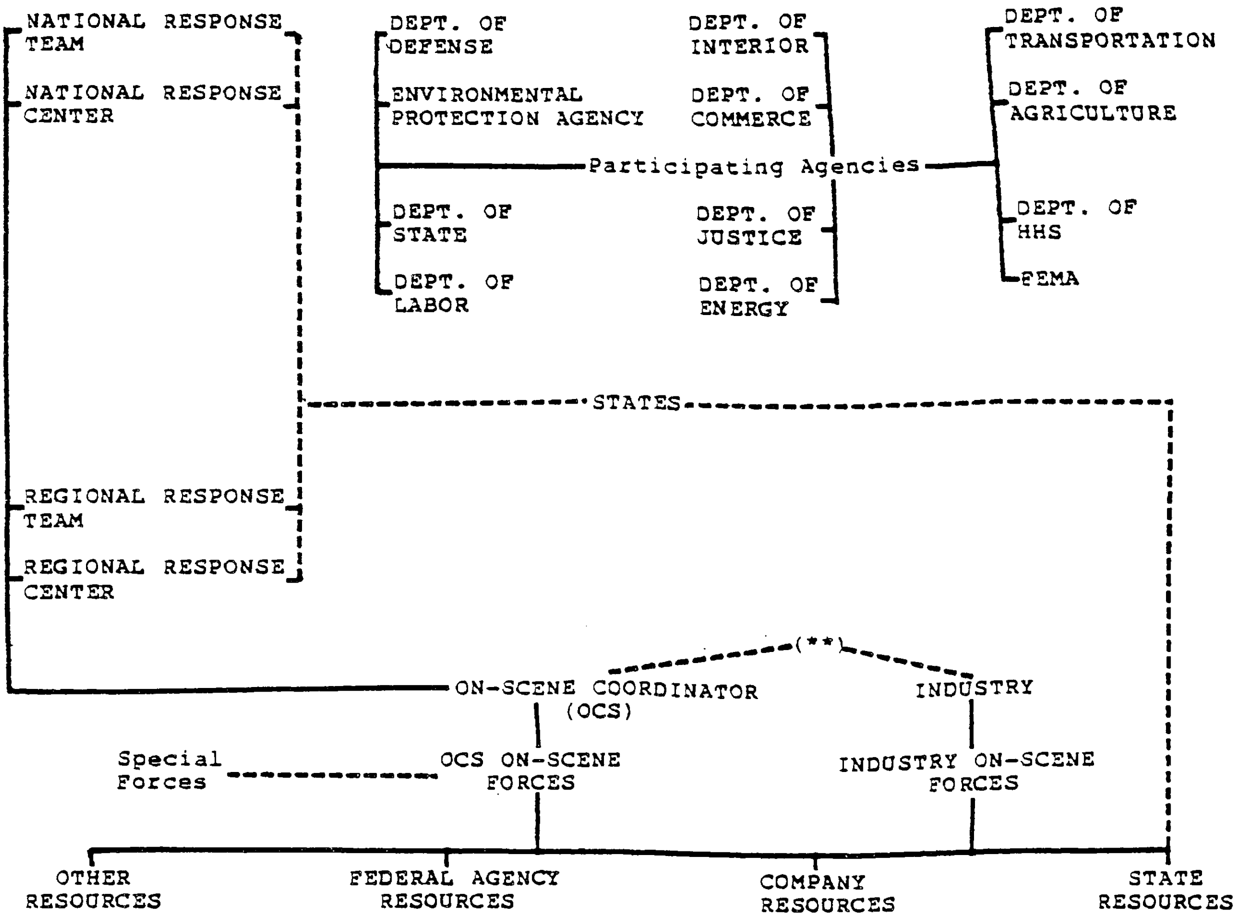
Roles of Cleanup Groups

Government

The Clean Water Act, through the National Contingency Plan (NCP), clearly defines the responsibilities of the government at the federal and regional levels for spill response. (6) The function of coordinating the government spill response is filled by the On-Scene Coordinator (OSC). (7) The role of the OSC is to make the spiller aware of its responsibilities under federal acts and regulations, and to advise the spiller on the proper cleanup countermeasures for the spill.

For most Gulf spill cases cleanup is undertaken by the spiller, with the OSC acting only in an advisory capacity. For those spills in which the OSC must take direct action, commercial contractors are usually used by the OSC to support the cleanup effort. If still greater capability is required, the OSC may call upon the Gulf Strike Force in Bay St. Louis, the Regional Response Team (RRT) in New Orleans or Miami, or the National Response Team (NRT). (8) See Figure 5, at page 279, for a description of the functions of these groups.

Regional Response Teams are usually only activated for medium sized spills, those between 10,000 and 100,000 gallons. (9) The National Response Team is generally activated only in the case of a major spill of over 100,000 gallons, where the spill creates a major threat to the public health or welfare, or where the spill threatens a particularly sensitive area. (10) Therefore, the Regional Response Team and the National Response Team usually act in only an advisory capacity to the OSC, with the OSC largely acting as a supervisor of the private spiller's cleanup efforts.



(**) - OSC acts as an advisor as long as cleanup activities undertaken by industry are deemed appropriate by the OSC. If the OSC does not find industry actions appropriate, OSC then activates the Regional Response Plan as needed through federal, state and other private resources.

FIGURE 5

NATIONAL CONTINGENCY PLAN STRUCTURE AND ROLE OF INDUSTRY IN NATIONAL CONTINGENCY PLAN

Sources: 40 C.F.R. Sec. 1510.31(c), Figure 1; and also discussion with industry representatives.

The Company

As a spiller, a company has first responsibility for cleanup. See Figure 5, at page 279, for the role that the spiller plays in the National Contingency Plan. A company may clean up the spill independently, or may hire other cleanup groups to take over the cleanup operations. A company's needs as outlined through contingency planning help determine the amount of dollars to be allocated to Y for cleanup expenditures. Development of a company cleanup plan is best approached through defining the organization's goals in the post-loss stage. The technical personnel, with expertise in such areas as physical properties of oil, spill tracking, equipment specifications and uses, and physical properties of the ocean and coastal environment, are responsible for the development of the operational side of the cleanup plan within the guidelines set forth by company management. (11)

Cooperatives

Available company resources also include cooperative organizations to which a company may belong. Through a sharing of resources, particularly sharing of equipment requiring greater capital outlays than can be justified at the single company level, the member companies can obtain greater coverage for their cleanup investment than if each company attempted to separately invest in all equipment necessary to protect itself in case of a spill event.

Many of the companies belonging to cooperatives use the cooperative cleanup plan as the basis for their individual company plan. As member companies supply advisory personnel to the cooperatives, many opportunities exist for information exchange within the industry, which is beneficial to all member companies.

Contractors

Contractors support companies and the government in cleanup efforts through offering specialized cleanup services. Contractors can supply experienced manpower, specialized equipment and experience in spill management. They reduce the overall personnel and capital investment costs to the companies, because a company only pays for the contractor's time when the contractor is actually needed.

Contractors are either retained by companies to respond to spills or are hired to clean up a specific spill problem. Size and interest define the specialization of contractors. Many choose to specialize in only a particular phase of cleanup.

Private Organizations

Organizations such as the Sierra Club and the Audubon Society can often provide trained volunteers for specialized, labor intensive phases of cleanup, such as wildlife rehabilitation. Obviously, when properly trained and supervised the groups can provide an invaluable service to supplement a company's limited resources. Consultants from universities can also often provide expertise beyond a company's staff and these consultants can be used for independent verification of actions taken and of spill effects if such support is required in subsequent litigation.

Gulf Cleanup Resources

Knowledge of the cleanup resources available in the Gulf of Mexico can help a company decide where its cleanup investment dollars will best be spent. See Appendix N for a list of available equipment in the Gulf. At the federal level the U.S Coast Guard can provide equipment, manpower and information on available resources. The SKIM system, a Coast Guard data base of available spill equipment, is used to obtain information on resources. The RRT can also provide advice in a spill situation.

State governments can often supply expertise on the local environment through their wildlife agencies and the state governments can also provide equipment and manpower. While information and specially needed expert advice is always available at the federal and state level, the equipment and manpower resources are usually made available only after all company, industry, and private contractor resources are used or are determined to be inappropriate.

Therefore the companies in the Gulf need to carefully consider what resources, particularly equipment and manpower, are available in the private sector. Cooperatives and contractors are particularly useful for the small company that cannot afford to purchase the larger offshore equipment or for a company whose accident rate is low enough that company ownership is not cost effective. Use of these organizations expands available equipment resources and manpower without a large individual company expenditure.

Contractor Resources

Few companies own equipment, reflecting the cost effectiveness of the other alternatives. There are many contractors located within the Gulf. Most specialize in coastal cleanup with only a few having offshore capability. Contractors tend not to get involved in offshore equipment investments because the capital investment required to achieve even a minimal response capability is too costly for most private companies. The number of offshore spills to which one contractor could be expected to respond are too few for the contractor to achieve a return on its investment comparable to the return available from maintaining a coastal response capability. (12) Only a few of the major contractors have offshore capabilities.

The major contractors within the Gulf are: Crowley Environmental, Coastal Services, Oil Mop, Peterson Maritime, J&L Industries, Western Environmental Services, Marine Pollution Control, Clean Channel Industries and Browning-Ferris Industries. There are many other contractors supplying a variety of services and equipment to the oil industry who can also be called upon during a spill to provide pumps, workboats and food service. The contractors are located along the Gulf coast near major ports or near areas of oil and gas industry concentration, and particularly along the Texas and Louisiana coasts.

Spill Cooperatives

There are currently two spill cooperatives located in the Gulf: Corpus Christi Area Oil Spill Control Association and Clean Gulf Associates. The Corpus Christi Association is a government-industry joint effort, while Clean Gulf is composed only of industry members. Clean Gulf is a Gulfwide cooperative with 72 members, while the Christi Association is a local cooperative of 47 members. See Appendix O for a list of the members of each cooperative.

Corpus Christi Area Oil Spill Control Association: This cooperative was formed by local government and industry groups as a nonprofit cleanup cooperative in 1970. It provides cleanup in the tidal waters (including bays, lagoons and estuaries) of Aransas, Nueces and San Patricio counties, behind the Texas barrier islands. There are currently 40 assessable industry members and 7 government members. (13)

An initial call is paid each year by the industry members for the current year's projected operating expenses, with any shortfall assessed among all members. The local government's assessment is based on oil tax revenue collected by each government. Currently 1/3 of the assessment is paid by the local governments and 2/3 is paid by the industry members. See Table 30, at page 285, for the current assessment levels.

The cooperative has approximately $750,000 in resources for dealing with spills, including both offshore and onshore capability. Initial equipment resources were purchased through grants: the state of Texas gave a grant of $80,000 to purchase equipment and the Environmental Protection Agency gave $49,000 for skimmers. (14) Grants were also received from industry, local governments and the Port of Corpus Christi.

Since 1971 the association has responded to 516 spills, with 98 of the spills occurring in 1978 alone. (15) The costs of spill recovery in 1982 were $31,213 for members and $93,912 for nonmembers. (16) Most spills are cleaned up by the association's trained personnel, making for a rapid and coordinated spill response due to

TABLE 30

ASSESSMENTS AND CONTRIBUTIONS TO THE
CORPUS CHRISTI AREA OIL SPILL CONTROL ASSOCIATION
(1983)

40 assessable members at $1,250 each	$50,000
City of Aransas Pass	250
City of Corpus Christi	9,150
Port of Corpus Christi Authority	9,150
City of Rockport	250
Aransas County	500
Nueces County	2,200
San Patricio County	1,000
TOTAL	72,500

Source: Corpus Christi Area Oil Spill Control Association, Statement of Income and Expenses, Year Ending December 31, 1982, (Corpus Christi, TX: CCAOSCA, 1983).

personnel familiarity with equipment and procedures.

This association is unusual in that it shares the responsibility for spill cleanup between local government and industry. Thus, while the industry may be responsible for a spill, the existence of this association reflects the community's recognition that it is dependent upon both tourism and also on oil revenues. To enable both the oil industry and tourism (tourist beaches, lodging, food and related services, and sport fishing) to exist in the Corpus Christi area and provide jobs and revenues to the area, the community has chosen to absorb some of the risk of oil spills by financially contributing to pre-spill cleanup through the association.

Clean Gulf Associates: Clean Gulf was formed initially to meet the needs of the offshore drilling and pipeline companies. (17) There has developed a Marine Transportation division within Clean Gulf to address the concerns of the tanker service divisions of member companies. See Appendix P for the Clean Gulf membership list. Clean Gulf provides greater coverage of the Gulf than does the Corpus Christi Association due to its different objectives.

Clean Gulf specializes in offshore cleanup and has the largest private inventory of offshore equipment in the Gulf. Clean Gulf has equipment based at several locations throughout the Gulf: Rockport, Galveston, Venice, Intercoastal City, Houma, Grand isle, and Cameron. These locations primarily reflect the needs of the offshore drilling and pipeline industry as opposed to tanker service. Most locations are close enough to the tanker risk areas, however, not to cause a major problem in equipment logistics. Clean Gulf, while owning its own equipment has contracted with Halliburton Services Company to provide actual spill response and to maintain the equipment. (18)

Clean Gulf equipment is available to members as needed. It is possible for non-members to use Clean Gulf's equipment in cases of emergency, provided the equipment is not required by members, at a higher non-member rate.

Individual Company Resources

The use of contractors and cooperatives is the most cost-effective solution for maintaining adequate response capability. The major drawback associated with the use of outside rather than in-house resources is that under some conditions, the company could be exposed and therefore vulnerable. Exposure can occur within a shared system when another member is using the resources. For example, when a large spill occurs, a system may be temporarily stripped of resources exposing the other companies to a lower response capability. In fact, after any spill occurrence where resources are used, there will be a lag time during which equipment is temporarily unavailable while it is repaired, receives maintenance or is restocked. Such a situation rarely reaches such a level that a company is seriously compromised, but even small spills have the potential to escalate during vulnerability periods. The larger companies operating in the Gulf of Mexico, Shell, Mobile, Exxon, Conoco, etc., in anticipation of such periods have invested in the nonreusable items that may not be easily restocked and in containment devices which can slow down the effects by delaying spreading of the spill. While not requiring major capital outlays, they provide an added protection against vulnerability points. There are at least nine major companies as identified through the USCG's SKIM System and Clean Gulf that stockpile pumps, small skimmers, spraying equipment, boom, dispersants,and

Sorbent boom on lightering vessels. These companies are Chevron, Coastal States, Conoco, Exxon, Gulf, Marathon, Mobile, Texaco, and Shell International Marine. Some of these companies are involved in oil recovery equipment design (such as Shell) or in the development of dispersants (including Exxon, Chevron and Shell). (19)

Gulf Offshore Capability

In addition to these equipment and response resource groups, a new group has appeared on the Gulf oil spill resource scene - MIRG. In 1981, 11 oil companies operating in the Gulf formed the Marine Industry Group to enhance oil spill response capability. Those companies involved are Amoco Marine Transportation, Arco Marine, Conoco, Coscol Marine, Exxon Shipping, Gulf Refining and Marketing, Marathon Marine, Mobil Oil, Philips Petroleum, Shell, and SOHIO. (20) In particular, MIRG is developing: a listing of resources and logistics for resource movement to the spill; an environmental element to identify sensitive areas and countermeasures; rules and regulations synopsis affecting spill response; and a capability analysis to study available resources and projected needs. (21) The environmental element (3 volumes) and resource-logistic elements (4 volumes) are complete at this time. These resources are available to members and membership is open to petroleum companies or those with related activities. (22)

The yet to be completed capability study by MIRG raises an important question: are the Gulf resources capable of handling a major spill response? This is a question that is being asked not only in the Gulf, but worldwide as damage claims for spills increase.

In the Gulf there are 141 establishments with at least some cleanup equipment on hand. (23) Of these facilities, only 16 have offshore capability. Those facilities are located as follows:

- Corpus Christi - 2 facilities;
- Galveston - 3 facilities;
- Port Arthur - 1 facility;
- New Orleans - 2 facilities;
- Mobile - 4 facilities; and
- Tampa - 4 facilities. (24)

In examining the question of capability this section will focus on three types of equipment: offshore skimmers, offshore boom and dispersants. Many other types of equipment are needed for an effective response, such as manpower, vessels, storage systems, airplanes, and other equipment, but if there is not enough equipment available at the basic level of booms, skimmers and dispersants, the availability of support resources is moot. Equipment availability as estimated for the Gulf in 1979 is shown in Table 31, at page 290.

Evaluating Cleanup Capability

The available cleanup equipment located within the Gulf region must be translated into cleanup capability in terms of oil removed or the amount of oil by which a spill is reduced. Reviewing equation 3 from Chapter II:

$$\text{EXPOSURE} = D(i) \times \text{IMPACT} \times \left(V(i) - \begin{pmatrix} \text{for } V(i) \geq \text{CLEAN: } & \text{CLEAN} \\ \text{for } V(i) < \text{CLEAN: } & V(i) \end{pmatrix}\right) + \text{IND} + F(k) + (O(i) \times V(i))$$

CLEAN is the maximum capability in the Gulf for both public/industry resources and private company dedicated resources. CLEAN is expressed in units of oil capable of being cleaned up. CLEAN also contains an effectiveness component, as seen in Equation 4 from Chapter II:

TABLE 31

GULF OF MEXICO OFFSHORE SPILL EQUIPMENT, 1979

Source:	Offshore Boom (ft.)	Offshore Skimmers	Dispersant (gal.)
U.S. Coast Guard	3,600	7	--
Industry	7,500	--	16,450
Clean Gulf Assoc.	7,000	12	1,210
Contractors	--	--	11,000
TOTAL:	18,100	19	28,660

Note: U.S. Navy and U.S. Coast Guard can provide 35 additional skimmers and 30,700 feet of boom from other non-Gulf areas if needed and if available.

Sources: Arco Marine, American Petroleum Institute, Clean Gulf Associates, U.S. Coast Guard.

CLEAN = (CAP(public/industry) x EFF) + (CAP(private company) x EFF)

EFF is the effectiveness measure of offshore cleanup capability based on historical performance of cleanup efforts in the region. Without an effectiveness measure, the calculations for CLEAN can be overly optimistic and may cause a company to underestimate its potential costs.

For the purposes of evaluating cleanup capability a set of assumptions and conversion factors will be used, based on assumptions that are used by the industry. See Appendix Q.

Skimming Capability

Large skimmers can recover 500 bbl./hour under optimistic conditions. During the IXTOC I well blowout in the Gulf of Mexico and the Amoco Cadiz spill in France, cleanup efforts experienced relatively low rates of recovery. In the IXTOC I spill the industry used the best collecting equipment available with very limited success. None of the equipment used was able to pick up more than 14% of the oil trapped, with total collection of the spilled oil being less than 5%. (25) The U.S. Coast Guard, Shell and Oil Mop all participated in the cleanup effort with the state of the art equipment. Poor performance was considered to be partially caused by Pemex's management, "but almost all private contractors and government officials agree that, given similar weather conditions, they would have had difficulty doing much better." (26)

Real world conditions such as wave height, bad weather, pumping capability limits from skimmer to barge storage, personnel inexperience, and many other factors, prevent equipment from being operated at peak capability. This limitation is reflected in the Chapter

II methodology by assigning EFF a value which represents a company's evaluation of the above real world factors, and its evaluation of equipment manufacturers' reports and historical equipment performance.

For the purpose of operationalizing the Chapter II methodology, EFF is assigned the value of 50%. This is actually an optimistic rate when compared to the IXTOC I cleanup performance. (27) A 50% EFF level means that one skimmer will be expected to have a 500 x (.5) = 250 bbl./hour cleanup capability.

Skimmer use is also limited by the amount of boom available. Boom is used to surround and trap the oil, concentrating the oil for skimmer pickup. The amount of boom available in the Gulf is 18,000 feet. At 3,000 feet per skimmer only six skimmers could operate at one time.

Based on a more optimistic assumption that each skimmer will require 2,000 feet, the available boom will allow nine skimmers to operate simultaneously. There are 19 skimmers in the Gulf available for use. See Table 31, at page 290. However, given the boom limitation, only 9 skimmers could be used at one time.

A third assumption made in evaluating skimmer capability is that a skimmer operable for 12 hours each day. The 12 hour assumption reflects the real world condition that on clear and good weather days and if adequate lighting can be arranged at night, more than 12 operating hours may be available; but that on poor visibility and bad weather days and most nights skimming cannot be performed.

Because most Gulf major spills have occurred near ports or heavily trafficked port approaches (see Table 20, at page 241, for tanker spill locations, and Appendix K for barge spill locations) it is likely that oil not skimmed will reach shore. This likelihood requires another assumption about the amount of time which will be available for offshore cleanup operations before oil reaches shore. A seven day assumption is made, which is an optimistic estimate, particular where a spill occurs within 50 miles of shore.

A corollary assumption to the seven day oil movement discussed above is an assumption about how many cleanup days will occur. Six days out of the seven will be assumed for actual cleanup activities, allowing one day lost for transit of equipment and manpower to the spill scene. Arco Marine has estimated that it takes from 16-44 hours from the time of spill occurrence to the time of equipment deployment at the scene. (28)

The amount of oil that Gulf skimmers can be expected to recover in six days of operation, given the assumptions concerning level of effectiveness, boom limitations, and daily hours of operation, is:

250 bbl./hr./skimmer x 9 skimmers = 2,250 bbl./hr.

2,250 bbl./hr. x 12 hr./day x 6 days = 162,000 bbl.
= 23,142 tons.

If only skimmers are used in cleanup in the Gulf, CLEAN will be assigned a value of 23,142 tons.

If instead of optimistic assumptions the less favorable assumptions for Gulf cleanup are used (i.e., 3,000 feet of boom required per skimmer), CLEAN for skimmers in the Gulf would be:

250 bbl./hr./skimmer x 6 skimmers = 1,500 bbl./hr.

1,500 bbl./hr. x 12 hr./day x 6 days = 108,100 bbl. =
= 15,444 tons.

Whether one considers the present Gulf cleanup capability adequate depends upon how a company views future possible spills in light of the historical Gulf spill occurrences. The Arco Marine study discussed above elected to use a spill volume of 3% of gross deadweight tonnage in its definition of "large but not unexpected spill size", for the purpose of sizing and selecting oil spill countermeasures. (29) This volume is clearly far below either "catastrophic" or "significant" spill events defined in Chapter IX. For example, a vessel of 40,000 DWT which spills 66% of its cargo produces a spill of 26,666 tons, which represents the very upper limit of the optimistic Gulf cleanup capability assumptions. Use of a 3% of deadweight tonnage estimate would cause the company to plan for spills of only 1,200 tons. In contrast, many companies operating in the Gulf face "significant" spills of 40,000-70,000 tons, and face potential "catastrophic" spills of +70,000 tons. See Chapter IX, and Table 22, at page 245.

Gulf cleanup capability can be expected to deal with substantial parts of spills that have occurred in the Gulf to date. See Table 20, at page 241, and Appendix K, for the range of spill occurrences by volume. The significant spill range in the Gulf during 1976-1980 ranged from 3.4 tons to above 34,014 tons.

However, if the Gulf spill experience is examined further, it can be seen that during 1976-1980 there were 3 spills in excess of 34,014 tons and one spill at the 21,000+ level. Therefore, even without the Gulf having experienced a "catastrophic" spill event on the order of Amoco Cadiz (a V(1) volume spill), there have been 4 spills in the "significant" range which either exceeded or were just at the maximum Gulf cleanup capability.

Dispersants

Dispersants will be briefly discussed from the perspective of adequacy of supply. In the Gulf there are 28,660 gallons of dispersant available. At an application rate of 1 part dispersant to 20 parts oil, approximately 13,647 tons (573,200 gallons) of oil can be dispersed. Reviewing the Gulf spill experience from 1976-1980, there were 6 tanker spills which exceeded this level.

The limitation on the use of dispersants is regulatory. Dispersant use for a spill on the scale of a "significant" spill in Gulf waters has not to date been approved by the Environmental Protection Agency, nor is such approval forseeable in the near future. (30) Dispersants, therefore, cannot at the present time be viewed as a viable cleanup resource in the Gulf for a large spill, and will therefore not be included in CLEAN.

Costs of Cleanup - Current Capability

The Gulf capability determined above allows nine skimmers to operate. The representative skimmer used in estimating costs is the High Volume Open Sea Skimmer ("HOSS"), a type of skimmer owned by Clean Gulf. The HOSS is an integrated system containing boom, skimmer and barge. The additional equipment required for operation are 3 tugs/skimmer unit for positioning the skimmer unit and for dragging the boom.

The personnel required to operate the HOSS system include 14 persons (8 workmen, 6 operators) for launching and retrieving activities; 9 persons (5 workmen, 4 operators) for cleanup operations; 1 forman; 1 mechanic; and 1 electrician. (31) The operating costs for nine skimmers of HOSS size (representing the maximum cleanup capability at present in the Gulf) set forth in Table 32, at page 296.

The approximate cleanup cost is represented in the Chapter II methodology by variable F(k). For 9 skimmers in operation for the periods estimated, this cost is averaged between the low and high estimates at $730,000.

TABLE 32

ESTIMATED COSTS OF CLEANUP OPERATIONS IN GULF OF MEXICO, ASSUMING 9 SKIMMERS OPERATIONAL

Item	Number Needed Per Skimmer	Total Number Needed for 9 Skimmers	$ Rate per 6 Days	Total Costs
Workmen(*)	5-8	45-72	$ 1,600	$ 72,000-$151,000
Operators(*)	4-6	36-54	$ 1,900	$ 68,000-$103,000
Foremen(*)	1	9	$ 2,200	$ 20,000
Sr. Mechanics(*)	1	9	$ 2,400	$ 22,000
Sr. Electricians(*)	1	9	$ 2,400	$ 22,000
Tugboats(**)	3	27	$12,000	$324,000
HOSS Skimmers(**)	1	9	$16,200	$146,000
Total Costs:				$674,000-788,000

(*)Note:
Workmen = $18/hr. straight time; $28/hr. overtime;
Operators = $23/hr. straight time; $32/hr. overtime;
Foremen = $25/hr. straight time; $37/hr. overtime;
Mechanic = $28/hr. straight time; $40/hr. overtime;
Electrician = $28/hr. straight time; $40/hr. overtime;

Time adjusted from 1979 figures to end of 1982 at 41% overall inflation rate.

(**)Note:
Tugs - Estimate from Industry of $2,000/day/tug;
HOSS - Clean Gulf Associates - adjust from 1978 price to 1982 level at 49% inflation rate.

Sources:
Jon Byroade, Ann Twedell, Peter LeBuff, U.S. Environmental Protection Agency, Handbook for Oil Spill Protection Cleanup Priorities (Cincinnati: EPA, 1981).
Clean Gulf Associates.

This cost will permit offshore removal of an estimated CLEAN = 23,142 tons of oil.

Because the maximum offshore cleanup capability cannot remove more than 23,142 tons of oil in the available time frame, a spill in excess of 23,142 tons can be expected to generate onshore cleanup costs. (32)

In Equation 3 from Chapter II (see page 39) the variable D(i) damage costs includes the cost of onshore cleanup, variable ONSHORE(i). These costs are included in the variable for damages because the level of onshore cleanup is dependent upon how much oil actually reaches shore (i.e.- is not removed at sea, evaporated or dispersed). The cost of onshore cleanup varies greatly, being estimated by one company to cost between $5,000 - $21,000 per ton. (33) Hypothesizing a "significant" spill of 30,000 tons, 6,858 tons of oil would remain for onshore cleanup. These cleanup costs could range from $34,290,000 (using the low $5,000/ton estimate) up to $144,018,000 (using the higher $21,000/ton estimate).

Onshore cleanup will be discussed at greater length in Chapter XI. It is clear from even the above example, however, that offshore cleanup costs per ton are far below onshore cleanup costs, offshore cleanup costs averaging $32/ton ($733,000 cost divided by a 23,142 ton cleanup capability). Further, oil cleaned up promptly offshore is not likely to produce damage claims from third parties for injuries to tourism, fishery resources, and property damage.

Reducing Exposure Costs by Increasing Cleanup Capability (CLEAN)

Because the cost exposure from onshore cleanup operations is clearly very high, increasing offshore cleanup capability is one alternative available to reduce the cleanup cost of a spill event. Additional skimmers already exist in the Gulf, limited in use primarily by the absence of sufficient boom. The acquisition of more boom would therefore allow these skimmers to become operational without the necessity of a company also having to purchase new skimmer systems. Each additional skimmer brought on line would provide an improved cleanup capability of 2,571 tons (250 bbl./hr./skimmer x 12 hours/day x 6 days).

The cost of acquiring boom for each skimmer would be: 2,000 ft. boom x cost/linear ft. Offshore boom costs are approximately $130-$150/linear foot. (34) Using the lower $130/ft., boom would cost $260,000/skimmer. When purchased through cooperative arrangements where costs are spread over 40 members or more the costs to an individual company would be significantly reduced (if divided equally among 40 members, an individual company cost could be as low as $6,500).

For each additional skimmer system brought on line, the operating costs during cleanup F(k) would be $81,000/skimmer. See Table 32, at page 296. If a spill is of a volume where 2,571 or more tons will still remain after 23,142 tons is cleaned up with presently existing Gulf capabilities, the addition of additional skimmer systems could result in an onshore cleanup savings of $12,855,000 - $53,991,000 for each skimmer added.

Reducing Exposure Costs by Increasing Effectiveness (EFF) of Cleanup Operations

The effectiveness of a cleanup operation is greatly affected by a company's awareness before a spill event of possible weaknesses and inefficiencies in its cleanup program. A review by a company of the adequacy of its operational and managerial cleanup plans in a pre-spill environment can often highlight these problems and permit adjustments to be made.

Factors Contributing to Inefficiencies in Cleanup Operations: There are a number of human interaction problems associated with oil spill cleanup. These stem from the spill event bringing together individuals representing various institutions who are strangers to one another; to bringing on-scene individuals without experience in cleanup activities; to performance inefficiencies due to lack of equipment and resources.

On-scene spill cleanup disputes among response team members, the response team and the company, or between government agencies and a company, can seriously disrupt the decisionmaking process and also interrupt effective cleanup operations. These disputes frequently concern such issues as who is in charge, determination of when cleanup has been completed, and decisions concerning the method of cleanup to be employed. "Effective decisionmaking is the key to managing a successful spill response effort" (35), and situations which impair effective decisionmaking are likely to reduce the efficiency and overall effectiveness of the cleanup effort.

The real effect of conflict from the perspective of the company, whether the company remains in charge of the cleanup effort or whether the OSC intervenes, is higher costs associated with cleanup and with damages. Most companies involved in a spill cleanup have indicated that inter-group conflict has not been an unusual situation. (36)

Conflict also leads to underutilization of available resources, through non-action or misguided action by groups left without direction or guidance. Lack of direction or proper monitoring can inadvertently increase damage from a spill through delay, improper cleanup techniques, or improper equipment use. These damages have tended to affect the environment, private property, living resources, and equipment. Well established chains of command and proper supervision are needed, particularly for those who are not cleanup professionals such as construction workers or public employees used for beach and marsh cleanup, or volunteers working with wildlife rehabilitation. (37)

Organization and planning have generally been identified as the weakest link in the company cleanup effort. Cleanup techniques and tools are more advanced than the management of spills. This difference in development is due in part to the differing nature of engineering and management. Technical advances can be accomplished outside of the spill setting by the assignment of qualified mechanical engineers or chemical engineers to develop cleanup techniques or tools.

Managerial success, on the other hand, depends upon the people who happen to become involved in cleanup and the success of the group interactions which take place. Low frequencies of spills, combined with short memories and new managerial players, compound this problem. A further complication is that many managerial decisions made during a particular spill cannot be generalized as an overall management strategy, because many decisions are site and spill specific. These strategies may also not be fully reflective of "optimal" management decisionmaking because of constraints during the spill, such as a time factor or limited resources.

The immediate need for tools and equipment dictated that many engineers became involved in cleanup problems. This led to an emphasis on the technology/operations side rather than the managerial/organization side of the cleanup process. (38) While managerial skills can be developed, the technical experts are not necessarily oriented toward acquiring and maintaining such skills. Therefore increased emphasis on manager training is needed.

Companies have also found that lack of training for cleanup personnel has been a serious handicap at many spill sites, resulting in wasted manpower and inefficient cleanup activities. (39) Both the upper/middle management levels responsible for supervising the plan, and also the operational, cleanup task oriented level, have suffered from lack of training.

Company Efforts to Identify Potential Inefficiencies: Many of the weaknesses in training and preparation discussed above can be identified by companies prior to the occurrence of a spill through the mechanism of testing plans, simulation of spills in a workshop environment or development of an "artificial disaster" scenario.

To address the problem of inadequacies in management training for spill cleanup control, Esso Resources Canada, Ltd., has devised a computer simulation for training company on-scene commanders to "make rapid decisions on the proper allocation of manpower and resources to optimize the spill cleanup and minimize environmental damage." (40) The simulation consists of a 48 hour scenario that can be completed in four hours of real time. Decisionmaking is measured both by the time delay before a decision is made and also by the outcome of the decision. Evaluation of the training scenario is based on "percentage of oil recovered, percentage of shoreline oiled and cost of cleanup". (41) Many other groups are also specifically addressing managerial skills. In the Gulf, the Texas A&M Oil Spill Control Course (Galveston, Tx.) and the National Spill Control School (Corpus Christi, Tx.) have workshop courses for spill response which focus on supervisory and managerial problems of spills as well as "hands-on" training.

Another approach used by companies to evaluate response capabilities is a "surprise test" of the spill response system in the form of a simulated disaster scenario. Sun Oil has conducted two such tests, in 1979 and 1981. Problems that became apparent during the Sun tests were:

- Confusion over alerting messages and confusion upon arrival on site;
- Inadequacies in planning for transportation to the spill site;
- Leadership roles en route and on-scene needed to be clearly defined;
- Lack of a home office coordinator and staff;
- Inadequate on-scene communication equipment;
- Need for security identification for on-scene personnel;
- Need for early availability of spill documentation equipment (including spill overflight); and
- Pre-spill core crew medical screening (for serious medical problems which preclude a high stress situations) (42)

All of these problems can cause delays and increased costs in cleanup operations.

Costs of Identifying Inefficiencies: The costs of computer simulations, surprise tests and training courses represent Y investments to achieve some enhancement in cleanup efficiency (enhanced EFF) and ultimately reduced NET EXP.

Training courses at spill control schools average between $500-600 per person for a one week course. See Appendix M. The cost to a company is both the cost of the course plus the employee's salary during the training period. For an employee in the $52,000 annual salary range, this cost would be $600 + $1,000 (one week's salary) = $1,600.

A surprise test includes the actual test period (ex: 1 day), the cost of pre-test planning, and the cost of post-test evaluation. Surprise test costs vary with the degree of elaborateness attempted in the test. One set of assumptions produces an estimate of between $60,000-100,000. See Appendix R.

The cost of developing a computer simulation depends on the degree of complexity of the simulation, making an estimate of costs difficult. If company can draw upon its own in-house resources for development of such a simulation, the cost of preparation can be better controlled and reduced. A very rough estimate based on programmer coding and testing costs is in the $60,000-100,000 range. Another factor affecting this cost is the extent to which a company has already developed computer programs, such as spill modeling programs, which could be incorporated into a cleanup simulation scenario.

The level of increased effectiveness (EFF) achieved from these measures has not at this time been measured in any useable form. Industry spokesmen, however, all feel that some increased effectiveness in cleanup operations is achieved by taking such identification and training measures. (43)

Conclusion

In this Chapter the various levels of capability in the Gulf, represented by "CLEAN", the costs of cleanup operations "F(k)", and alternatives available to a company to improve its cleanup capacity and cleanup effectiveness ("EFF"), have been presented. These elements will be reviewed in Chapter XII as part of operationalizing the Chapter II methodology.

NOTES

1. Clean Water Act, 91 Stat. 1566-1611, Sec. 311.

2. See discussion of Federal and State liability laws in Chapters V, VI, VIII.

3. See discussion of Federal and State liability laws in Chapters V, VI, VIII.

4. Interviews with company representatives and API.

5. National Oil and Hazardous Substances Pollution Contingency Plan, Federal Register 40(28) (February 10, 1975): 6282-6302, Sec. 1510. Hereafter referred to as "National Contingency Plan".

6. Clean Water Act, Sec. 311, and National Contingency Plan, Sec. 1510. Government involvement at the federal level is mandated through legislation such as the Clean Water Act, the Fisheries Conservation and Management Act, and the Marine Protection, Research and Sanctuaries Management Act.

The focus of the regulations is to plan an integrated system for "efficient, coordinated, and effective action to minimize damage from oil and hazardous substance discharges, including containment, dispersal and removal of oil and hazardous substances."

7. In the case of spills occurring in the coastal areas of the U.S., thus encompassing most Gulf spills, the OSC is a U.S.Coast Guard officer.

8. Assistance is also available through state and local governments, universities, and special agency groups such as NOAA's Scientific Support Coordinators. These groups can provide additional equipment, personnel and scientific exepertise.

9. National Contingency Plan, Sec. 1510.5(r)(1)-(3).

10. Ibid.

11. Leon Kazmierczak, "Major Spill Response Planning for Tanker Operations", Proceedings, American Petroleum Institute Oil Spill Conference, 1979 (Washington, D.C.: API, 1979), 125. A response plan should include the following elements:

- An activating or alerting mechanism to notify the company response team and the U.S. Coast Guard;

- Organization of the chain of command;

- Task identification including: supervision, biological, chemical and physical analysis, and personnel and resource needs, legal/cost documentation and public relations;

- Task assignment, usually on an "on call" basis;

- Advisory and equipment resource identification;

- Detailed instruction to all personnel on what the plan is, how it works, what responsibilities apply to each individual, and how equipment is used; and

- Personnel training and plan updating.

12. U.S. Congress, House Committee on Science and Technology, Subcommittee on Environment and Atmosphere, Hearings of June, 1977 on Oil Spill Recovery Technology, 95th Cong., 1st Sess. (1977), 11. Testimony by Stephen Dorrler.

13. Membership is open to oil industry manufacturers, refiners, shippers, pipeline companies and any oil related business. Membership is also open to local governments.

14. Interview, Mr. Sky-Eagle, General Manager, Corpus Christi Area Oil Spill Control Association.

15. Corpus Christi Area Oil Spill Control Association, brochure of operations (untitled) (Corpus Christi, TX: CCAOSCA, 1982); and interview, Mr. Sky-Eagle, General Manager, CCAOSCA.

16. Corpus Christi Area Oil Spill Control Association, Statement of Income and Expenses, Year Ending December 31, 1982.

17. Interview with Clean Gulf Associates.

18. Ibid.

19. Interviews with oil companies.

20. Interview with Arco Marine, Inc.

21. R. Meyers and M. Bennett, "Marine Industry Group (MIRG)", Proceedings, American Petroleum Institute Oil Spill Conference, 1983 (Washington: API, 1983), 191.

22. Roger Veilvoye, "A Sobering Message on Spills", Oil and Gas Journal, 78 (Aug. 11, 1980): 37.

23. U.S. Department of Interior, Minerals Management Service, Draft Regional Environmental Impact Statement, Gulf of Mexico (Washington: Minerals Management Service, 1982), 295.

24. Ibid., 294.

25. "Summing Up the Big One", The Economist 275 (June 7, 1980): 81.

26. Ibid.

27. Ibid. The fate of oil from IXTOC I:
- 5% collected;
- 50% burned at wellhead;
- 17% evaporated; and
- 28% formed an oil slick, present location unknown.

28. Arco Marine, Inc., "Oil Spill Risks in the Gulf of Mexico", in-house report, May, 1980, p. III-5.

29. Ibid., p. II-2.

30. Interview with U.S. Environmental Protection Agency, Staff of Dallas Regional Office.

31. Clean Gulf Associates estimate.

32. This assumes that no evaporation occurs, which would reduce the amount of oil remaining to be cleaned up; but this also assumes that no emulsification has occurred. Emulsification would increase the spill mass that would require cleanup by a factor of 3.5 x spilled oil. Note that these offsetting assumptions are highly optimistic assumptions. If 10,000 tons of oil are spilled, then if both evaporation and emulsification are considered, the result is: 10,000 tons x .4 evaporation x 3.5 emulsification = 21,000 tons of spill mass. Thus, considering both evaporation and emulsification doubles the true spill mass that will have to be cleaned up.

33. Exxon Corporation, Oil Spill Cleanup Manual, Vol. II: Response Guidelines (Exxon Corp., December 1979), p. 4-7.

34. Interviews with industry representatives.

35. H. E. Mew, A. H. Rooney-Char, Capt. J. D. Webb, "Organizational Obstacles to Decision Making During Oil Spills", Proceedings, American Petroleum Institute Oil Spill Conference, 1983 (Washington, D.C.: API, 1983), 202.

36. Personal interviews with companies and the USCG.

37. U.S. Senate, Committee on Appropriations, Subcommitee on Transportation and Related Agencies, Hearings on Coast Guard Oil Spill Cleanup Program, 95th Congress, 2nd Sess. (1978), 59. Testimony by Captain Schubert.

38. In reviewing API Oil Spill Conference proceedings, the number of papers focusing on improving management performance in spill prevention planning and cleanup operations has risen sharply. For example, see the series of articles by L. Kazmierczak in discussing Sun Oil's "surprise test" procedures: Leon Kazmierczak, "Major Spill Response Planning for Tanker Operations", 125; Leon Kazmierczak, et.al., "Results of a Surprise Test of Sun Transport Company Oil Spill Response Plan", Proceedings, American Petroleum Institute Oil Spill Conference, 1981 (Washington, D.C.: API, 1981), 109-111; and Kazmierczak, et. al., "Results of a Full-Scale Surprise Test of Sun's Major Spill Response Plan", Proceedings, American Petroleum Institute Oil Spill Conference, 1983 (Washington, D.C,: API, 1983), 229-231. See also C. H. Peabody and R. H. Goodman, "Innovative Training: Computer Assisted Learning" Proceedings, American Petroleum Institute Oil Spill Conference, 1983 (Washington, D.C.: API, 1983), 244, discussing Exxon's real time simulation for management of cleanup operations.

39. G. Oberholtz and James Acuff, "Targeting Spill Prevention and Control Training to the Responsible Individual", Proceedings, American Petroleum Institute Oil Spill Conference, 1979 (Washington, D.C.: API, 1979), 201-203.

40. Peabody and Goodman, "Innovative Training: Computer Assisted Learning", 244.

41. Ibid., 246.

42. Leon Kazmierczak, et.al., "Results of a Surprise Test of Sun Transport Company Oil Spill Response Plan", 109-111; and Kazmierczak, et. al., "Results of a Full-Scale Surprise Test of Sun's Major Spill Response Plan", 229-231.

43. Discussions with National Spill Control School, Corpus Christi, TX.

See also Kazmierczak, "Results of a Surprise Test of Sun Transport Company Oil Spill Response Plan", 109-111; Kazmierczak, "Results of a Full-Scale Surprise Test of Sun's Major Spill Response Plan", 229-2318; and Peabody and Goodman, "Innovative Training: Computer Assisted Learning", 246.

CHAPTER XI

DAMAGE COSTS

Introduction

Potential damage costs related to oil spills occurring near coastlines are directly related to the effectiveness of offshore cleanup efforts. Any oil not recovered offshore, or that is not evaporated, dispersed or carried out to sea by winds and currents, has the potential of causing damage onshore or to the near-shore environment. This Chapter examines the costs asociated with the oil that remains after an offshore cleanup is terminated.

A methodology is suggested for estimating the value of coastal resources for the Gulf of Mexico region, focusing on those resources that have traditionally been awarded compensation for damages incurred. While this approach is applied to the Gulf in this Chapter, the same approach can be used to evaluate other regions of interest to a company. The main purpose of a damage calculation is to give a company operating in the region an estimate of the scale of possible damages that might be incurred should a large spill with major coastal contamination take place.

The potential costs associated with oil not cleaned up offshore or dispersed are represented in equation 4 in Chapter II, at page 40:

$$D(i) = ONSHORE(i) + DAMAGES(i) + LIT(i) + CONTRACTS(i)$$

ONSHORE(i) represents the costs per ton of cleaning up the oil that has reached shore. These costs are likely to be substantially higher than offshore cleanup costs per ton, due to the highly labor intensive nature of onshore cleanup. The variable DAMAGES(i) is the estimate of the cost per ton of potential third party damages for economic injury, loss of income, damage to physical property and damage to natural resources. While it is difficult to measure the actual tonnage causing third party damages, these damage costs generally far exceed total cleanup costs because of the inclusion in DAMAGES(i) of factors for economic injury and loss of income.

LIT(i) and CONTRACTS(i) represent the legal expenses associated with spill damage suits and losses due to breach of contracts associated with nondelivery of oil. These variables are difficult to estimate in general terms, because each individual company has its own individualized range of alternatives for dealing with such costs (in-house counsel versus independent outside counsel; mitigation of damages clauses in delivery contracts, and other ways to control these costs). The costs associated with LIT(i) and CONTRACTS(i) are generally not as substantial as the costs for ONSHORE(i) or DAMAGES(i).

Finally, this Chapter frequently refers to the 1978 Amoco Cadiz tanker spill off the coast of France as a historical spill reference point when discussing damages. The Amoco Cadiz is the best documented catastrophic spill to date, and also represents a spill that generated a significant amount of onshore cleanup costs and high damage claims. Therefore, comparisons between estimates generated for D(i) variables for the Gulf of Mexico and costs associated with Amoco Cadiz will often be used as a validation tool.

Estimating ONSHORE(i)

Estimates of the cost of onshore cleanup vary widely. Historically, costs have ranged from $5,000 - $30,000 per ton. (1) This cost variation is due to both the amount of oil impacting a cost and also to the sensitivity of the area to oil. Usually the highest onshore cleanup costs are the result of a relatively small spill of heavy oil impacting a highly sensitive area. The costs of the careful, labor intensive methods used to clean a sensitive area, when spread over the relatively small amount of oil spilled, can generate a high cleanup cost/tonnage spilled ratio. Since the spills to be examined in this discussion are relatively large, the onshore cleanup variable ONSHORE(i) will be chosen from the lower end of the scale at $5,000 per ton.

By way of comparison, after the 1978 Amoco Cadiz spill 25,000 tons were cleaned onshore at a cost of $100 million, or $4,000 per ton. (2) When this figure is adjusted to 1983 dollars the cost would be $5,652 per ton. (3) Therefore, use of $5,000 per ton to estimate onshore cleanup costs is well within the range of historical spill cleanup costs.

Estimating DAMAGES(i): Methodology

Geographic Divisions: For the purpose of estimating DAMAGES(i), the Gulf has been divided into sub-areas. Because it is unlikely that any spill could damage the entire Gulf coast, divisions based on some reasonable parameters are needed to permit a reasonable assessment of damage exposure.

The divisions chosen for the Gulf are Summary Synoptic Meteorological Observation (SSMO) areas, as delineated by the U.S. Naval Weather Service Command. (4) These areas divide the Gulf coastline into seven areas, each approximately three degrees in width. See Figure 6, at page 313.

The primary reason for selecting SSMO divisions is that data exist on an area by area basis of weather conditions and ocean currents, which are factors that greatly affect spill movement of oil toward or away from shore. Spill trajectory models are used for predicting spill movement, and make use of weather and current data to predict time and location of landfall. (5) Selection of the SSMO divisions permits trajectory and other models to make use of existing additional information at a lesser cost for data collection. Having area divisions with existing necessary data also allows a company evaluation process to be more quickly brought to the implementation stage.

The Gulf area could, of course, be divided into smaller arbitrary units such as counties, known economic areas or port areas. There are, however, problems with using these types of divisions. For example, much of the cost data is not available on a county by county basis, and what data are available are not collected within every Gulf state. (6) This makes accurate comparisons of area by area data difficult at that level. The same difficulty holds true for known economic areas; the data needed for comparison are either not collected or are not in a form that permits data comparisons. (7) Use of port area divisions tends to discount all other areas. This approach also fails to account for spill effects that can extend beyond port areas or to account for those spills that do in fact occur outside of a port area designation.

As individual companies define particular areas of interest beased on their own exposure, these larger areas can be divided and more precise data can be collected.

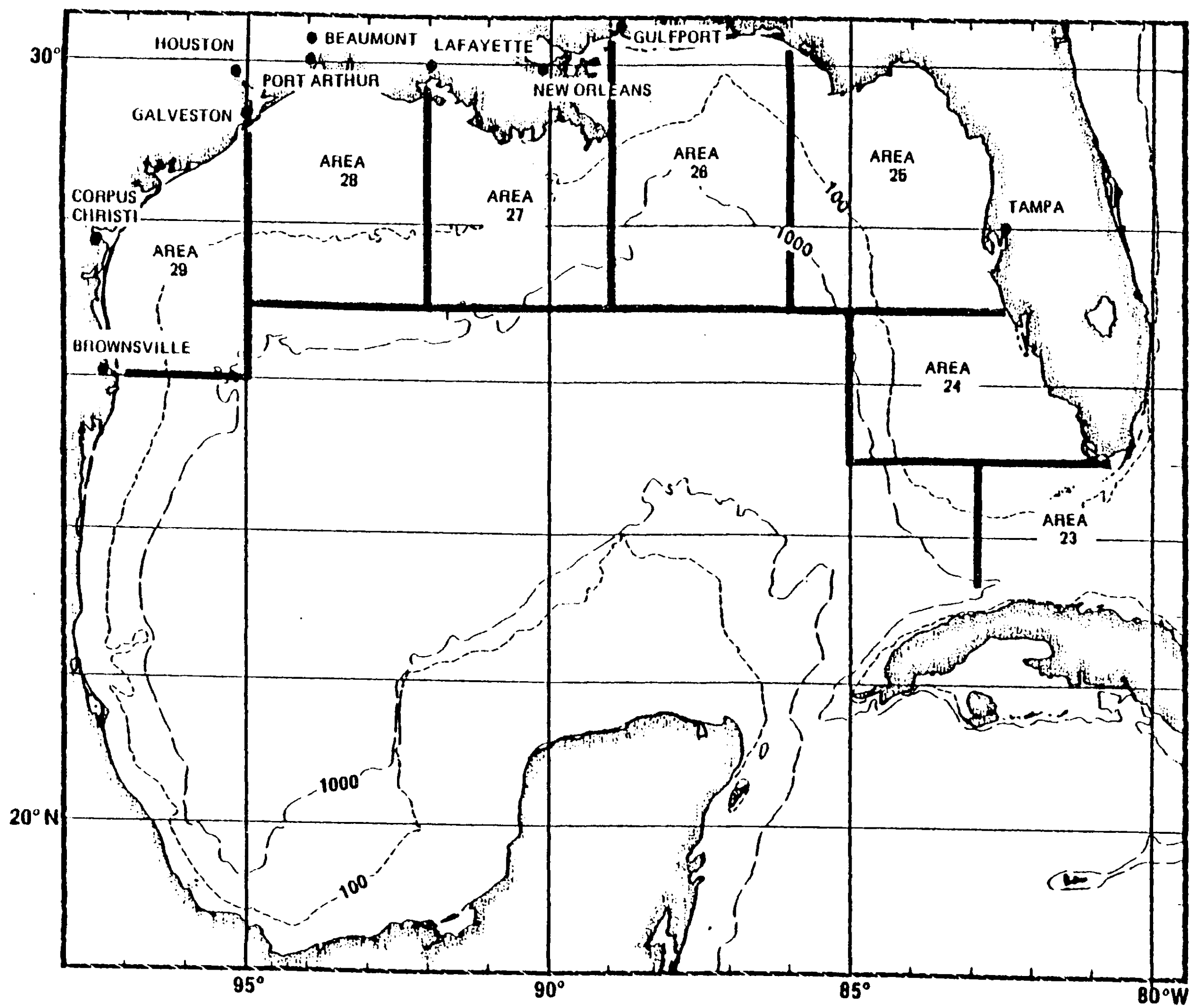


FIGURE 6

SUMMARY SYNOPTIC METEOROLOGICAL
OBSERVATION DIVISIONS FOR THE
GULF OF MEXICO

SOURCE: U.S. NAVAL WEATHER SERVICE COMMAND, SUMMARY OF SYNOPTIC METEOROLOGICAL OBSERVATIONS (S'S'M'O'), NORTH AMERICAN COASTAL MARINE AREAS REV. ATLANTIC AND GULF COASTS: VOL. 4 (ASHEVILLE, NC: NATIONAL CLIMATIC CENTER, 1976).

Until specific interests can be defined, it is not cost effective for individual companies to undertake such a specific evaluation for the entire Gulf.

Affected Resources: The cost consequences to a company whose vessel or cargo is involved in a spill will relate directly to which factors may be claimed in lawsuits as appropriate sources of reimbursement. Thus, particular attention was paid to those factors specifically included in spill liability legislation. (8) Factors were also chosen to be as inclusive as possible within the current data limitations, of which the primary limitation is an inability to quantify damages for many resources. Given these limitations, the choice was made to determine the dominant factors that generate the greatest vulnerability in terms of costs to the spiller company, and to use only these factors for the area comparisons. This allows a more pragmatic assessment to be made of the potential damages to third parties that could occur in each area.

In taking the above approach, it should be remembered that an inability to quantify damages does not mean that damages cannot occur to a resource. Additionally, it is possible that damage to a presently unquantifiable resource may also have an indirect effect on quantifiable resources. One example is damage to seagrasses and marine productivity areas, which in turn may impact fisheries and other commercially harvested resources. (9)

For each SSMO area concentrations of the following six factors were estimated:

- Acreage of high marine productivity;
- Acreage of high density shellfish;
- Acreage of high finfish abundance;
- Miles of major shorefront recreational beaches;

- Acreage of coastal wetlands; and
- Number of charterboats and headboats. (10)

Of these factors, two have no current dollar values attached: coastal wetlands and high marine productivity. These factors are included because they are important nursery areaa for most fisheries, and if either of these two factors are damaged it is possible for damage to result to fisheries at a later stage.

A review of claims for damages from spills reveals that the traditional recovery awards have been granted for damages to fishermen, the tourist industry and the recreation industry based upon these groups' use of coastal and nearshore marine resources. (11) These recoveries usually so dominate damage compensation that they all but eclipse the other factors.

Four factors are used as proxies to estimate the importance of commercial fishing for shellfish and finfish (high density shellfish and high finfish abundance), recreational fishing (charterboat/headboat fleets) and coastal tourism (major shorefront recreational beaches) for each area.

Estimating Resource Values in SSMO Areas: Because the dollar values of commercial fishing, recreational fishing and coastal tourism are only available on a statewide basis, it is necessary to determine each SSMO's percentage share of statewide values for these resources. The location of these factors in the Gulf were further defined from existing data on economic and ecological factors collected by the U.S. Fish and Wildlife Service, NOAA, and the Minerals Management Bureau. (12)

The concentrations for the factors by SSMO area were obtained from county data and from Outer Continental Shelf leasing areas contained within each area. (13) See

Appendix S for data elements, and Appendix T for leasing area divisions. By comparing counties in each state and SSMO areas, it was possible to determine the percentage of each state's factors that were contained in each SSMO area. These percentages were determined for each factor in every SSMO area. See Table 33, at page 317.

Where data unavailability prevented a more refined breakdown of data, several assumptions were made about the relationship between the dollar value of the resources and the level of the resource in a given area:

In the case of recreational fishing as compared to other tourism expenditures only Texas made a dollar estimate separating these two elements. For Texas, 19% of tourism dollars were attributable to recreational fishing. (14) Lacking other evidence, the assumption was made that for the other Gulf states a similar relationship exists between recreational fishing and other tourism expenditures. Therefore, 19% of tourism dollars were attributed to recreational fishing (using charterboat/headboat fleet as a proxy for the level of recreational fishing) and 81% were attributed to coastal tourism (using miles of major shorefront recreational beaches as a proxy for the level of coastal tourism).

Commercial fisheries values are reported in terms of total catch value. To separate shellfish from finfish it was assumed that past figures on apportionment of catch were equivalent to current apportionment of catch. For Texas in 1978, 98% of the catch value was reported as shellfish, with finfish then representing 2% of the catch. (15) Louisiana and Mississippi in 1976 reported shellfish catch equivalent to 92% and 63% respectively. (16) Alabama and Florida in 1977 reported shellfish catch at 91% and 75% respectively. (17) Since no later estimates are available, catch was divided proportionally between shellfish and finfish for each state based on the

TABLE 33

CONCENTRATIONS FOR SELECTED COASTAL RESOURCES
IN THE GULF OF MEXICO
(SSMO Areas as a Percentage of State Concentrations)

State/ SSMO Area	High Marine Productivity (Acres)	High Density Offshore Shellfish (Acres)	Finfish High Abundance (Acres)	Major Shorefront Recreation Beaches (miles)	Coastal Wetlands, forested/ unforested (Acres)	Charterboat/ Headboat Fleet (No. boats)
TEXAS	1,628,711	9,927,577	14,820,069	140.2	948,663	130
Area 29	79%	71%	64%	62%	55%	79%
Area 28	21%	29%	36%	38%	45%	21%
LOUISIANA	10,740,332	9,675,425	16,656,554	22.9	3,687,395	46
Area 28	35%	57%	52%	15%	31%	22%
Area 27	65%	43%	48%	85%	69%	78%
MISSISSIPPI	2,071,807	305,461	2,679,745	83	132,543	37
Area 27	64%	33%	52%	51%	29%	16%
Area 26	36%	67%	48%	49%	71%	84%
ALABAMA	516,032	--	872,224	19.2	194,630	37
Area 26	100%	--	100%	100%	100%	100%
FLORIDA	9,779,507	14,191,247	33,967m211	591.1	3,513,989	415
Area 26	12%	6%	9%	11%	6%	15%
Area 25	43%	32%	45%	22%	41%	20%
Area 24	43%	62%	45%	59%	32%	30%
Area 23	2%	--	1%	8%	22%	35%

Sources:

U.S. Department of Interior, Minerals Management Service, Draft Regional Environmental Impact Statement, 1982 (Washington: Minerals Management Service, 1982), "Measurement Tables of Environmental Resources", Visual No. 14;and "Fisheries Resources and Recreation", Visual No. 4 (chart on back of visual).

E. B. Liebow, K. S. Butler, and T. R. Plaut, et. al., Texas Barrier Islands Region Ecological Characterization: A Socioeconomic Study, Vol. I: Synthesis Papers, U.S. Fish and Wildlife Service, Office of Biological Studies, FWS/OBS-80/19 (1980).

D. K. Larson, et. al., Mississippi Deltaic Plain Region Ecological Characterization: A Socioeconomic Study, Vol. I: Synthesis Papers, U.S. Fish and Wildlife Service, Office of Biological Studies, FWS/OBS-79/05 (1980).

above percentages. See Table 34, at page 319.

The percentages in each SSMO area for each factor were then used in combination with state dollar values for the factors to arrive at dollar estimate for each factor in each SSMO area. See Table 35, at page 320, for the dollar value for each factor by SSMO area.

Finally, because the dollar values for the affected resources were based on 1979 and 1980 dollar values, it was necessary to adjust these values to present 1983 dollar levels. See Table 36, at page 321, adjusting Table 35 values to present dollars.

Validation of Potential Damage Levels in SSMO Areas: The total potential damage costs for each SSMO area range from almost $6 billion (Area 24) to $1.5 billion (Area 23). The average potential damages for the SSMO Areas is $2.5-3 billion.

The scale of potential damages estimated is not excessive when compared to other historical spills. The *Amoco Cadiz* litigation has pending lawsuits totalling $2 billion for damages caused in 1978. (18) If adjusted to present dollars the damages claimed would be valued at $2.8 billion, which is within the range of the average potential damages for Gulf SSMO areas.

DAMAGES(i): Estimating Potential Resource Damage

Estimating Oil Movement: During the Amoco Cadiz spill, of the 230,000 tons spilled, 70,000-80,000 tons impacted 250 miles of beach. (19) Oil from the *Torrey Canyon* spill travelled over 225 miles impacting 242 miles of shoreline in France and Britain. (20) In the Gulf of Mexico oil from the IXTOC I spill in the Bay of Campeche travelled over 600 miles northward to impact beaches in Texas. It is estimated that 4,000-11,000 tons either impacted beaches or were offshore in the form of tar

TABLE 34

DOLLAR VALUE OF SELECTED COASTAL RESOURCES IN THE GULF OF MEXICO, BY STATE

State/SSMO Area	Catch Value Shellfish (1979) ($ million)	Catch Value Finfish (1979) ($ million)	Tourism (Coastal) (1980) ($million)	Recreational Fishing (1980) ($ million)
TEXAS	156.8	3.2	2,991.0	709.0
Area 29	111.3	2.0	1,854.4	560.1
Area 28	45.5	1.2	1,136.6	148.9
LOUISIANA	183.7	116.0	1,701.0	399.0
Area 28	104.7	8.2	255.2	87.8
Area 27	78.0	7.7	1,445.9	311.2
MISSISSIPPI	20.2	11.8	648.0	152.0
Area 27	6.7	6.2	330.5	24.3
Area 26	13.5	5.7	317.5	127.7
ALABAMA	44.6	4.4	178.2	41.8
Area 26	44.6	4.4	178.2	41.8
FLORIDA	68.3	22.8	6,885.0	1,615.0
Area 26	4.1	2.0	757.4	242.3
Area 25	21.0	10.3	1,514.7	323.0
Area 24	42.3	10.3	4,062.2	484.5
Area 23	--	0.2	550.8	565.3

Sources:

Table 33, at page 317.

U.S. Department of Interior, Minerals Management Service, Draft Regional Environmental Impact Statement, 1982 (Washington: Minerals Management Service, 1982), "Measurement Tables of Environmental Resources", Visual No. 14;and "Fisheries Resources and Recreation", Visual No. 4 (chart on back of visual).

E. B. Liebow, K. S. Butler, and T. R. Plaut, et. al., Texas Barrier Islands Region Ecological Characterization: A Socioeconomic Study, Vol. I: Synthesis Papers, U.S. Fish and Wildlife Service, Office of Biological Studies, FWS/OBS-80/19 (1980).

D. K. Larson, et. al., Mississippi Deltaic Plain Region Ecological Characterization: A Socioeconomic Study, Vol. I: Synthesis Papers, U.S. Fish and Wildlife Service, Office of Biological Studies, FWS/OBS-79/05 (1980).

TABLE 35

VALUES FOR SELECTED COASTAL RESOURCES IN THE GULF OF MEXICO, BY SSMO AREA

SSMO Area	Catch Value Shellfish (1979) ($ million)	Catch Value Finfish (1979) ($ million)	Tourism (Coastal) (1980) ($million)	Recreational Fishing (1980) ($ million)
Area 29	111.3	2.0	1,854.4	560.1
Area 28	150.2	9.5	1,391.7	236.7
Area 27	85.6	13.8	1,776.3	355.5
Area 26	58.1	10.0	1,253.1	411.7
Area 25	21.9	10.3	1,514.7	323.0
Area 24	42.3	10.3	4,062.2	484.5
Area 23	--	0.2	550.8	565.3

Sources:

Tables 33 and 34, at pages 317 and 319.

U.S. Department of Interior, Minerals Management Service, Draft Regional Environmental Impact Statement, 1982 (Washington: Minerals Management Service, 1982), "Measurement Tables of Environmental Resources", Visual No. 14;and "Fisheries Resources and Recreation", Visual No. 4 (chart on back of visual).

E. B. Liebow, K. S. Butler, and T. R. Plaut, et. al., Texas Barrier Islands Region Ecological Characterization: A Socioeconomic Study, Vol. I: Synthesis Papers, U.S. Fish and Wildlife Service, Office of Biological Studies, FWS/OBS-80/19 (1980).

D. K. Larson, et. al., Mississippi Deltaic Plain Region Ecological Characterization: A Socioeconomic Study, Vol. I: Synthesis Papers, U.S. Fish and Wildlife Service, Office of Biological Studies, FWS/OBS-79/05 (1980).

TABLE 36

TIME ADJUSTED (TO 1983) VALUES FOR SELECTED COASTAL RESOURCES IN THE GULF OF MEXICO, BY SSMO AREA

SSMO Area	Catch Value Shellfish (1983*) ($ million)	Catch Value Finfish (1983*) ($ million)	Tourism (Coastal) (1983*) ($million)	Recreational Fishing (1983*) ($ million)	Total Value, All Resources (1983*) ($ million)
Area 29	157.3	2.8	2,410.7	728.1	3,298.9
Area 28	212.2	13.4	1,809.2	307.7	2,342.5
Area 27	121.0	19.5	2,309.2	462.2	2,911.9
Area 26	82.1	14.1	1,629.0	535.2	2,260.4
Area 25	30.9	14.6	1,969.1	419.9	2,434.5
Area 24	59.8	14.6	5,280.9	629.9	5,982.2
Area 23	--	0.3	716.0	734.9	1,451.2

(*) 1979 values for shellfish and finfish adjusted by factor of 41.3% CPI; 1980 values for tourism and recreational fishing adjusted by factor of 30% CPI.

Sources:

Tables 33, 34 and 35, at pages 317, 319 and 320.

U.S. Department of Interior, Minerals Management Service, Draft Regional Environmental Impact Statement, 1982 (Washington: Minerals Management Service, 1982), "Measurement Tables of Environmental Resources", Visual No. 14;and "Fisheries Resources and Recreation", Visual No. 4 (chart on back of visual).

E. B. Liebow, K. S. Butler, and T. R. Plaut, et. al., Texas Barrier Islands Region Ecological Characterization: A Socioeconomic Study, Vol. I: Synthesis Papers, U.S. Fish and Wildlife Service, Office of Biological Studies, FWS/OBS-80/19 (1980).

D. K. Larson, et. al., Mississippi Deltaic Plain Region Ecological Characterization: A Socioeconomic Study, Vol. I: Synthesis Papers, U.S. Fish and Wildlife Service, Office of Biological Studies, FWS/OBS-79/05 (1980).

mats. It was further estimated that 50,000-100,000 tons passed offshore in the Texas OCS region in the form of emulsified oil. (21) An offshore current shift prevented this oil from coming ashore.

In another Gulf incident, the Burmah Agate in 1979 collided with the freighter Mimosa five miles off Galveston. The oil from the Burmah Agate travelled approximately 170 miles from the spill site, to the south Texas coast. Of the oil released 150-200 tons impacted just south of Galveston, 70 tons at San Jose Island and 1 ton at the northern end of Brazos Island. (22)

For other historical spills and their level of coastal impact, see Table 37, at page 323.

The distance that oil travels and the amount of coastline impacted is largely a function of spill location in relation to distance from shore, and the ocean currents active at the time. Spill trajectory is measured by vector analysis using water current speed, 3.5% of wind speed, and the coriolis deflection. (23) From this it can be seen that currents play a larger role than wind in determining oil movement direction. As can be seen from current charts of the Gulf much of the year the nearshore currents could cause the oil from a coastal spill to impact large stretches of coast, particularly in Texas. See Appendix H.

The approximate length of coastline in each SSMO area is: Area 29 - 300 miles; Area 28 - 200 miles; Area 27 - 300 miles; Area 26 - 200 miles; Area 25 - 400 miles; Area 24 - 180 miles; and Area 23 - 100 miles. (24) Since historical worldwide and Gulf of Mexico major oil spills have impacted on the order of 200+ miles of coastline and have travelled hundreds of miles at sea (even after offshore cleanup efforts), it will be estimated that a catastrophic Gulf spill will impact the coastline of one entire SSMO area.

TABLE 37

LENGTH OF COASTLINE IMPACTED BY SELECTED HISTORIC SPILLS

Date	Spill Source	Quantity (tons)	Location	Cause	Coastline Contamination
3/18/67	Torrey Canyon	121,000	Scilly Islands, English Channel	Ran aground	242 miles
12/28/69	Santa Barbara offshore platform	4,714	Santa Barbara Channel, 5.5 miles from shore	Well blowout	40 miles
2/4/70	Steam Tanker Arrow	16,000	Chedabucto Bay, Nova Scotia	Struck a rock	190 miles
4/15/74	Imperial Sarnia	500	Whale Bank Shoal, Canada, less than 1 mile from shore	Grounded	65 miles
12/18/74	Mizushima Refinery	38,500	Inland Sea, Japan	Occurred on land, emptied into sea	291 miles
3/17/78	Amoco Cadiz	230,000	Portsall rocks off Coast of France, less than 1 mile from shore	Ran aground	250 miles (130 miles on Brittany coast)
12/9/78	Peck Ship (barge)	1,571	Off Puerto Rico near Cape San Juan, P.R.	Rupture	16.2 miles
12/31/78	Andros Patricia	46,028	23.6 miles west of Cape Villano, Spain	Hull fract., explos-ion, fire	5,114 tons hit 62.1 miles (24.9 miles heavily impacted Cape Burlla to Foz)
11/1/79	Burmah Agate/ Mimosa	2,857	5 miles off Galveston Bay, TX	Tanker/ freighter collision	(**)

(**) Oil from Burmah Agate travelled 170 miles down the Texas Coast impacting the shoreline from south of Galveston to Brazos Island in south Texas.

Source: Exxon Corporation, Oil Spill Cleanup Manual, Vol. III: Reliance on Chemical Dispersants for an Oil Spill Response (Exxon Corp., April, 1980), p. A-4 to A-10.

Estimating Damages and Onshore Cleanup: The length of time for an onshore cleanup effort for a major spill has varied considerably, depending upon the sensitivity of the area impacted and the degree of cleanup desired. Onshore cleanup time for some of the better documented spills is shown below:

Spill	Amount (tons)	Peak Manpower	Number of Months
Amoco Cadiz	230,000	6,000	7
Nepco 140	1,134	700	3.5
Santa Barbara	5,225	1,000	4
Mizushima	42,800	230,000(total)	6 (25)

Based on these and other large spills, onshore cleanup for a catastrophic spill will be assumed to take six months.

The other important duration question which must be estimated is: what is the length of time that a catastrophic spill can be expected to impact area resources? A six month period will also be estimated for this value, because in the case of certain affected resources such as coastal tourism, the time that the spill has not been substantially cleaned up onshore is a good estimate of the length of time that a region will experience a dropoff in tourism. This duration value is in reality a highly volatile one: negative publicity can cause a longer term impact even after cleanup is performed; a highly sensitive area may be decimated for a more prolonged period.

It is also important to note that if a spill occurs during a critical season for resource use (for example, the high tourist season, or the period of prime harvesting of shellfish), the true impact on the region may be for most of the year's expected revenues from such resources. The use of a six month estimate should therefore offset the potential overestimation of impacted areas with the potential underestimation of damage duration.

In order to determine a value of damages per ton, it is necessary to make an estimation of the amount of oil that might go ashore during a catastrophic spill. For this estimation, the Amoco Cadiz spill will again be used as a proxy. During the Amoco Cadiz spill approximately 35% of the oil not cleaned up by offshore cleanup operations went ashore and impacted the coast and environment. (26) Assuming a 200,000 ton catastrophic spill in the Gulf coastal area, approximately 23,150 tons represents the maximum Gulf cleanup capability. See Chapter X. Of the remaining 176,850 tons not cleaned up, use of a 33-35% IMPACT value (see Equation 3, Chapter II, at page 39) produces an expected volume of oil impacting the area of between 58,360-61,898 tons. Taking the midrange for these values produces 60,000 tons of oil that are expected to impact the area from a 200,000 ton spill. The damages per ton expected for each area using this estimated level of oil is shown in Table 38, at page 326.

Referring again to the Amoco Cadiz, the claimed damages from the spill are approximately $2 billion. See Appendix U. The claimed damages per ton for Amoco Cadiz are therefore $28,600/ton in 1978 dollars. If these damage claims are adjusted to 1982 dollars (based on the CPI), the claims would rise to $2.8 billion, or $40,000/ton. Thus, the Gulf SSMO estimated damage figures, ranging from $12,500/ton (Area 23) to $50,000/ton (Area 24) fall within the range that includes the Amoco Cadiz event.

TABLE 38

GULF CATASTROPHIC SPILL ESTIMATED POTENTIAL DAMAGES PER TON (*) (by SSMO Area)

SSMO Area	Total Value per Year ($)	Value per 1/2 Year ($)	Dollars per Ton (*) Assuming 1/2 Value Damage Level ($)
29	$3.30 billion	$1.65 billion	$27,500
28	$2.30 billion	$1.15 billion	$19,200
27	$2.90 billion	$1.45 billion	$24,000
26	$2.30 billion	$1.15 billion	$19,200
25	$2.40 billion	$1.20 billion	$20,000
24	$6.00 billion	$3.00 billion	$50,000
23	$1.50 billion	$0.75 billion	$12,500

(*) Based on a 200,000 ton spill, with 60,000 tons of oil reaching shore.

Source:
For total dollar values for each SSMO area, see Tables 33, 34, 35 and 36, at pages 317, 319, 320 and 321, and see also Appendix S.

Estimating LIT(i) and CONTRACTS(i)

The cost to a company of entering litigation after a large spill can be quite high due to the number of years that court cases may slowly progress. It has been estimated that the litigation costs after the Santa Barbara spill were at least $5 million. (27) The costs for the Amoco Cadiz litigation will be much higher because after four years of litigation there has not yet even been a decision as to which jurisdiction (the U.S. or France) will hear the case. A trial is unlikely for another three to five years.

Considering the magnitude of the data gathering, fact analyzing, witness contacts, and pleadings in a case the scope of Amoco Cadiz, it is not unreasonable to anticipate litigation costs on the order of $10-15 million. These costs will vary based on the company's degree of using outside counsel versus in-house attorneys; the number of expert witnesses used; and whether or not a settlement can be reached before trial.

The cost of broken contracts due to non-delivery of cargo is likewise difficult to estimate. A company may have insurance to cover non-delivery, contracts may provide for exemptions in cases of *force majeure* conditions (such as acts of God), or a specified liquidated damage level may be provided in contracts to limit maximum exposure. Additionally, it is possible that at a particular time, other shipments of oil may be substituted to meet refinery operation needs, eliminating damage to the refinery. It is unlikely in any event that the cost of broken contracts will exceed the cargo value lost.

Refining the Valuation of Costs

As current studies of the economic and ecological factors along the coast continue over time, valuation of resources and quantification of damages will become more feasible. Those factors that were previously unquantifiable and therefore rarely subject to damage compensation will assume larger and larger proportions in damage recoveries. Company awareness of any trends that could cause a status change in the valuation of factors can be attained through continued observance and periodic reassessment of affected resources in a region. Particular areas that the company may choose to observe for such trends are: current resource studies; damage recovery awards; and legislative changes regarding damage compensation, parties which may seek recovery, and damages for which recovery may be sought. See Table 39, at page 329, historical damage awards. Note, for example, the award in the Zoe Colocotrania spill, in which compensation was awarded for damage to mangroves, one of the first decisions awarding compensation for coastal wetlands damage.

While it is important for the industry to obtain the most recent data available, the actual collection of primary data may be costly to engage in and proprietary in nature. For example, the federal or state governments have multiple uses for data collected on economic or ecologic factors within a region while for industry such data would have only limited uses. Also, if data were collected at a government level with special attention to compatibility of form and reliability of data there would be increased data coherence between regions and therefore of more value for cross comparison of factor and areas. Data collection for the company is a two edged sword: as more is known greater accuracy can be achieved through

TABLE 39

OIL SPILL DAMAGE AWARDS FOR RESOURCES

Date	Ship Name	Place of Incident	Size of Loss (Tons)	Damages Paid
1962	Eagle Courrier	Japan	400	Fishing Industry: $500,000 (Claimed $1 million)
1969	Darhachi Toyo Maru	Japan	500	Fishing Industry: $160,000 (Claimed $800,000)
1971	Juliana	Niigata (Japan)	7,000	(Proposed Y 204 million to fishery association Y 1 million to fish dealers)
1973	Zoe Colocotrania	Puerto Rico	5,500	$5.5 Million for mollusks and $0.6 million for mangroves
1974	Universe Leader	Bantry Bay (Ireland)	2,000	Fishermen: £ 300,000
1976	STC-101	Chesapeake Bay	1,000	Damage to birds $115,000
1976	Urquiola	Cornua (Spain)	101,000	Oysters and mussel fishery claim Ptas. 35.5 million
1977	Adrian Maersk	Hong Kong	1,000	To Seafarmers HK 5 million
1978	Amoco Cadiz	Brittany	230,000	Provisional Comp: Fishermen: Frs. 23-45 million Oystermen: Fr. 22 million
1978	Ryû-yô-Maru	Japan	105	Fishery Association: Y 1,031 million

Source; Organization for Economic Cooperation and Development, Combatting Oil Spills: Some Economic Aspects (Paris: OECD, 1982), 127-137.

models, allowing better planning; while at the same time more factors will be quantitatively defined such that greater damage claims become possible. Therefore primary data collection from a cost stand point may not be desirable for the company to pursue but analysis of primary data is of great interest. As the known information cannot be canceled, the best course is to use the information as it becomes available to refine current assessments.

Individual companies can also consider refining the evaluation of damages on the basis of their particular area of interest. Most companies use relatively few ports of entry for the majority of their shipments. (28) This can be seen by examining those companies that imported oil into the Gulf in the first ten months of 1982 and their major ports of entry. See Tables 40, at page 331. These companies could concentrate only on the areas where their major ports are located: Champlin, using Corpus Christi, should concentrate on SSMO Area 29; Exxon, using Houston and Baton Rouge, on Areas 28 and 27; Chevron, using Pascagoula, on Area 26; Phillips Petroleum, using Freeport, on Area 29; and GHR Energy, using New Orleans, on Area 27. See Table 41, at page 333. Additionally, all companies should consider any other areas they cross during shipping, such as Area 23 if their routing is through the Straits of Florida, as potentially important areas of impact.

TABLE 40

GULF OF MEXICO PORTS USED BY OIL IMPORTERS, JANUARY-OCTOBER, 1982

Importing Company	Major Ports Used (no. of shipments)	SSMO Areas
Amoco	Galveston (143), Gramercy (21)	28,27
Ashland	New Orleans (69), Gramercy	27
Arco	Houston (28), Texas City (6)	29
Champlin	Corpus Christi (30)	29
Charter	Houston (5), Garyville (3)	28,27
Chevron	Pascagoula (103)	26
Cities Service	Lake Charles (26), Houston (10), Mobile (8)	27,28,26
Clark Oil	St. James (40)	27
Coastal Corp.	Corpus Christi (49)	29
Conoco	Lake Charles (5)	28
Coral Pet.	St. James (3), Gramercy (3)	27
Continental	New Orleans (2)	27
Crown Central	Houston (13), Texas City (6)	28
Delta Ref.	New Orleans (14)	27
Exxon	Baton Rouge (66), Houston (54), New Orleans (7)	27,28,27
GHR Energy	New Orleans (33)	27
Gulf Oil	New Orleans (34), Port Arthur (21), Beaumont(14)	27,28,28
Gulf States	Corpus Christi (14)	29
Horizon	Nederland (4)	28
Houston Oil	Freeport (3)	29
Hunt	Mobile (9)	26
Intercoastal	New Orleans (3)	27
Intl. Pet.	New Orleans (6)	27
Kerr-McGee	Corpus Christi (27)	29
Koch Ind.	Corpus Christi (3)	29
La Gloria	Beaumont (6), New Orleans (4)	28,27
Marathon	New Orleans (39), Gramercy (19) Galveston (5)	27,27,28
Mobil	Beaumont (39)	28
Mobile Bay	Mobile (6)	26
Murphy	New Orleans (9), Meraux (3)	27
National Coop.	Freport (1)	29
Phillips Pet.	Freeport (36)	29
Placid Ref.	New Orleans (2)	27
Sea Horse	New Orleans (63)	27
Sentry	Bayport (3), Mobile (3)	28,26

TABLE 40, Continued

Importing Company	Major Ports Used (no. of shipments)	SSMO Areas
Shell Oil	New Orleans (78), Houston (68), Gramercy (29)	27,28, 27
Sigmor	Corpus Christi (7)	29
Std Oil-Ohio	New Orleans (18), Beaumont (15)	27,28
Sohio Supply	Beaumont (15), New Orleans (14)	28,27
Str. Pet. Res.	Freeport (123), Beaumont (32), Gramercy (27)	29,28,27
Sun Company	Beaumont (2)	28
Tenneco	NewOrleans (6)	27
Texaco	Port Arthur (59), LOOP (47), Baton Rouge (34)	28,27,27
Texas City	Galveston (43)	28
Tosco Corp.	Nederland (5), Beaumont (4)	28
Total Pet.	Beaumont (5)	28
Union Oil-Cal.	Gramercy (13)	27
Vulcan	Mobile (4)	26

Source: American Petroleum Institute, Imported Crude Oil and Petroleum Products (Washington: API, 1982).

TABLE 41

PORTS USED FOR OIL TRANSPORTS - 1982, BY SSMO AREA

S.S.M.O. Area	Ports
Area 29:	Corpus Christi Freeport
Area 28	Galveston Texas City Baytown Bayport Houston Port Arthur Beaumont Nederland Lake Charles
Area 27	St. James Capline Garyville Baton Rouge Port Allen Gramercy New Orleans LOOP Meraux Norco Convent
Area 26	Pascagoula Mobile
Area 25	n/a for 1982
Area 24	n/a for 1982
Area 23	n/a for 1982

Source: American Petroleum Institute, Imported Crude Oil and Petroleum Products (Washington: API, 1982).

NOTES

1. See I. C. White and J. A. Nichols, "The Cost of Oil Spills", in Proceedings, American Petroleum Institute Oil Spill Conference, 1983 (Washington: API, 1983), 541.

2. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of Ocean Resources Coordination and Assessment, Assessing the Economic Damages of Oil Spills: The Amoco Cadiz Case Study (Washington: ORCA, 1982), 1-26. See also Roy Hann, "Unit Operations, Unit Processes and Level of Resource Requirements for the Cleanup of the Oil Spill from the Supertanker Amoco Cadiz", in Proceedings, American Petroleum Institute Oil Spill Conference, 1979 (Washington: API, 1979), 157.

3. Using the consumer price index inflator, the inflation rate from 1979 to the end of 1982 was 41.3%.

4. U.S. Naval Weather Service Command, Summary of Synoptic Meterological Observations (S'S'M'O'), North American Coastal Marine Areas Rev. Atlantic and Gulf Coasts: Vol. 4 (Asheville, N.C.: National Climatic Center, 1975). See also: U.S. Department of Interior, Minerals Management Service, Draft Regional Environmental Impact Statement, Gulf of Mexico (Minerals Management Service, 1982), Visual 6.

5. J. C. Huang and F. C. Monastero, Review of State-of-the-Art Oil Spill Simulation Models, Final Report (Washington: API, 1982), p. 3.2-3. At least 35 spill tracking and simulation models are currently in use.

6. For example, see comparisons in two publications:

E. B. Liebow, K. S. Butler, and T. R. Plaut, et. al., Texas Barrier Islands Region Ecological Characterization: A Socioeconomic Study, Vol. I: Synthesis Papers, U.S. Fish and Wildlife Service, Office of Biological Studies, FWS/OBS-80/19 (1980), 155-156.

D. K. Larson, et. al., Mississippi Deltaic Plain Region Ecological Characterization: A Socioeconomic Study, Vol. I: Synthesis Papers, U.S. Fish and Wildlife Service, Office of Biological Studies, FWS/OBS-79/05 (1980).

7. Liebow, et. al., Texas Barrier Islands Region Ecological Characterization; and Larson, et. al., Mississippi Deltaic Plain Region Ecological Characterization.

8. See generally the Federal Water Pollution Control Act, 86 Stat. 816; the Clean Water Act of 1977, 91 Stat. 1595; the Outer Continental Shelf Lands Act, 92 Stat. 629; the Deepwater Port Act, 88 Stat. 2141; and the Fishery Conservation and Management Act, 90 Stat. 331.

9. U.S. Congress, House Committee on Merchant Marine and Fisheries, Subcommittee on Coast Guard and Navigation, Hearings of March 11, 1981 on Oil Pollution Liability - H.R. 85, 97th Cong., 1st Sess. (1981), 141. Testimony by Clifton Curtis, Center for Law and Social Policy.

10. Values for all factors, except charterboat/headboat, were obtained from U.S. Department of Interior, Minerals Management Service, Draft Regional Environmental Impact Statement, 1982, Visual No. 14, "Measurement Tables of Environmental Resources". Data were compiled by Minerals Management Service, New Orleans OCS Office; Fisheries and Wildlife Service Region 4 (Panama City) and Region 2 (Galveston); and Fish and Wildlife Service, National Coastal Ecosystems Team (Slidell).

Charterboat/headboat figures were obtained from U.S. Department of Interior, Minerals Management Service, Draft Regional Environmental Impact Statement, 1982, Visual No. 4, "Fisheries Resources and Recreation" (chart on back of visual).

11. Organization for Economic Cooperation and Development, Combatting Oil Spills: Some Economic Considerations (Paris: OECD, 1982), 125-138.

12. See generally, U.S. Department of Interior, Minerals Management Service, Draft Regional Environmental Impact Statement, 1982; Liebow, et. al., Texas Barrier Islands Region Ecological Characterization; and Larson, et. al., Mississippi Deltaic Plain Region Ecological Characterization.

13. For any county split by SSMO areas, the county was assigned to the area containing the largest portion of the county. OCS leasing areas, due to their size, were divided between SSMO areas within their boundaries.

14. Bland Crowder, "Saltwater Fishing", The University and the Sea 16(1) (1983): 4-5. See also U.S. Department of Interior, Minerals Management Service, Gulf of Mexico OCS Regional Office, Draft Regional Environmental Impact Statement, 1982, 220.

15. Liebow, et. al., Texas Barrier Island Region Ecological Characterization, 117.

16. Larson, et. al., Mississippi Deltaic Plain Region Ecological Characterization, 153.

17. U.S. Department of Interior, Minerals Management Service, Draft Regional Environmental Impact Statement, 1982, 208, 211.

18. U.S. General Accounting Office, International Oil Pollution: Current and Alternative Liability and Compensation Arrangements Affecting the United States (Washington: GAO, 1983), 2.

19. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of Ocean Resources Coordination and Assessment, Assessing the Economic Damages of Oil Spills, 2-47.

20. Exxon Corporation, Oil Spill Cleanup Manual, Vol. III: Reliance on Chemical Dispersants for an Oil Spill Response (Exxon Corp., April, 1980), p. A-4.

21. P. Boehm, IXTOC Oil Spill Assessment, Vol. III, Executive Summary (Washington: U.S. Department of Commerce, 1982), 1.

22. Ibid., 3-4.

23. Exxon Corporation, Oil Spill Cleanup Manual, Vol. II: Response Guidelines (Exxon Corp., 1980), p. 1-32.

24. Estimates from coastal maps. Total estimated coastline for the areas is 1,680 miles. Shoreline total as measured is 1,631 miles.

25. Dennis Reid and Roy Hann, "Levels of Effort from Previous Spills: A Means of Predicting Personnel, Equipment and Monetary Requirements Necessary to Clean Up a Spill", unpublished paper, Texas A&M University Department of Environmental Engineering, 1978, 3.

26. Roy Hann, "Unit Operations" 157.

27. Organization for Economic Cooperation and Development, Combatting Oil Spills, 127.

28. American Petroleum Institute, Imported Crude Oil and Petroleum Products, 1982 (Jan.-Oct.) (Washington: API, 1982).

CHAPTER XII

OPERATIONALIZING AN OIL SPILL STRATEGY METHODOLOGY

Introduction

In the preceding Chapters, the variables contained in the Chapter II methodology for evaluating spill consequences have been discussed, focusing upon the Gulf of Mexico area as a test region for U.S. companies importing oil into Gulf ports. The present Chapter brings these variables together and evaluates alternatives of a company through the Chapter II approach. When evaluating company alternatives, the following questions are considered:

- Is the proposed alternative to reduce consequences sufficiently cost-effective to the company?

- How certain or speculative is the proposed alternative?

- What is likely to be the public perception of each alternative? Will this perception be likely to affect the company's willingness to undertake the strategy?

- Is there any difference between small and large companies in the cost-effectiveness of the alternative?

- Where there are limits in operationalizing the methodology due to information gaps, can the methodology be used for the alternative purpose of helping a company identify the type of information it requires in order to be willing to undertake the investment?

Examination of a particular oil company in the Gulf of Mexico is difficult, because many important pieces of information concerning company activities and policies cannot be obtained. For a company undertaking its own appraisal of spill consequences, variables ACTIVITY, D(i) for the localized port area in which the company operates, and V(1) and V(2), will be the company's own level of activity, potential damage for the port area of operation, and the volumes represented by the company's largest shipment into the region and its average shipment into the region.

For the purpose of illustrating how a company could utilize the Chapter II methodology in planning a strategy for dealing with oil spill consequences, two company scenarios will be employed. One scenario is reflective of a small company operating in the Gulf, while the second is a representation of a large company operation. The Small Company scenario includes the following information:

- Small Company makes 25 oil cargo trips into the Gulf annually, with total tonnage shipped equalling 1,375,000 tons;

- Average shipment volume for Small Company is 55,000 tons (i.e.- V(2) = 55,000 tons);

- The largest single shipment of Small Company is 200,000 tons (i.e.- V(1) = 200,000 tons); and

Small Company utilizes the port of Corpus Christi exclusively for its shipments;

The Large Company scenario includes the following information:

- Large Company makes 150 oil cargo trips into the Gulf annually, with total tonnage shipped equalling 8,250,000 tons;

- Average shipment volume for Large Company is 55,000 tons (i.e.- V(2) = 55,000 tons);

- The largest single shipment of Large Company is 200,000 tons (i.e.- V(1) = 200,000 tons); and

Large Company utilizes the port of Corpus Christi exclusively for its shipments;

The two scenarios contain essentially common elements in order to more easily compare and contrast differences in small and large organization decisionmaking. The key difference between Small Company and Large Company is the level of activity in the Gulf, with Large Company operating at six times the level of Small Company.

The Small Company example of 25 trips is representative of many smaller Gulf companies. See Table 21, at page 243. The average shipment tonnage of 55,000 is midway in the range of 40,000-70,000 tons, which includes 34 of the 49 Gulf companies operating during 1982. See Tables 21 and 22, at pages 243 and 245. The use of Corpus Christi as a port of preference permits the selection of a port which experiences heavy vessel activity, and which is also one of the three ports with the greatest spill exposure for tankers and barges. See Table 25, at page 257.

The Large Company example draws upon companies at the level of Mobil, Marathon, Chevron, Exxon, and others in the Gulf. The 150 trips is representative of any of the six companies in the 100-180 trips/year range. (See Tables 21 and 22, at pages 243 and 245. The selection of 200,000 tons for largest single shipment is actually a low assumption in light of six companies in the Gulf with 200,000 and above single shipment tonnage: Marathon (432,000); Texaco (283,000); Mobil (280,000); Shell (270,000); Strategic Petroleum Reserve (266,000); and Union Oil (200,000). Selection of Corpus Christi permits direct comparisons of damage potential with Small Company.

The approach taken in this Chapter is to illustrate both the cost-effective aspect of the Chapter II methodology, as seen in Equations 1-7, and also the more evaluative, qualititative aspect of the methodology, as generally described in Equation 8. The analysis in this Chapter will consider the following situations:

Basic Case - No Y Investments:
- Example 1. Corpus Christi area spill; no insurance; existing Gulf cleanup resources. This is the "base case" example, which suggests the greatest NET EXP for Small Company and Large Company if no Y investments are undertaken.

- Example 2. South Florida spill, illustrating the different consequences that result from changing the location of a spill site.

- Example 3. Applying the Chapter II methodology to a company that utilizes two or more different ports of operation.

Insurance Alternatives:
- Example 4. Y investment in TOVALOP and CRISTAL only.

- Example 5. Y investment in P&I club, TOVALOP and CRISTAL.

- Example 6. Y investment in third party individual company policy, TOVALOP and CRISTAL.

Cleanup Alternatives:
- Example 7. Y investment made by one company of increasing existing Gulf cleanup resources by adding new capability.

- Example 8. Y investment made by multiple companies in a cooperative arrangementt of increasing existing Gulf cleanup resources by adding new capability.

- Example 9. Y investment by company to improve the efficiency of Gulf cleanup efforts.

- Example 9A. A variation on the Chapter II methodology to be used where a company wishes to determine a threshold level of improvement from a Y investment necessary before the company will proceed with the investment.

Reduced Spill Probability Alternatives:
- Example 10. Y investment by company to reduce the probability of a spill event through crew training.

- Example 11. Y investment to reduce the probability of a spill event through vessel equipment improvements and modifications.

Legislative Changes:
- Example 12. Y investment by company to reduce overall consequences by seeking legislative changes setting a limit on (a) liabilities for damages; and (b) liabilities for cleanup costs incurred by third parties.

Combining Alternatives:
- Example 13. In this example, planning for a spill in the Corpus Christi area is performed by combining a number of alternative Y investments. This example considers the example of a company using:
    - P&I insurance, TOVALOP and CRISTAL;
    - Acquisition of additional cleanup resources;
    - Crew training to reduce probability of a spill event.

Computations for all examples in this Chapter are found in Appendix V. The results of the examples are summarized at the conclusion of this Chapter.

Example 1:
Basic Example, No Y Investment

This example postulates the consequences of oil spills having effects in the SSMO Area 29. This area contains the port of Corpus Christi, which has a high incidence of significant volume spills. This example illustrates the NET EXP of Small Company and Large Company, assuming no Y investments, and only the existing Gulf cleanup resources available.

Initializing Variables

SPILLS(i): SPILLS(i) has been estimated for the Gulf in Chapter IX. SPILLS(1) equals 0.16 "catastrophic" spills per year; and SPILLS(2) equals 2.0 "significant" spills per year. These frequencies are applied for both Small Company and Large Company calculations, because SPILLS(i) represents a Gulfwide frequency. The variable ACTIVITY will be used to apportion to each company its share of SPILLS(i).

ACTIVITY: To determine ACTIVITY, both the number of shipments for each company, and the region's total shipments, must be obtained. For the Gulf region annual activity, an estimated 2,000 shipments will be used. This level is consistent with the ten month Gulf data for 1982. See Table 21, at page 243.

Small Company's ACTIVITY equals 25 trips/2,000 trips Gulfwide = 0.0125. Large Company's ACTIVITY equals 150 trips/2,000 trips Gulfwide = 0.075.

FACTOR: This variable, which represents reductions in spill frequency for a company resulting from Y investments in alternatives such as crew training, vessel safety equipment and other investments, is set in Example 1 at 1.0. This suggests that Small Company and Large Company have not undertaken any Y investments which reduce their frequency of spill occurrence.

V(i): The spill volumes V(1) and V(2) have been discussed in the assumptions about Small Company and Large Company. V(1) equals 200,000 tons and V(2) equals 55,000 tons, for both Small Company and Large Company.

CLEAN and F(k): The Gulf cleanup capability has been evaluated in Chapter X at 23,142 tons. This represents 9 skimmers capable of simultaneous operation, working for 6 days, 12 hours a day. The effectiveness of the offshore cleanup effort, EFF, has been estimated at 0.5 in Chapter X.

Variable F(k) represents the cost to the company of an offshore cleanup operation. To cleanup at the maximum Gulf capability, F(k) = $730,000. See Chapter X.

D(i): D(i) represents the costs incurred as a direct result of that part of the spill which has not been cleaned up at sea and which reaches shore or affects other economic resources. D(i) is composed of four elements, DAMAGES(i), ONSHORE(i), LIT(i) and CONTRACTS(i).

DAMAGES(i) is the measure of damages to the affected region's coastal tourism, commercial fishing, and other economic and natural resources. The table depicting DAMAGES(i) for each SSMO area in the Gulf is Table 38, at page 326. For a spill affecting Area 29, DAMAGES(i) = \$27,500/ton.

LIT(i), the cost of litigating claims for damages, is estimated at \$250/ton. See Chapter XI. ONSHORE(i), the cost of onshore cleanup of oil reaching the coast, has been estimated in Chapter X at \$5,000/ton. Finally, CONTRACTS(i) is not assigned a value in these examples, because the company may be in a position to minimize its actual costs for nondelivery of oil to refineries. See Chapter XI.

D(i) for a spill in the Corpus Christi area therefore equals: \$27,500 + \$250 + \$5,000 = \$32,750.

<u>IMPACT</u>: Variable IMPACT, representing the estimated fraction of oil not cleaned up by offshore cleanup operations which is expected to affect the coastline and natural resources in the spill area. IMPACT, as discussed in Chapter XI, is estimated at 0.35.

<u>IND and O(i)</u>: Variable IND represents the indirect costs to a company from diversion of management and other resources to follow up after a spill event. IND is estimated at \$250,000, reflecting one year of time for one upper manager, one scientific person, one legal counsel, one public relations/government relations person, and other personnel. See Chapter XI.

Variable O(i), the value per ton of the lost oil, is estimated at \$35/bbl., or \$245/ton.

<u>Determining EXPOSURE(i)</u>: For both Small Company and Large Company in this example, EXPOSURE(i) will be the same value. The setting of V(1) and V(2) at the same values for Small and Large Companies results in both companies facing the same EXPOSURE for "catastrophic" and

"significant" spills. In addition, neither company is undertaking Y investments, and so the difference in NET EXP will be based on the company's different levels of activity in the area. Values for EXPOSURE(i) are set forth below:

EXPOSURE(1) = $2,077,214.825.
EXPOSURE(2) = $ 379,627,325.

The importance of EXPOSURE(i) is that this variable reflects the cost which a company may face if a spill of volume V(i) occurs which affects the selected geographic region. For a catastrophic spill impacting the lower Texas coast, the potential cost exposure of the company is in excess of $2 billion. Note that this figure is well within the estimates of costs from the Amoco Cadiz spill off the coast of France. See Chapter XI, and Appendix U. If the company experiences a significant spill event, the range of costs is at the level of the hundreds of millions of dollars, with EXPOSURE(2) equalling $379.6 million.

A company cannot simply plan its strategy around this EXPOSURE(i) variable, because the frequency of a spill occurring in the region (SPILLS(i)) and the likelihood of a company experiencing the event (ACTIVITY) must also be considered. However, even where a company discounts the EXPOSURE(i) value by SPILLS(i) and ACTIVITY, the company must remain aware that if a spill should occur to that company, the cost potential is reflected by EXPOSURE(i).

Small Company NET EXP

To calculate Small Company's NET EXP in Example 1, the company's P(i) must be determined: For Small Company:

P(1) = 0.002.
P(2) = 0.025.

P(1) is far lower in value than P(2), because the expected frequency of a "catastrophic" spill has been estimated as being only 8% of the frequency of a "significant" spill. See Chapter IX. Note that P(i) for Small Company results in a substantially discounted value for Small Company's share of spill events, due to Small Company's low ACTIVITY variable.

NET EXP(Small) = $13,645,118.

The value of $13.6 million represents the potential cost consequences from spills of 200,000 and 55,000 tons that impact the lower Texas area, discounted by the annual frequencies of these spills, discounted further by Small Company's share of shipment activity in the Gulf.

<u>Large Company NET EXP</u>

Large Company's NET EXP is calculated in the same fashion as Small Company, except that different P(i) values are used to reflect Large Company's higher level of activity:

P(1) = 0.012.
P(2) = 0.150.

Large Company's NET EXP for example 1 is now determined:

NET EXP(Large) = $81,870,703.

The value of $81.9 million represents the potential cost consequences from spills of 200,000 and 55,000 tons that impact the lower Texas area, discounted by the annual frequencies of these spills, discounted further by Large Company's share of shipment activity in the Gulf.

Example 2: South Florida Coast Spill, No Y Investment

This example illustrates the manner in which a company can adjust its evaluation of NET EXP consequences based on a change in the location that is impacted by a spill. In example 2, the consequences from a spill that impacts the lower Florida coast is examined. The lower Florida coast, Area 24, is the SSMO area with the highest potential damage consequences in the Gulf. See Chapter XI, and particularly Table 38, at page 326. Where the Corpus Christi Area 28 is approximately the mean value of damages among the SSMO areas, Area 24 is almost twice the level of Area 29. As in example 1, this example illustrates the NET EXP of Small Company and Large Company, assuming no Y investments, with only the existing Gulf cleanup resources available.

Initializing Variables

The only variable from the example 1 discussion which will require adjustment is DAMAGES(i), the measure of damages to third party economic and environmental resources that are associated with a spill impacting SSMO Area 24. For a spill affecting Area 24, DAMAGES(i) = $50,000/ton. See Table 38, at page 326.

Having adjusted DAMAGES(i) for an Area 24 spill, variable D(i) is also adjusted to reflect the higher DAMAGES(i) value: $50,000 + $250 + $5,000 = $55,250/ton.

The values used to determine EXPOSURE(i) are the same as those used in example 1, with the exception of the adjusted D(i):

EXPOSURE(1) = $3,469,971,575.
EXPOSURE(2) = $ 630,509,075.

Small Company NET EXP

Small Company's NET EXP in this example is performed in the same fashion as in example 1. The P(i) values for Small Company are unchanged, because P(i) reflects a Gulfwide spill frequency as affected by Small Company's level of activity in the Gulf. The only change from example 1 is that the EXPOSURE(i) variable now reflects a spill impacting the South Florida coast.

NET EXP(Small) = $22,702,670.

Large Company NET EXP

Large Company's NET EXP in example 2 is calculated in the same fashion as Small Company. The example 2 calculation of NET EXP uses the same P(i) determined for Large Company in example, because this is a Gulfwide value, as affected by Large Company's level of Gulfwide operations. The EXPOSURE(i) variable is the calculation for a spill impacting the Southern Florida coast.

NET EXP(Large) = $136,216,020.

It can be seen that the potential consequences of a spill which impacts Area 24 are far greater than spills which impact Area 29 (example 1). The lower Florida coast damage from a catastrophic spill may reach $3.4 billion, in contrast to the lower Texas coast estimate of $2.0 billion. A significant spill affecting the lower Florida coast may produce $630 million in costs, while the estimate for a lower Texas spill is $379 million.

In a similar fashion, the NET EXP values for both Small Company and Large Company have shifted upward, because a larger EXPOSURE(i) value is being adjusted for the company level of Gulf activity.

Example 3: Multiple Ports of Operation

This example briefly describes the way in which the Chapter II methodology can be modified to reflect company activities in which more than one port of operations is used. From an examination of Table 40, at page 331, there are a number of Gulf companies which use two or more ports regularly. For example, Shell Oil uses the ports of New Orleans, Houston and Gramercy, making 78, 68, and 29 shipments respectively.

The adjustment in the Chapter II methodology is to treat the company's operations in each port as though each was the activity of a separate company; and then these two values are added together. Thus, adjusting the Chapter II equations:

$$\text{NET EXP} = \left(\sum_{b=1}^{c} \sum_{i=1}^{2} P(i) \times (\text{EXPOSURE}(b,i) - \text{INSURANCE})\right) + Y.$$

Where:

(b=1...c) is each port of operation used by a company during the year.

D(b,i) = Damages associated with port "b";

ACTIVITY(b) = level of activity at each port "b"; and

EXPOSURE(b,i) =
Exposure to costs from spills of volume "i", in port "b".

By way of illustration, if new Small* Company has 25 shipments, of which 10 are into Corpus Christi and 15 into southern Florida/Tampa Bay (Area 24 potential impact):

NET EXP(Small*) = "Corpus Christi NET EXP" + "S. Florida NET EXP" = $19,079,649.

A company will use for its D(b,i) value the per ton value determined for the SSMO area in which the company's principal port of operation is located. See Tables 38 and 41, at pages 326 and 333.

Considerations in Making Y Investments

The "base case" example 1, and the companion example 2, have been presented in some detail because the examples that follow will be contrasted against this "no alternatives selected" scenario. The value of the NET EXP determination for a company is that this result may be used for the purpose of comparing alternatives for cost-effectiveness. In making this cost-effectiveness analysis, a company will not only ask whether there is any improvement (reduction) of NET EXP from selection of an alternative, but will also ask whether the improvement is sufficient to warrant the company expenditure on Y.

This question of magnitude of improvement in NET EXP has two components. First, a company will wish to know the ratio of (change in NET EXP):(level of Y investment). A company may view Y expenditures from the perspective that the reduction in NET EXP must equal some multiple of the associated Y investment. Thus, a company may decide that it will undertake a $250,000 investment in cleanup equipment, provided there is a reduction in NET EXP of $1,250,000, five times the size of the Y investment.

The second factor which a company will consider is the size of the Y investment itself. It must be remembered that the calculation of NET EXP does not represent an actual "out of pocket" expense by a company. Rather, NET EXP is a value which is the potential cost to the company if spills of V(i) occur, discounted by the share of the spill frequencies in the area that the company should bear, based on its activity in the region. In contrast, Y represents an actual expenditure of company resources, which will reduce the estimate of NET EXP.

Thus, a company has two competing financial considerations: on the one hand, any expenditure in Y investments is money not available for other production or shareholder uses; but on the other hand, the potential financial outlay represented by EXPOSURE(i), and discounted for the purpose of planning by NET EXP, reflects potential outlays which are sufficiently large to require some preventative and mitigative planning.

The third factor in a company's consideration of a Y expenditure is the degree of "certainty" associated with the expenditure. How certain can the company be that an outlay of Y dollars will definitely result in the anticipated reduction in NET EXP? The Y investment can be "speculative" for a number of reasons, including:

- If the Y investment is made, can the company be certain that the associated strategy will actually be implemented? Example: Dollars expended on lobbying for legislative and regulatory changes; a company cannot be certain that the expenditure will result in a successful change in the law.

- Is the degree of effectiveness of the Y investment known? Example: While investments in crew or management training in spill prevention and cleanup are viewed as beneficial, it is not known how much improvement, if any, is associated with the training.

The final consideration of a company in undertaking a strategy is the public perception of the company's course of action.

Example 4: TOVALOP and CRISTAL Coverage

Example 4 uses the Corpus Christi area, and considers a company's only Y investment to be insurance through TOVALOP and CRISTAL, obtaining up to $36 million in coverage. Some of the smaller companies operating in the Gulf use only TOVALOP and CRISTAL coverage for protection from the consequences of oil spills. (1) Examples 4, 5 (P&I coverage) and 6 (third party individual company insurance policy) will be examined and subsequently discussed.

Initializing Variables

The only variables from the example 1 discussion which will require adjustment are INSURANCE, the level of coverage from insurance alternatives selected by a company, and Y, the annual cost of obtaining the insurance protection. In example 4, INSURANCE is the coverage available under TOVALOP and CRISTAL, and Y is the estimated cost to a company of these programs:

INSURANCE = $36,000,000 in coverage;
Y = $70,000/tanker of average 55,000 tonnage. (2)

The values used to determine EXPOSURE(i) are the same as those used in example 1. INSURANCE and Y do not change EXPOSURE(i), but only affect the Equation 1 determination of NET EXP. Therefore:

EXPOSURE(1) = $2,077,214,825.
EXPOSURE(2) = $ 379,627,325.

Small Company NET EXP

Small Company's NET EXP in this example is performed in the same fashion as in example 1. The P(i) values for

Small Company are unchanged, because P(i) reflects a Gulfwide spill frequency as affected by Small Company's level of activity in the Gulf. The changes from example 1 are that INSURANCE now has a value of $36,000,000 rather than $0, and Y has a value of $70,000 per vessel of 55,000 tons.

To determine the value of Small Company's total Y investment in this example, it is necessary to translate Small Company's 25 shipments into an estimated number of vessels. This is necessary because insurance alternatives are linked to vessels, not voyages. For the purposes of estimating number of vessels, an estimated 10 voyages/vessel/year will be used. (3)

Y(Small) = $175,000.

The determination of NET EXP is now made.

NET EXP(Small) = $12,848,113.

Large Company NET EXP

Large Company's NET EXP in example 4 is calculated in the same fashion as Small Company. The example 4 calculation of NET EXP uses the same P(i) determined for Large Company in example 1, because this is a Gulfwide value, as affected by Large Company's level of Gulfwide operations. In example 4, INSURANCE has a value of $36,000,000, and Y has a value of $70,000 per vessel of 55,000 tons.

As with Small Company, Large Company's total Y investment in this example requires that the 150 shipments of Large Company be translated in to a number of vessels.

Y(Large) = $1,050,000.

The determination of NET EXP is now made.

NET EXP(Large) = $77,088,677.

Example 5: P&I Insurance Coverage

Example 5 uses the Corpus Christi area, and considers a company's only Y investment to be insurance through P&I club insurance, and also through TOVALOP and CRISTAL. Both P&I insurance and the TOVALOP-CRISTAL coverage are considered in this example, because P&I club insurance typically requires that the insured also furnish TOVALOP coverage. Therefore, the alternative of P&I insurance necessarily includes the TOVALOP-CRISTAL alternative. The level of protection under P&I insurance plus TOVALOP-CRISTAL is $319.2 million: P&I coverage of $300 million, plus $19.2 million from TOVALOP and CRISTAL when these resources are used in the context of P&I club insurance. (4)

Initializing Variables

As in example 4, only variables INSURANCE and Y are adjusted from the "base case" example 1. In the present example 5, INSURANCE is the combined protection afforded by P&I insurance, TOVALOP and CRISTAL, and Y is the combined cost of obtaining coverage under these programs. The cost of P&I insurance and the cost of TOVALOP-CRISTAL have been estimated in Chapter IV as being approximately equal. Therefore:

INSURANCE = $319,200,000 in coverage;
Y = $70,000/vess.(P&I) +
$70,000/vess.(TOVALOP-CRISTAL) = $140,000/vessel.

The values used to determine EXPOSURE(i) are the same as those used in example 1:

EXPOSURE(1) = $2,077,214,825.
EXPOSURE(2) = $ 379,627,325.

Small Company NET EXP

Small Company's NET EXP in this example is performed in the same fashion as in example 1, with P(i) values for Small Company unchanged. In example 5, INSURANCE has a value of $319,200,000, and Y has a value of $140,000 per vessel of 55,000 tons. The determination of estimated number of vessels is made for Small Company in the same fashion as in example 4 (i.e., 15 shipments/10 shipments per year per vessel).

Y(Small) = $350,000.

The determination of NET EXP is now made:

NET EXP(Small) = $5,376,713.

Large Company NET EXP

Large Company's NET EXP in example 5 is calculated in the same fashion as Small Company:

Y(Large) = $2,100,000.

The determination of NET EXP is now made:

NET EXP(Large) = $32,260,277.

Example 6: Company Purchase of Individual Third Party Insurance

Example 6 uses the Corpus Christi area, and considers a company's only Y investment to be insurance purchased by the individual company through third party carriers, and also purchase of TOVALOP and CRISTAL protection. This situation occurs where a company is precluded from membership in a P&I club but still desires a level of insurance coverage beyond the $36 million afforded by TOVALOP and CRISTAL. Exclusion from P&I clubs can occur for a variety of reasons, including smallness of the company seeking membership; the poor safety record of the company; and other reasons. (5)

Individual company purchase of third party insurance carries two limitations: first, the level of coverage available under an individual company policy is significantly lower than P&I maximum coverage, typically limited to $100 million. A second drawback is that individual company insurance is more expensive than P&I group leveraged coverage. (6)

The level of protection under third party insurance plus TOVALOP-CRISTAL is $119.2 million: third party insurance coverage of $100 million, plus $19.2 million from TOVALOP and CRISTAL when these resources are used in the context of third party insurance.

Initializing Variables

As in example 4, only variables INSURANCE and Y are adjusted from the "base case" example 1. In the present example 6, INSURANCE is the combined protection afforded by third party insurance, TOVALOP and CRISTAL, and Y is the combined cost of obtaining coverage under these programs. The cost of third party insurance, at the lesser $100 million level, is estimated to be equivalent to double the cost of P&I insurance (at the higher coverage level of $300 million). See Chapter IV.

INSURANCE = $119,200,000 in coverage;
Y = $140,000/vess.(third party insurance) +
$70,000/vess.(TOVALOP-CRISTAL) = $210,000/vessel.

The values used to determine EXPOSURE(i) are the same as those used in example 1.

EXPOSURE(1) = $2,077,214,825.
EXPOSURE(2) =$ 379,627,325.

Small Company NET EXP

Small Company's NET EXP in this example is performed in the same fashion as in example 1, with P(i) values for Small Company unchanged. In example 6, INSURANCE has a value of $119,200,000, and Y has a value of $210,000 per vessel of 55,000 tons. The determination of estimated number of vessels is made for Small Company in the same fashion as in example 4.

Y(Small) = $525,000.

The determination of NET EXP is now made:

NET EXP(Small) = $10,951,713.

Large Company NET EXP

Large Company's NET EXP in example 6 is calculated in the same fashion as Small Company:

Y(Large) = $3,150,000.

The determination of NET EXP is now made:

NET EXP(Large) = $65,710,277.

Evaluating Insurance Oriented Alternatives

Cost Effectiveness of Insurance Alternatives

Reviewing Examples 4, 5 and 6, it is clear that from a cost-effectiveness viewpoint, use of P&I club insurance plus TOVALOP and CRISTAL provide the greatest reduction in NET EXP for both Small Company and Large Company. The P&I alternative reduces Small Company's NET EXP by $7.8 million, and Small Company's return on its Y investment is 23.1 (i.e., $23.1 improvement for each $1 expended on the P&I alternative). Similarly, Large Company experiences a $49.6 million reduction in its NET EXP, with a return on Y investment of 23.6.

The P&I insurance alternative is far superior to either TOVALOP-CRISTAL only, or third party insurance which the company must purchase individually. TOVALOP-CRISTAL, example 4, produces only a $.8 million improvement for Small Company, and $4.8 million improvement for Large Company, both producing a return on Y investment of only 4.6. The third party insurance option is superior to TOVALOP-CRISTAL despite its higher per/vessel cost, but still falls far short of the degree of reduction in NET EXP produced by P&I insurance.

One point which can be observed from examples 4-6 is that Small Company's and Large Company's level of investment in Y, and the reduction in NET EXP, are proportional to one another. This is due to the fact that insurance oriented alternatives are linked to the company's level of activity (i.e.- tonnage transported or vessels operated).

While P&I insurance may be optimal for both Small and Large Companies, the alternative may not be equally available. As noted earlier, many small companies cannot gain access into P&I clubs, due to size, poor performance, or other factors. Thus, in the real world, Large Company can be expected to have the opportunity to make use of the P&I insurance alternative, while Small Company may be forced to fall back on either third party insurance or the bare minimum of TOVALOP and CRISTAL.

Degree of Certainty of Insurance Alternatives

Of all the alternatives to be discussed in this Chapter, the insurance alternatives have the greatest certainty of providing the protection which has been purchased by a company's Y investment. Provided the spill event does not fall into one of the exculpatory clauses of the insurance program (ex., acts of God, war, intentional spills), a company can be certain that the policy will pay out for appropriate damages. This certainty, coupled with the extremely large reduction in NET EXP available from P&I insurance in particular, makes insurance alternatives very strong candidates from a cost-effectiveness perspective.

Public Perception of Insurance Alternatives

The public can be expected to regard insurance alternatives in a favorable light.

For those individuals who might be injured by the effects of a spill, the strongest preference is likely to be alternatives which reduce the actual risk of spills or which will ensure that a spill, if it occurs, will be minimized and controlled. These alternatives are linked to company alternatives that affect variables FACTOR and CLEAN.

The public, however, may also accept an insurance alternative in lieu of actions to minimize spills. While the risk of the spill and its consequences has not been affected by an insurance decision, the potential victim of a spill event can be assured that there is a pool of money available from which he or she can expect fairly rapid reimbursement.

This perspective of the public can be seen in the legislative context by the shift occurring in the previous and present Congress toward establishment of a public compensation fund. Such a fund, which will be explored more fully in Chapter XIII, basically operates as a publicly-controlled insurance program, reimbursing victims of spills under specified conditions. (7) That such legislation appears to be acceptable suggests that the representatives of the public recognize that elimination of the risk of spills is presently impossible; yet also recognize the need to protect members of the public from bearing the risk of damage without the protection of compensation.

Example 7: Additional Cleanup Capability - Single Company Purchase

Example 7 uses the Corpus Christi area, and considers a company's only Y investment to be acquisition of cleanup equipment to enhance offshore cleanup capability. As discussed in Chapter X, in the Gulf of Mexico the lack of boom necessary to support skimmers would cause 9 skimmers to remain idle if a major cleanup operation was required. Therefore, enhancement of cleanup capability can be achieved by acquisition of additional boom (rather than necessitating purchase of an additional skimmer and boom).

Example 7 represents a single company undertaking the purchase of boom. Example 8 reflects the same boom acquisition, but performed through a cleanup cooperative in which costs can be shared among members.

Initializing Variables

The principal variables from the example 1 discussion which will require adjustment are CAP, the optimistic cleanup capability (both private and public) for offshore cleanup in the Gulf; and CLEAN, the variable representing the effective cleanup capability in in the Gulf. An increase in CAP will act to increase CLEAN; because more oil can be removed offshore, the EXPOSURE(i) equation will also be modified, to reflect the lower overall exposure in the Gulf due to enhanced cleanup capability.

Finally, Y will reflect the additional cost of acquiring boom, and F(k), the cost of the Gulf offshore cleanup operation, will also be increased to include the operating cost of a tenth skimmer.

CLEAN = 25,715 tons of oil removed;
F(k) = $811,000 for offshore operations;
Y = $260,000 for 2,000 ft. boom.

The determination of EXPOSURE(i) now includes the enhanced CLEAN and the higher cost of F(k):

EXPOSURE(1) = $2,047,802,813.
EXPOSURE(2) = $ 350,215,313.

<u>Small Company NET EXP</u>

Small Company's NET EXP in this example is performed in the same fashion as in example 1. The P(i) values for Small Company are unchanged, because P(i) reflects a Gulfwide spill frequency as affected by Small Company's level of activity in the Gulf. The change from example 1 are that EXPOSURE(i) has been recalculated, and the value of Y is $260,000.

NET EXP(Small) = $13,110,989.

<u>Large Company NET EXP</u>

Large Company's NET EXP in this example is calculated in the same fashion as Small Company. The P(i) values for Small Company are unchanged, because P(i) reflects a Gulfwide spill frequency as affected by Small Company's level of activity in the Gulf.

NET EXP(Large) = $77,365,931.

Example 8: Additional Cleanup Capability - Cooperative Purchase

Example 8 uses the Corpus Christi area, and considers a company's only Y investment to be acquisition of additional boom equipment (the same addition to cleanup capability as described in example 8). Example 8 differs from example 7 in that the present example reflects acquisition of the same cleanup capability by a cooperative cleanup entity to which the company belongs.

Initializing Variables

Variables CAP, CLEAN, EXPOSURE(1), EXPOSURE(2), and F(k) are all set in this example as in example 7.

CLEAN = 25,715 tons of oil removed;
F(k) = $811,000 for offshore operations;
EXPOSURE(1) = $2,047,802,813.
EXPOSURE(2) = $ 350,215,313.

Small Company NET EXP

The main difference between example 7 and example 8 is in variable Y. While a company experiencing a spill will shoulder the burden of cleanup operations itself (i.e., variable F(k)), the cost of acquiring additional equipment in example 8 is shared among members of a cooperative group.

For the purposes of illustration, Small Company and Large Company belong to a cooperative in which Small Company represents 5% of the tonnage shipped among the cooperative members, and Large Company represents 30% of the tonnage shipped by the members. The members of the cooperative are assumed to apportion costs of expenditures on the basis of tonnage shipped, a common practice of a variety of private industry groups. (8)

Small Company's Y expenditures are therefore 5% of the $260,000 cost of additional boom:

Y(Small) = $13,000.

Small Company's NET EXP in this example is performed in the same fashion as in example 7. The P(i) values for Small Company are unchanged, because P(i) reflects a Gulfwide spill frequency as affected by Small Company's level of activity in the Gulf. The change from example 7 is that Y is now $13,000 rather than $260,000.:

NET EXP(Small) = $12,863,989.

Large Company NET EXP

In this cooperative purchase example, Large Company, representing 30% of tonnage among cooperative members, bears 30% of the cost of additional boom.

Y(Large) = $78,000.

Large Company's NET EXP in this example is performed in the same fashion as in example 7. The P(i) values for Large Company are unchanged, because P(i) reflects a Gulfwide spill frequency as affected by Small Company's level of activity in the Gulf. The change from example 7 is that Y is now $78,000 rather than $260,000.:

NET EXP(Large) = $77,183,931.

Evaluating Cleanup Capability Alernatives

Cost Effectiveness of Cleanup Capability Alternatives

The example of an individual company purchasing additional cleanup capability (example 7) again raises differences between small and large company considerations. Note that Small Company derives only

$.5 million in reduced NET EXP from the acquisition of boom, generating a return on Small Company's Y investment of 2.1. In contrast, for Large Company the saving in NET EXP produced is $4.5 million, which represents a return on Large Company's Y investment of 17.3.

This difference in cost-effectiveness for the two companies is explained by the fact that acquisition of additional cleanup resource is the same absolute cost for each company; however, because Small Company's NET EXP for a spill event is so much smaller than Large Company's due to Small Company's low level of activity in the Gulf, the level of benefit felt by Small Company is minor.

This difference may be compared against the insurance alternatives discussed earlier. As noted in the evaluation discussion, the level of insurance Y expenditures are proportional to the level of activity of the company in the region. In contrast, the acquisition of a piece of cleanup equipment by one company causes Small Company to bear a large Y cost relative to its benefit received.

In example 8, however, the proportionality of Y outlay to level of benefit derived is restored. Through the cooperative mechanism, the cost of additional equipment is shared, typically in proportion to the company's share of activity among the cooperative members. In example 8, Small Company's relatively small contribution causes the cost effectiveness of its Y investment to sharply increase. Large Company's return on its Y investment also increases to approximately the same level of return, 60.1.

This analysis suggests that small and large companies can be expected to pursue different strategies if the alternative under consideration is cleanup equipment. Despite the cost of purchasing equipment itself, a large company will derive a sufficiently large benefit in reduction of NET EXP (approximately 17.3) to justify the large company undertaking such a purchase even in the absence of a cooperative sharing arrangement. In contrast, a small company, because it derives a smaller NET EXP benefit, will be expected not to make an individual purchase of equipment, and will instead be more likely to purchase equipment only through a cooperative group.

Degree of Certainty of Cleanup Capability Alternatives

As noted in Chapter X, many assumptions were required to generate the CAP values for use in the Chapter II methodology. Variable conditions such as weather, visibility, winds, crew experience, proximity of equipment, all make a precise estimation of the benefit of an additional piece of equipment somewhat uncertain.

However, among the various alternatives available to a company, the improvement in cleanup capability ranks second only to insurance in terms of certainty. While an insurance program assures that funds will be generated, the precise cleanup capability of a region must be estimated. This estimate, however, is still far more certain than the alternatives to be discussed shortly such as crew training, management training in spill cleanup operations, and vessel improvements, which are alternatives for which not even a sense of utility presently exists.

Public Perception of Cleanup Capability Alternatives

The public can be expected to be very favorably disposed to enhancements of regional cleanup capability. Cleanup capability means that damage may be averted by successful cleanup operations, therefore avoiding any question of disruption of individual lives and businesses. The acquisition of cleanup equipment must therefore be weighed by a company: on the one hand, the value of additional equipment is less certain than the acquisition of insurance; but on the other hand, the public will be likely to view cleanup acquisitions more positively than insurance, therefore making some acquisition of cleanup equipment a wise election in terms of company relations with the public at large.

Example 9: Improving Cleanup Effectiveness of Company

Example 9 uses the Corpus Christi area, and considers a company's only Y investment to be company training, testing, simulations, and other actions to improve the company's effectiveness in cleanup operations. Such activities include "surprise tests" as conducted by Sun Oil, computer simulations as developed by Exxon, management training programs, and purchase of strategic equipment (such as on-site communications gear) to enhance the ability of personnel to interact efficiently. (9). See Chapter X.

What makes this alternative somewhat different from prior alternatives considered is that improvements in EFF are not presently quantifiable in terms of magnitude of effect. Therefore, a company undertaking any of these example 9 alternatives cannot know what the level of improvement in EFF, and therefore of NET EXP, will be. Example 9 will therefore consist of two parts: Alternative A, which hypothesizes a 10% improvement in EFF; and Alternative B, which hypothesizes a 5% improvement in EFF.

Example 9 reflects a cleanup effectiveness strategy that includes three elements: conducting a "surprise test"; use of management training; and purchase of on-site communications equipment. The estimated Y cost for these three actions is $210,000.

Initializing Variables

The principal variables from the example 1 discussion which will require adjustment are EFF, the variable representing the effectiveness of cleanup activities in the Gulf; and CLEAN, the variable representing the cleanup capability in the Gulf as adjusted by EFF. An increase in EFF will act to increase CLEAN; because more oil can be removed offshore through enhanced effectiveness and efficiency, the EXPOSURE(i) equation will also be modified, to reflect the lower overall exposure in the Gulf due to enhanced cleanup capability. Y will reflect the additional cost of the effectiveness improvement undertaken.

Because the level of improvement from effectiveness training and testing cannot be quantified, two hypothetical values of improvement in EFF will be examined: Alternative A: 10% level of improvement in EFF; and Alternative B: 5% level of improvement in EFF.

Alternative A: 10% improvement in EFF:

- EFF(10%) = 0.55.
- CLEAN(10%) = 25,458 tons.
- EXPOSURE(1) = $2,050,677,675.
- EXPOSURE(2) = $ 353,080,175.

Alternative B: 5% improvement in EFF:

- EFF(5%) = 0.525.
- CLEAN(5%) = 24,300 tons.
- EXPOSURE(1) = $2,063,941,250.
- EXPOSURE(2) = $ 366,353,750.

Small Company NET EXP

Small Company's NET EXP in this example is performed in the same fashion as in example 1. The P(i) values for Small Company are unchanged, because P(i) reflects a Gulfwide spill frequency as affected by Small Company's level of activity in the Gulf. The changes from example 1 are that EXPOSURE(i) has been for Alt. A and Alt. B, and that Y is $210,000.

Alternative A (10% improvement in EFF)
NET EXP(Small) = $13,138,359.

Alternative B (5% improvement in EFF)
NET EXP(Small) = $13,496,727.

Large Company NET EXP

Large Company's NET EXP in this example is calculated in the same fashion as Small Company. The P(i) values for Small Company are unchanged, because P(i) reflects a Gulfwide spill frequency as affected by Small Company's level of activity in the Gulf.

Alternative A (10% improvement in EFF)
NET EXP(Large) = $77,780,158.

Alternative B (5% improvement in EFF)
NET EXP(Large) = $79,930,358.

Example 9A
Changing the Application of Chapter II Methodology To Evaluate Company Alternatives

Example 9A continues the example of a company alternative to enhance cleanup effectiveness, using the Corpus Christi area and a company Y investment of company surprise test, management training, and purchase of on-site communications equipment.

As noted in example 9, certain alternatives presently cannot be quantified by a company for the purpose of evaluation. Example 9A explores a different use of the Chapter II methodology which represents a more realistic and useful planning device for company alternatives which resist firm quantification. In example 9A, rather than the company hypothesizing a level of improvement, the Chapter II methodology will be applied from "back to front", with the company undertaking the following steps:

- Identify the Y cost of the alternative;

- Make a company decision about the ratio of Y cost to level of reduction in NET EXP the company will require before being willing to undertake the investment;

- Algebraically determine the new NET EXP which would be required, and solve the NET EXP equation for the new value of CLEAN which would be required to produce the new NET EXP;

- Algebraically determine the new EFF that would be required to produce the new CLEAN value determined; and

- Algebraically determine the percentage improvement in EFF required to reach the new EFF value. This percentage improvement is now the value which a vendor of the alternative (training, simulations, etc.) will have to demonstrate can be achieved by undertaking the alternative. If this level of improvement cannot be warranted or assured, the company can decide that from a cost-effectiveness standpoint, the investment should not be made.

In this example 9A, only the Small Company scenario will be used to illustrate how this variation of the Chapter II methodology can be applied.

Initializing Variables

Reflecting the different approach of example 9A, a company first identifies its Y investment, and than makes a determination of the reduction in NET EXP desired:

- Y = $210,000.
- Ratio of (reduction in NET EXP):(Y investment) desired by Small Company: 5:1.
- Amount of reduction in NET EXP(Small) required: $1,050,000.
- New NET EXP(Small) must therefore be: $12,595,118.

Determining Improvement in EFF Necessary for Company to Undertake Investment

Having determined that new NET EXP(Small) must be no greater than $12,595,118 for Small Company to undertake the investment in Y, solving for CLEAN by use of the NET EXP and EXPOSURE(i) equations produces:

New CLEAN(Small) = 26,534.5 tons.

The new cleanup capability of the Gulf must be 26,535 tons to produce the new NET EXP. Solving for EFF using the CLEAN equation produces:

New EFF(Small) = 0.588.

The new effectiveness level which would be necessary to generate a CLEAN of 26,535 tons is 0.588. Therefore, the degree of improvement in cleanup effectiveness required to move from a 0.50 EFF level to a 0.588 EFF level is:

Degree of improvement required in EFF = 17.62%

Thus, the degree of improvement which must be demonstrated by a vendor of cleanup oriented training to induce a company to undertake a Y investment of $210,000 where the company seeks a 5:1 return in reduced NET EXP is 17.62%. That is, the training must be demonstrated to produce a 17.62% improvement in cleanup efficiency and effectiveness.

The approach of example 9A to strategic alternatives that are difficult to quantify has a number of benefits to a company. First, the company is making its key planning assumption based on information within the knowledge of the company: the management assumption in example 9A is the return on Y investment desired by the company. Note that in contrast, the key assumption of example 9 is a guess as to the level of effectiveness of the Y investment.

A second and related benefit is that the company has under an example 9A approach, a standard against which it can evaluate vendor offers of training programs, simulations, and other "cleanup effectiveness" programs. The company now knows the level of performance improvement it desires, and can explicitly discuss with a vendor whether such an anticipated improvement can even be anticipated.

Example 10: Crew Training to Reduce the Probability of a Spill

Example 10 moves to a company alternative seeking to reduce a company's likelihood of experiencing a spill event. The exposure of a company to a spill is represented by P(i), which consists of the Gulf or regional spill frequency (SPILLS(i)), the level of activity of a company as a fraction of the region's activity (ACTIVITY), and the variable FACTOR. FACTOR is an unquantified value reflecting that some company decisions will increase the company's weighted likelihood of experiencing a spill, while other decisions can act to reduce this expectation.

Example 10 examines the Corpus Christi area, and considers a company's only Y investment to be training of vessel crews in safety and oil spill prevention and cleanup activities. This type of training has been discussed in Chapter IX.

Crew training, like examples 9 and 9A dealing with improvements in cleanup effectiveness, is presently not capable of precise quantification. Therefore, in examining the crew training alternative, the variation in

Chapter II methodology described in example 9A will be used. Therefore, the question to be answered concerning crew training is: given the investment Y required, then if management wants a level of reduction in NET EXP, what improvement must a crew training program be able to demonstrate in order for a company to undertake the investment? As with example 9A, only the Small Company scenario will be examined:

Initializing Variables

Reflecting the example 9A approach, a company first identifies its Y investment, and than makes a determination of the reduction in NET EXP desired:

- Y = ($750/person/course) x (2 crews/vessel) x (5 members from each crew attending) x (2.5 vessels operated by Small Company) x (2 courses taken per year) = $37,500.
- Ratio of (reduction in NET EXP):(Y investment) desired by Small Company: 5:1.
- Amount of reduction in NET EXP(Small) required: $187,000.
- New NET EXP(Small) must therefore be: $13,458,118.

Determining Improvement in EFF Necessary for Company to Undertake Investment

Having determined that new NET EXP(Small) must be no greater than $13,458,118 for Small Company to undertake the investment in Y, solving for FACTOR by use of the NET EXP and EXPOSURE(i) equations produces:

New FACTOR(Small) = 0.984.

The level of improvement in FACTOR generated by improved crew performance required to move from a 1.00 FACTOR level to a 0.984 FACTOR level is: 1.60%

Therefore, the degree of improvement which must be demonstrated by a vendor of crew training to induce a company to undertake a Y investment of $37,500 where the company seeks a 5:1 return in reduced NET EXP is 1.60%. That is, the training must be demonstrated to produce a 1.60% improvement in the company's share of exposure to a Gulf spill event.

Example 11: Vessel Improvements to Reduce the Probability of a Spill

Example 11 continues the examination of alternatives seeking to reduce a company's likelihood of experiencing a spill event through reduction of FACTOR. Example 11 examines the Corpus Christi area, and considers a company's only Y investment to be making vessel improvements which are expected to reduce the likelihood of the vessel suffering a collision or grounding, or which will reduce the likelihood of a spill even if a grounding or collision occurs.

Vessel improvements can occur at two different levels of complexity and cost. On a smaller scale, improvements may consist of installation of navigational and safety aids which increase vessel safety. Such aids include radar, LORAN systems, collision avoidance systems, shallow water speed indicators, and other equipment. (10) On a larger scale, a vessel may undergo extensive retrofitting, which focuses on structural changes to a vessel. Such changes include double hulling a vessel for added safety.

Vessel improvements, like examples 9, 9A, and 10, are not presently capable of precise quantification. Therefore, in examining vessel improvement alternatives, the variation in Chapter II methodology described in example 9A will be used. The question to be answered concerning vessel improvements is: given the investment Y required, then if management wants a particular reduction in NET EXP, what improvement must a vessel provide in order for a company to undertake the investment? As with example 9A, only the Small Company scenario will be examined.

Initializing Variables

Reflecting the example 9A approach, a company first identifies its Y investment, and than makes a determination of the reduction in NET EXP desired. Alternative A will examine the smaller scale improvement of installing vessel navigational aid equipment (such as collision avoidance) on each vessel. Alternative B will consider the larger scale improvement of a partial vessel retrofit, with an estimated cost per vessel of $1.5 million. (11)

Alternative A: Navigational Aid Installation:

- Y = ($150,000/vessel) x (2.5 vessels operated by Small Company) = $375,000.
- Ratio of (reduction in NET EXP):(Y investment) desired by Small Company: 5:1.
- Degree of reduction in NET EXP(Small) required: $1,875,000.
- New NET EXP(Small) must therefore be: $11,770,118.

Alternative B: Vessel Partial Retrofit:

- Y = ($1,500,000/vessel) x (2.5 vessels operated by Small Company) = $3,750,000.
- Ratio of (reduction in NET EXP):(Y investment) desired by Small Company: 5:1.
- Degree of reduction in NET EXP(Small) required: $13,645,118.(*)
- New NET EXP(Small) must therefore be: $0.(*)

(*) Note: Even if NET EXP is reduced to $0, it is still not possible to produce a 5:1 return on Small Company's Y investment.

Determining Improvement in FACTOR Necessary for Company to Undertake Investment

The new value for FACTOR, and the degree of improvement required in order for a company to be willing to make the Y investment, are solved in the same fashion as example 10. The results for each alternative in this example are set forth below:

Alternative A: Installation of Navigational Aid:

- New FACTOR must be: 0.835.
- The improvement in FACTOR which will be required before a company will undertake the navigational aid improvement is: 16.5% improvement.

Alternative B: Vessel Partial Retrofit:

- New FACTOR must be: 1.0. (*)
- The improvement in FACTOR which will be required before a company will undertake the vessel improvement is: 100% (*)

(*) Note: Even if NET EXP is reduced to $0, it is still not possible to produce a 5:1 return on Small Company's Y investment.

In the example above, Alternative B cannot produce a 5:1 return on Y invested in extensive vessel modifications. The cost of the vessel retrofit is so great when compared to the NET EXP of Small Company that no amount of reduction of NET EXP can reach a 5:1 ratio.

Evaluating Alternatives For Which Benefit is Uncertain

Cost Effectiveness and Degree of Certainty of Alternatives

Examples 9 and 9A (improving cleanup effectiveness, variable EFF), example 10 (reducing spill event probability through crew training, variable FACTOR), and example 11 (reducing spill probability through vessel improvements, variable FACTOR), share a common characteristic: in none of these alternatives is the degree of improvement in NET EXP known with any degree of certainty. For example, estimates for crew training vary from as high as 5-10%, to low estimates of 0% improvement.

At the present time the level of improvement cannot be predicted for any of these alternatives. Further, as discussed in Chapter IX, the problem is compounded because the many factors that contribute to the likelihood of spill occurrence (FACTOR) or that contribute to the efficiency of a cleanup operation (EFF) are not presently capable of being weighted with any real accuracy. (12)

As suggested in examples 9A, 10 and 11, a company considering this type of alternative will serve its cost-effectiveness interests best by using the Chapter II methodology to produce a threshold level of improvement in FACTOR or EFF that will be necessary before the company will undertake the investment. If a company is satisfied by the assurances of vendors that this threshold will be met, then the Y investment should be made.

A company considering alternatives which reduce probable spill occurrence (FACTOR) or which enhance cleanup efficiency (EFF) will arrive at different decisions depending upon whether the problem is examined from a cost-effectiveness or public relations perspective. As noted above, the lack of assurance of the value associated with these alternatives will probably result in a cost-effective determination not to make the Y investment. Few if any vendors of training programs and vessel equipment will guarantee that their services and products will reduce NET EFF by a specified factor. The company will therefore not have had its threshold level of performance improvement met, suggesting a "no Y investment" decision.

Public Perception of Alternatives

As noted in the evaluation of alternatives associated with cleanup equipment acquisitions, the public at large can be expected to be very favorably disposed toward company investments in measures that are directed to minimizing spill occurrence and minimizing damage. A company therefore faces the offsetting considerations that the public will respond positively to the act of investing in alternatives that will lower FACTOR or increase EFF, but the company also must consider that the true improvement in terms of reduced NET EXP is an open issue.

Strategy for Alternatives Where Benefit is Uncertain

Since a company cannot expect a particular level of improvement in its NET EXP, the only benefit associated with the investments affecting FACTOR or EFF is the positive public perception of such alternatives. Faced with the contradictory considerations of cost and public response, a company may elect the strategy of undertaking the FACTOR or EFF oriented alternatives that represent the least costly measures from among this type of investment.

Referring again to examples 9A, 10 and 11, a company can be expected to be least willing to undertake vessel retrofit measures, this alternative being the most expensive measure of the group. A company will be less opposed to purchasing vessel equipment because the per vessel cost is much lower.

The alternatives which a company will probably accept most readily are management, staff or crew training programs, or the acquisition of simulation and other training devices. For Small Company, training programs, simulations, and surprise tests of cleanup response systems have been estimated in Chapter X to be in the $70,000 range each (See also examples 9 and 9A, in which all three measures were combined); and the training of crews is estimated at $37,500. In contrast, vessel equipment expenditures for collision avoidance systems may be $100,000-200,000 per vessel, while vessel retrofitting may be any level, running in excess of $1-2 million per vessel.

The clearest solution is for a company to express its willingness to pursue alternatives that lower FACTOR or increase EFF, but for the company to stress the training oriented alternatives and to reject pressure to undertake larger Y investments.

Example 12:
Legislative Reductions in Cost Consequences

Example 12 describes two types of possible legislative developments which would, if implemented, affect a company's NET EXP:

- Damage liability limits; and
- Cleanup liability limits.

These two types of legislative changes have been considered both nationally and internationally. In the international environment, damage liability limits are reflected in the Civil Liability Convention (see Chapters V and VI). In U.S. domestic law, there exist cleanup liability limits for federal government cleanup efforts, but unlimited liability for costs incurred by states and private parties. There has also been extensive debate in Congress from 1976 through the present to establish damage liability limits for spill events. (13)

This example again considers a spill event in the Corpus Christi area. Example 12 approaches the question of company strategies to support lobbying for legislative changes using a second variant of the Chapter II methodology. Examples 9A, 10 and 11 asked the question: given a Y level expenditure, what level of improvement must be realized?. The approach to damage ceilings asks:

> Given a stated objective (i.e.- a desired liability ceiling), what expenditure will the company be willing to make in support of industry lobbying for this ceiling level?

This variant of the Chapter II methodology applies the following steps:

- The objective is identified (the desired ceiling);
- The degree of improvement in NET EXP is calculated;
- The management decision is made of the required degree of return on the company's Y investment; and
- The size of the Y expenditure that meets this management objective is determined.

Initializing Variables

Although damage limits and cleanup limits can theoretically be set at any level, there are clear ranges for ceilings which have gained support as being realistic objectives. Therefore, Alternative A considers a damage liability limit of $200 million, a level which is presently in force in legislation dealing with Trans-Alaska Pipeline activities. (14). Alternative B evaluates a cleanup liability ceiling of $30 million, which has been suggested as one possible ceiling level.

Alternative A - Limit on Liability for Damages: A $200 million liability limit has the effect of modifying the portion of the EXPOSURE(i) equation consisting of:

DAMAGES(i) x IMPACT x (V(i)-CLEAN)

If the value for this part of the EXPOSURE(i) equation is greater than $200 million, then a liability ceiling will cause the value of $200 million to be substituted in place of the DAMAGES(i)... part of the equation. This has the effect of reducing both EXPOSURE(1) and EXPOSURE(2) substantially:

EXPOSURE(1) = $574,956,575.
EXPOSURE(2) = $272,994,075.

For a small company, the effect on NET EXP and the Y investment decision is as follows:

- Reduction in NET EXP(Small) from existence of a $200 million liability limit: $5,670,353.

- If Small Company seeks a 5:1 return on its Y investment, Small Company will be willing to invest: Y(Small) = $1,134,071 in support of such legislation.

For a large company, the effect on NET EXP and the Y investment decision is as follows:

- Reduction in NET EXP(Large) from existence of a $200 million liability limit: $34,022,113.

- If Large Company seeks a 5:1 return on its Y investment, Large Company will be willing to invest: Y(Large) = $6,804,423 in support of such legislation.

Alternative B - Limit on Cleanup Liabilities: A $30 million cleanup liability limit has the effect of modifying the portion of the EXPOSURE(i) equation consisting of:

ONSHORE(i) x IMPACT x (V(i)-CLEAN) + F(k)

If the value for this part of the EXPOSURE(i) equation is greater than $30 million, then a cleanup liability ceiling will cause the value of $30 million to be substituted in place of the (ONSHORE(i)...) part of the equation. This has the effect of reducing both EXPOSURE(1) and EXPOSURE(2):

EXPOSURE(1) = $1,796,983,000.
EXPOSURE(2) = $ 353,145,820.

For a small company, the effect on NET EXP and the Y investment decision is as follows:

- Reduction in NET EXP(Small) from existence of a $30 million cleanup liability limit: $1,222,507.

- If Small Company seeks a 5:1 return on its Y investment, Small Company will be willing to invest: Y(Small) = $244,501 in support of such legislation.

For a large company, the effect on NET EXP and the Y investment decision is as follows:

- Reduction in NET EXP(Large) from existence of a $30 million cleanup liability limit: $7,335,034.

- If Large Company seeks a 5:1 return on its Y investment, Large Company will be willing to invest: Y(Large) = $1,467,007 in support of such legislation.

Evaluating Legislative Alternatives

Cost Effectiveness of Legislative Alternatives

Examples 11 and 12 reflect the two principal areas where legislative rulemaking changes have been sought by the oil industry: damages to third parties, and reimbursement for cleanup expenditures of third parties. From a purely cost-effective perspective, the benefit obtained by contributing to efforts to generate legislative liability ceilings is very high. Large Company in example 12, Alternative A would realize a reduction in its NET EXP of $34 million if a $200 million liability limit were passed into law. Small Company would experience a similar proportional improvement.

Note, however, that even a $200 million ceiling is neither as cost effective in terms of return on Y investment, nor as absolutely effective in reducing NET EXP, as an investment in P&I insurance. The reason for this is that while the present legislative regime imposes unlimited liability, there are realistic upper limits on the value of resources in a region that suffers a spill event. Thus, while the law speaks in terms of "no limit", areas in the Gulf region do in fact have upper limits for resource and commercial damage. See Chapter XI.

A corollary conclusion which can also be drawn is that a company will see a legislative alternative as being more favorable than the P&I insurance option where the liability ceiling is lowered to some value below $200 million. As will be discussed in Chapter XIII, the oil industry is actively pursuing legislative solutions with liability limits far lower than $200 million (15), suggesting that at some level the value of a liability ceiling is sufficiently great to cause additional Y(interest group lobbying) investments.

Degree of Certainty of Insurance Alternatives

Alternatives focusing on legislative change are highly uncertain. Efforts to achieve liability ceilings have been in process from as early as 1976, and are still unresolved issues today. The legislative change route is a slow process, and because much of the process consists of public congressional hearings, the oil industry has the added uncertainty of having to publicly state its desire for a limit on its own liability. A further uncertainty is that the industry's ability to persuade a Congress may change drastically with new elections or with the death of a key congressional chairman. For example, see the discussion in Chapter III concerning changes in Senate and House committees in 1965.

Public Perception of Legislative Alternatives

Of all the alternatives discussed in this Chapter, the public has historically shown the greatest disfavor and suspicion toward legislative limits on liability. The reason is apparent: the representatives of the public cannot be sure that the ceiling set is a correct and fair ceiling; and once in place, the burden then falls on the public to attempt to change the ceiling upwards. The Congress has demonstrated this reluctance in statements made to industry representatives in legislative hearings on oil spill liability. (16) This reluctance has also recently been seen in another context, where Congress flatly rejected liability ceilings for compensation to victims of air disasters. (17)

Strategy for Legislative Alternatives

Once companies individually and through the industry, collectively, have determined legislative changes dealing with spill liability that are sufficiently valuable to pursue, the essential strategy is that of tradeoff and compromise. Knowing that the public may view efforts to limit liability with hostility, companies in the industry should consider other, offsetting changes in their own handling of spills which the public will view favorably. As discussed, the public views measures to reduce spill occurrence and severity most favorably, and is also favorably disposed toward insurance oriented solutions. Therefore, companies seeking change should modify their legislative efforts away from seeking the sole benefit of liability limits, and should move toward a broader set of solutions that include components favorable to the public.

The beginning of such a shift in American Petroleum Institute and large company member testimony can be seen in the most recent Congressional hearings on oil pollution liability. See Chapter XIII.

Example 13:
Combining Alternatives

The many alternatives examined in this Chapter can be used in combination by a company seeking a strategy to deal with the consequences of an oil spill. It is also possible for a company to approach its strategy using the Chapter II methodology and one or more variations of the methodology (ex, example 9A, example 12). Example 13 briefly indicates how a company strategy using three different alternatives together can be analyzed. The example focuses on the Corpus Christi area, and is a strategy approach for Large Company.

Large Company elects the following three alternatives:

- P&I Coverage (plus TOVALOP-CRISTAL);

- Large Company purchase of 2,000 ft. boom;

- Large Company then wishes to know what level of improvement in vessel safety would be required to justify spending $225,000 on crew training, where Large Company wishes a 5:1 reduction of NET EXP for its Y(crew training) investment.

Analysis

For the insurance alternative and the cleanup alternative, the process for determining the effect on NET EXP follows example 5 for P&I insurance, and example 7 for improvement of cleanup capability. The following variables are affected:

- INSURANCE = $319,200,000.
- CLEAN = 25,715 tons.
- Y(insurance) = $140,000 x 15 vessels = $2,100,000.
- Y(cleanup) = $260,000 for boom.

The effect of the insurance and cleanup capability alternatives on EXPOSURE(i):

- EXPOSURE(1) = $2,047,802,813.
- EXPOSURE(2) = $ 350,215,313.

The effect on Large Company's NET EXP is set forth below:

NET EXP(Large Company) = $27,755,529.

Large Company now wishes to evaluate a further expenditure of Y on crew training. The approach is analogous to example 10:

Y(crew training) = $225,000.
Management decision: 5:1 ratio of reduction in NET EXP):(Y).
The new value for variable FACTOR required to generate this level of improvement is 0.951. The degree of improvement required from old FACTOR to new FACTOR = 4.9% Therefore, the company, having undertaken Y(insurance) and Y(cleanup capability) expenditures, will require that a further Y expenditure on crew training will require a reduction in company exposure to spill events of 4.9%.

Conclusion

To permit direct comparison of the cost-effectiveness of the various examples presented in this Chapter, see Table 42, at page 385. A summary table, Table 43, at page 387, has also been presented which qualitatively compares the key considerations facing a company in making its overall assessment of whether a strategy is acceptable:

- What is the magnitude of the improvement in NET EXP?

- What is the size of the Y outlay required?

- Is the investment certain to produce the hoped for improvement in NET EXP?

- What is the public perception of the strategy?

TABLE 42

SYNOPSIS OF EXAMPLES OF PLANNING ALTERNATIVES

Example	Small Company				Large Company			
	(1) Y (000's)	(2) NET EXP using Y (000's)	(3) Improvement from NET EXP (000's)	(4) Ratio (3)/(1)	(1) Y (000's)	(2) NET EXP using Y	(3) Improvement in NET EXP (000's)	(4) Ratio (3)/(1)
1. no Y	0	13,645	n/a	n/a	0	81,871	n/a	n/a
(2 and 3 omitted)								
4. TOVALOP /CRISTAL	175	12,848	797	4.5	1,050	77,089	4,782	4.6
5. P&I	350	5,377	8,268	23.6	2,100	32,260	49,611	23.6
6. Third Party Ins.	525	10,952	2,693	5.1	3,150	65,710	16,161	5.1
7. Cleanup equip., individual company	260	13,111	534	2.1	260	77,366	4,505	17.3
8. Cleanup equip., cooperative	13	12,864	781	60.1	78	77,184	4,687	60.1
9. Alt. A- EFF program, 10% effect	210	13,138	507	2.4	210	77,780	4,091	19.5
9. Alt. B- EFF program, 5% effect	210	13,497	148	0.7	210	79,930	1,941	9.2
9A. EFF program, if 17.6% effect	210	12,595	1,050	5.0	(not calculated)			
10. Crew training, if 1.6% effect	37.5	13,458	187	5.0	(not calculated)			

TABLE 42, Continued

Example	Small Company				Large Company			
	(1) Y (000's)	(2) NET EXP using Y (000's)	(3) Improve-ment from NET EXP (000's)	(4) Ratio (3)/(1)	(1) Y (000's)	(2) NET EXP using Y	(3) Improve-ment in NET EXP (000's)	(4) Ratio (3)/(1)
11. Alt A- Nav. aids, if 16.5% effect	375	11,770	1,875	5.0	(not calculated)			
11. Alt B- Vessel retro-fit, if 100% effect	Cannot achieve 5:1 ratio of (reduction in NET EXP): (Y investment)				(not calculated)			
12. Alt. A- Damages ceiling of $200M	1,134	7,975	5,690	5.0	6,804	47,849	34,022	5.0
12. Alt. B- Cleanup ceiling of $30 M	245	12,423	1,223	5.0	1,467	74,536	7,335	5.0
13. Combining Alternatives (if crew training has 4.9% effect)	(not calculated)				2,585	26,631	55,240	21.4

TABLE 43

QUALITATIVE COMPARISON OF COMPANY ALTERNATIVES

Alternative	Magnitude of Improvement in NET EXP	Level of Y Outlay	How Certain is the Improvement	What is the Public Perception
Insurance Alternatives	HIGHEST	MODERATE	CERTAIN	FAVORABLE
Legislative Changes (Liability Ceilings)	HIGH(*)	MODERATE/ HIGH	UNCERTAIN	UNFAVORABLE
Cleanup Equip.	MODERATE/ LOW	LOW(**)	FAIRLY CERTAIN	HIGHLY FAVORABLE
Reducing Spill Freq. and Severity				
- Training	UNKNOWN	LOW	UNCERTAIN	HIGHLY FAVORABLE
- Nav. Aids	UNKNOWN	MODERATE	UNCERTAIN	HIGHLY FAVORABLE
- Retrofit	UNKNOWN	VERY HIGH	UNCERTAIN	HIGHLY FAVORABLE

(*) Legislative changes may be "HIGHEST" magnitude of benefit if limit sought is sufficiently low (i.e.- below $200 million).

(**) The "LOW" Y outlay designation includes a small company election to purchase equipment only through a cooperative arrangement.

From both Tables 42 and 43, it is clear that an insurance oriented alternative (either alone or in conjunction with other alternatives) is by far the alternative of first importance to a company. The magnitude of improvement in NET EXP is high (and extremely high in the case of P&I insurance); the Y outlay is moderate; but justifying the Y investment is the fact that the alternative is certain to produce the desired benefit if a spill occurs; and finally, the public looks favorably on the alternative.

After insurance, the desirability of alternatives is unclear, because a cost-effectiveness perspective will conflict with a public-oriented perspective in terms of which alternatives to pursue. From a cost-effective viewpoint, pursuit of a legislative solution is the next best alternative to insurance, because despite the high level of uncertainty, the potential benefit to NET EXP is very high. Improving cleanup resources is also a strong consideration, because although the magnitude of improvement is only moderate, the Y investment (particularly if a cooperative is used) is low, and the alternative is fairly certain to produce its intended result. A distant last are the alternatives to improve FACTOR and EFF, because of the lack of knowledge about the level of benefit, and the high Y costs associated with these solutions (particularly for vessel retrofits).

From a publicly oriented perspective, a reversal in alternative preference results. Acquisition of cleanup equipment is the second choice after insurance, because of the strongly positive public reaction and also because of the high certainty of a reduction in NET EXP. The third level of selection is to undertake the lowest Y cost FACTOR or EFF oriented alternatives available (such as training programs), because the Y investment serves a positive public image value and may have some beneficial effect on NET EXP. The two alternatives of legislative changes and high-cost FACTOR and EFF measures are least desirable: the legislative changes, because of public hostility toward the industry and member companies; and the high-cost FACTOR and EFF solutions, because of the large Y outlay required.

Chapter XIII, concluding this work, briefly explores trends of the industry in seeking to plan for the consequences of oil spill events, and suggests that the industry perspective may be starting to reflect certain of the strategy considerations presented in this Chapter.

NOTES

1. Inverview with Robert Hooker, Manager, Marine Transportation, Champlin Oil Company.

2. Oil Companies International Marine Forum and Oil Companies Institute for Marine Pollution Compensation, Ltd., Oil Spill Pollution Liability and Compensation: A Position Statement Concerning Revisions to the Civil Liabilities Convention, 1969, and the Fund Convention, 1976 (OCIMF, 1982). TOVALOP, CRISTAL, P&I insurance, and third party insurance all operate on a sliding scale of premiums based on tonnage of tankers and tonnage shipped. To facilitate presentation of this example, the use of 70,000 per tanker of average 55,000 tons permits a basic averaging of the lower per ton premiums of large tankers and the higher per ton premiums of smaller tankers in Small Company's and Large Company's fleets.

3. Interview with G. Sullivan, Esq. Mr. Sullivan, in addition to presently being a maritime attorney, was formerly a licensed mate in the U.S. merchant marine, where he has sailed aboard oil tankers of various sizes.

4. See Chapter IV.

5. Interview with William Koerth, Vice President of Finance and Head of Insurance Department, Coastal Corp.

6. Ibid.

7. Funds have been heavily debated during the 97th Congress (1981-1982) in bills H.R. 85 and S. 681; and proposals for a fund of approximately $100 million, in conjunction with an additional level of direct liability against the spiller, are presently undergoing debate in the present 98th Congress in bills H.R. 2115, H.R. 2222 and H.R. 2368.

8. Interview with M. Burdbacher, Clean Gulf Associates Representative, Shell Oil Co.

9. See Chapter X. See also C. H. Peabody and R. H. Goodman, "Innovative Training: Computer Assisted Learning", in Proceedings, American Petroleum Institute Oil Spill Conference, 1983 (Washington: API, 1983), 244; Leon Kazmierczak, "Major Spill Response Planning for Tanker Operations", in Proceedings, American Petroleum Institute Oil Spill Conference, 1979 (Washington: API, 1979); and Leon Kazmierczak, et. al., "Results of a Surprise Test of Sun's Major Spill Response Plan", in

Proceedings, American Petroleum Institute Oil Spill Conference, 1981 (Washington: API, 1981).

10. Interview with G. Sullivan, Esq.

11. Ibid. A navigation aid such as a collision avoidance system is estimated at between $100,000-200,000.

12. See Chapter XI, and specifically the ORCA study discussed. See Norman Meade, et. al., "An Analysis of Tanker Casualties for the Ten Year Period 1969-1978", presented at the 1981 Oil Spill Conference, March 2-5, 1981, Atlanta, Georgia.

13. In the 97th Congress: H.R. 85 and S. 681. In the present 98th Congress: H.R. 2115, H.R. 2222, and H.R. 2368.

14. Trans-Alaska Pipeline Authorization Act of 1973, 43 U.S.C. Sec. 1651-1655.

15. Among the 98th Congress proposals H.R. 2115, H.R. 2222 and H.R. 2368, liability limits of as low as $30-50 million are being considered, in conjunction with a public fund which would compensate up to $100 million for damages from a single spill event.

16. See generally, U.S. Congress, House Committee on Merchant Marine and Fisheries, Subcommittee on Coast Guard and Navigation, Hearings of March 11, 1981 on Oil Pollution Liability - H.R. 85, 97th Cong., 1st Sess. (1981); and U.S. Congress, Senate Committee on Environment and Public Works, Subcommittee on Environmental Pollution and Resource Protection, Hearings of March 25, 1981 on S. 681 - Oil Spill Liability and Compensation Act of 1981, unpublished stenographic transcript, 97th Cong., 1st Sess. (1981).

17. Congress in April, 1983, rejected adoption of the "Montreal Protocols", which would have amended the Warsaw Convention and the Hague Convention to create a maximum exposure of $350 million per person, composed of direct liabilities and required insurance coverage by carriers.

CHAPTER XIII

TRENDS AND RECOMMENDATIONS

Introduction

In selecting strategies for the management of catastrophic oil spills, a final question remains. What trends are evolving in the external environment that may change the number or scope of alternatives for dealing with oil spill consequences? This dissertation concludes by briefly discussing trends in the areas of insurance, cleanup capability, alternatives to reduce spill frequency or severity, and prospective legislative changes. It is important for individual companies to note these potential changes and to adjust their strategies. For a company to evaluate trends affecting the company's range of alternatives, the company will consider the following factors:

- How valuable to the company is the change represented by the trend?
- What is the ability of the company itself to influence or to bring about the change?

A company's examination of trends is in some ways analogous to its review of existing alternatives as discussed in Chapter XII. A company has ability to spend funds on long term or speculative solutions that are represented by trends that will change alternatives. A company can also attempt to participate directly in the effort to bring about a change by furnishing personnel, expert assistance and equipment. This Chapter will first review potential changes that will affect available alternatives, and will then briefly discuss which of these trends a large company (i.e.- one that represents a significant share of the industry) and a small company ought to pursue.

Current Trends

Insurance and Compensation Funds

International Conventions and International Industry Programs: In 1984 a diplomatic conference will be held by IMO to discuss adoption of new provisions to the Civil Liabilities Convention (CLC) and Fund Convention (FC). (1) The major provisions to be discussed are:

- Increasing liability limits (CLC);
- Increasing compensation fund coverage (FC);
- Broadening the scope of coverage;
- Providing a mechanism for equitable readjustment as necessary.

Of primary importance to companies is the possible increase in fund limitations, liability limits and scope of coverage. The Oil Companies International Marine Forum (OCIMF) and the Oil Companies Institute for Marine Pollution Compensation Limited (the Institute, which administers CRISTAL) both strongly support revisions in the present international liability limits. (2) These groups propose establishing the CLC liability limit at $50 million and setting the FC fund limit at $75 million. (3) This would provide a new combined coverage of $125 million, with compensation of $50 million directly from the spiller and $75 million being provided by the fund. OCIMF and the Institute have also proposed that both TOVALOP and CRISTAL limits be revised upward to parallel the changes being sought in CLC and FC, suggesting that total TOVALOP and CRISTAL coverage also equal $125 million. Since the oil company members and their affiliates in OCIMF and the Institute own 43% of the world's commercial tankers, it is likely that these proposed revisions to limitation will occur in the future. (4)

Small companies in particular would greatly benefit by this increase in coverage under TOVALOP and CRISTAL, and also from revision of CLC and FC in the event the United States ratifies these conventions. In effect, the changes to TOVALOP, CRISTAL, CLC and FC provide an increase in insurance available at premium rates that are spread over the entire industry. Further, once the funds are built up to the required new maintenance levels, payments into the funds would be required only when large spills occurred that would deplete the fund (i.e., a "call" arrangement). Therefore, the return on Y investment in this insurance coverage alternative would be quite high.

P&I Club Insurance: A second trend in the insurance area that may occur in the private sector is the possibility that P&I club insurance coverage may increase in the near future. Reviewing the history of P&I insurance coverage of oil spill damages, in 1969 P&I coverage for oil pollution damages was limited to $10 million. By 1981, only twelve years later, P&I coverage for oil spill damage has risen to $300 million. The progression of growth in coverage is noted below:

Year	Level of Coverage ($ million)	
1969	10.0	
1971	14.4	
1973	15.0	
1975	25.0	
1977	30.0	
1979	100.0	
1981, and presently	300.0	(5)

The rapid increases between 1977 and 1979, and from 1979 to 1981, indicates that there is growing certainty within the insurance market about assessing the risk of spill occurrence and the probability of payout. As the insurance market becomes more certain of its situation and as coverage is expanded through other funds (such as FC, and proposed U.S. domestic funds), P&I insurance will be required only to cover the largest spills. Therefore, because the incidence of payout of P&I can be expected to drop, P&I vendors can be expected to show greater willingness to expand this upper limit coverage during the later 1980's.

For those companies that can qualify for P&I coverage, any increase in P&I maximum levels will greatly improve their net exposure because insurance alternatives represent the Y investment with the greatest effect on NET EXP. See Chapter XII.

Domestic Compensation Funds: In the present 98th Congress, three bills have been proposed which include compensation funds for damages from oil spills: H.R. 2115, H.R. 2222 and H.R. 2368. In H.R. 2222 and H.R. 2115, after a spiller's liability limit has been reached (the level of liability limit under this legislation to be discussed shortly), the compensation fund is responsible for payment of outstanding claims without any maximum or ceiling. (6) Under H.R. 2368 a compensation fund will be liable up to a maximum of $100 million for each spill incident. (7)

All three bills require a fee to be paid of $0.013/bbl. on crude oil received at a U.S. refinery and on petroleum products entering the U.S. for "consumption, use or warehousing." (8) Such a fund in essence provides all companies with a publicly administered form of insurance coverage.

The American Petroleum Institute, during hearings on these bills, has indicated that while the industry agrees with the concept of a compensation fund, the industry strongly desires an upper limit on fund compensation such as the limit included in H.R. 2368. (9)

A compensation fund is particularly favored by the public. This desire for an adequate and available compensation for damages from oil pollution was expressed at hearings held during the 97th Congress in 1981 on bills H.R. 85 and S. 681. (10) At the time of the hearings on H.R. 85 and S. 681, the level of the cleanup fund created under the Clean Water Act (note: only compensating for cleanup costs incurred by the government) was only $5 million, with an additional $5 million owed by the U.S. Environmental Protection Agency. (11) Further, witness testimony also noted that in 1976 the fund had actually been bankrupt and U.S. Coast Guard appropriations had to be used to cover cleanup costs. (12)

It is generally acknowledged by both the public and by industry that the current cleanup fund situation is inadequate to meet the needs of major spills. By supporting the revisions included in pending bills, individual companies can obtain increased "insurance" protection for damage claims at a reasonable "cost" (the $0.013/bbl. tax). For the public, a fund such as has been proposed under pending legislation also guarantees a stated level of protection for both cleanup and for damages suffered, regardless of the spiller's ability or willingness to pay such claims.

Cleanup Capability

Individual companies appear to be showing an increasing interest in expanding cleanup capability. The International Oil Spill Organization, a group of 14 multinational oil companies proposed increasing capability worldwide through prepositioning of three major stockpiles (one in the Gulf of Mexico) of cleanup equipment. (13) Although agreement ultimately was not reached, one of the companies is considering the possibility of continuing to work toward this goal. As seen in the previous Chapter, large companies can benefit from individual purchases of equipment. For a small company such a purchase may not provide a large enough benefit for the investment.

Research and development is continuing by the industry particularly in the area of developing more effective and less toxic dispersants. Exxon Corporation and Shell Oil are leaders in this field. While dispersants are rarely approved by the EPA for use on spills in the U.S., and never in large quantities, this lack of approval is primarily based on the toxicity of dispersants on marine organisms. As dispersants are improved, their use may become feasible. This would allow companies to greatly increase cleanup capability as dispersants are already stockpiled in many areas. The value of individual expenditures for research and development is also greater for the large company than the small one due to the high cost for uncertain or long term ventures.

In contrast, cleanup records by cooperatives (see Chapter X) have indicated that this type of shared resource arrangement can be beneficial to all companies but particularly those smaller in size. Cooperatives allow enhancement of capability at a much lower cost than any company can achieve alone. Cooperatives with a local focus can perhaps better meet the needs of a company operating in a particular area as equipment can be geared for specific needs. As the Corpus Christi Area Oil Spill Cooperative has shown, the additional benefit of local coops is that experience and familiarity with a particular area can lead to a faster and smoother response to spills. (14) While large companies have the resources and generally the activity to justify joining several regional cooperatives, small companies may find that joining a cooperative with interests locally focused on their activity areas is the most cost effective decision. It was apparent in Chapter XII that purchases of cleanup equipment can produce large benefits as most areas do not have the capability to adequately handle major spills.

One of the postulated reasons for the inadequate cleanup equipment stockpiles maintained by industry is that there has been an overreliance by companies on projected government equipment purchases. (15) U.S. Coast Guard projections in published reports up through 1979 indicated that major purchases of cleanup equipment would occur through the mid-1980's. As the federal government's budget was cut dramatically in the early 1980's, funds were not allocated for these purchases. Therefore any reliance placed upon these pre-1979 projections will be misplaced. Given this situation and the companies' awareness of need for increased capability, individual companies can be expected to add to cleanup capability, particularly through cooperatives.

As the Corpus Area cooperative has shown, the public is willing to share in a cooperative effort in order to attain their specific needs. This sharing mechanism particularly in sensitive areas (tourist beaches, fisheries areas) is a strategy that deserves further exploration. A cooperative program could also act to reduce the need perceived by states to have their own cleanup fund. As most funds are based on taxes to the oil industry it might be more prudent for the company to combine equipment purchases with the state in a cooperative fashion rather than face an additional tax. This is especially useful where the company plans to buy equipment anyway.

It should be noted that states retain their ability to create their own state level funds for damages and cleanup. (16) During hearings on H.R. 85 and S. 681 in 1981, representaives from Florida, Maryland, New Jersey and New York all agreed that the ability to maintain state cleanup capability for their special interests was very important. (17) Actively working with the state on their special interests could be of great benefit to the industry.

A wise strategy for companies may be to form these cooperatives with local and state governments in the areas of their primary exposure. This would allow the company to increase its coverage through a shared arrangement while also directly addressing the special needs of an area's sensitive resources. With the public sharing in the costs and decisions through local governments, the demand for equipment and level of cleanup should remain at a more reasonable level than if there is little or no involvement. Additionally much goodwill could be generated for the industry which should reduce specious damage claims.

Reduction of Frequency and Severity

Lack of data on the efficiency and effectiveness of most measures proposed for reducing the frequency and severity of spills has been a long term problem. Even the historical data bases that currently exist are not felt to be of extensive predictive value for large spills. This is a result of the changing profile of the industry (number and size of tankers, number of trips, etc.) over the past fifteen years and low probability of large spill events. Any data collection to improve predictability will be a long term effort and fairly costly. Given the uncertainty that surrounds predictions of effectiveness for the various reduction options such as crew and management training, vessel modifications and spill simulations, companies can be expected to focus on those options that are likely to produce a benefit with low cost outlays. When the cost outlay is low campanies can afford to take a chance on the unknown level of benefit.

Those options that a company is likely to choose are: crew and management training programs and courses; gathering and exchanging information to eventually build better data bases; the use of real time simulations and surprise tests to familiarize the players with problems likely to be encountered; and the addition of equipment to vessels that will improve navigation, communication, and steering, particularly when changes in international standards requiring such additions appear imminent. Most of these options only require outlays in the thousands or hundreds of thousands of dollars. All sizes of companies can participate at this level.

Major ship modifications on the other hand require outlays in the millions for speculative results. Because of uncertainty about the level of effectiveness of such modifications, coupled with the large dollar outlay required, such investments are not likely to be made in the forseeable future.

Areas where increased knowledge is likely to be sought are those areas that reduce severity. Studies by the industry, such as MIRG (see Chapter XI), are currently focusing on obtaining information such as sensitive area location, value of resources and sites for fast deployment of equipment. This type of knowledge allows the individual company to better assess possible damages and to plan cleanup operations with the goal of reducing damages.

Changes in the Legislative Regime

It is highly likely that changes will occur in the U.S. legislative regime dealing with oil pollution. Bills proposing change have been introduced in the last five Congresses with none passing both houses. Change is becoming especially likely in view of the new legislation introduced in the 98th Congress which has incorporated the changes and compromises suggested by both the oil industry and the public during the hearings on H.R. 85 and S. 681 in the 97th Congress. As there has been an evolution of the bills introduced from the 97th Congress to the 98th Congress this discussion will focus on the provisions in the latest bills that reflect the changes that occurred in 1981 to 1983. Of particular interest are the short and long term effects that could occur should any of the new legislation (H.R. 2222, H.R. 2115 and H.R. 2368) pass in the near future.

During the hearings held on H.R. 85 and S. 681 in 1981 industry very strongly opposed the idea of unlimited liability. The American Institute of Merchant Shipping, the American Petroleum Institute, the American International Group, the American Insurance Association and the American Institute of Marine Insurance all testified at the hearings on S. 681 and H.R. 85 requesting a liability limit because insurance to protect against spills would not be obtainable without a limit. (18) Because federal legislation requires proof of financial responsibilty, without insurance many companies would not be able to meet tis requirement and therefore would not be able to operate. (19) Only those companies large enough to self-insure would be able to meet these requirements.

The American International Group stated this concept very clearly in its testimony on H.R. 85:

> Unlimited liability for removal costs cannot be insured. The specific imposition of this liability should be made with this knowledge that the incident could force even major offshore interests into severe financial difficulty and affect the continued development of offshore oil and gas reserves. (20)

Companies clearly are not interested in having unlimited liability as the exposure is very high. They would prefer a known limit. The public on the other hand is not favorable toward liability limits, due to a suspicion that liabilities could far exceed the limits with no recourse for damage compensation. A possible compromise would combine liability limits with a compensation fund for those damages above the limits thus benefiting both sides. It is important that the liability limits are set high enough to cover most spills and the fund is large enough to cover the costs from a major spill that exceed the limit. The newly proposed legislation presents this compromise. The proposed limits in H.R. 2222 are $500,000 or $400/grt whichever is greater not to exceed $40 million. (21) As previously discussed in this chapter there would also be a fund to cover damages that exceed the spiller's liability limit. This fund could either have a $100 million cap or be unlimited depending upon which bill were to pass. While this compromise addresses the needs of both sides a further compromise may eventually evolve that would increase the liability limit for the spiller and set a limit on the fund compensation. It would provide a higher level of compensation for damages (the public's main interest) and would also provide set limits to liability (the company's main interest).

Preemption of state laws that have unlimited liability provisions and independent funds is a corollary issue. The industry favors preemption of state laws so that one uniform set of operating rules can be evolved at the federal level. Whether or not the public favors state preemption depends on the state viewing the legislation. Those states not heavily dependent upon the oil industry and those with sensitive coastal areas are strongly opposed to preemption clauses. The compromise suggested during the H.R. 85 and S. 681 hearings was to preempt states on liability limits but to allow retention of state funds. (22) This compromise has appeared in the new legislation. (23) It is likely that this trend will remain due to high public interest.

From the company view the new legislation, on the whole, is attractive as a cost-effective measure. It sets a ceiling on liabilities, provides a fund which is in effect increased insurance coverage and prevents individual states from removing the liability ceiling. What the companies must now evaluate is how the public will react to this set of changes.

Public Perception of Change

The public view of the trends will be examined to review those company alternatives that the public will view favorably. The public will greatly favor additional cleanup equipment because increased cleanup capability acts to mitigate spill severity. Insurance and funds are also viewed favorably as they provide assurance of the availability of funds for damage compensation. The public will favor any measures that act to reduce frequency and severity as those measures act to reduce the actual spill damage.

The question of liability is a very difficult one not directly addressed in most state and federal laws. Therefore, most damage claimants currently must rely on common law for recovery in an area where little case law has evolved. As most claimants do not have the resources to pursue such a case under the certain tort law many are currently forced to abandon claims or accept small settlements out of court. It is also possible in some cases for the shipowner to limit liability to the value of the ship and salvaged cargo. Note, however, that the cargo owner continues to be fully liable. (24) While the public does not favor the concept of a liability ceiling (because of the potential damages uncompensated above the ceiling) a clear definition of spiller liability and public right to recovery for damages will be viewed as a desirable objective.

A further question must also be asked: if these proposed changes are passed into law will they be stable and enduring changes? As currently proposed, the changes will probably not last if a catastrophic spill of Amoco Cadiz proportions were to occur, because the potential damage from such a spill would far exceed the current provisions for compensation. For example, under the new legislation the spiller's liability would be only $40 million; during Amoco Cadiz, the cleanup costs alone were $115 million. As a further illustration, the proposed funds are ranging from $100 million to $200 million with industry favoring the $100 million limit. If the fund were $100 million, combined with the spiller's liability of $40 million, after a $115 cleanup operation there would only be $25 million left to cover other damages after cleanup (based on Amoco Cadiz costs).

In the case of Amoco Cadiz suits were filed in excess of $2 billion. Such extremes are likely to induce the public to immediately undo such favorable legislation following such an incident. The legislation passed in the aftermath of a catastrophic spill could be very unfavorable to industry such as unlimited liabilities. Such reactive changes are extremely likely based on past history: the legislation passed after Torrey Canyon and Santa Barbara in the U.S. and the International Conventions passed after Amoco Cadiz.

It is very important that any legislation passed, no matter how favorable it appears for the company, not have the potential to greatly frustrate the public should a catastrophic spill occur. The bad will generated by such an event can greatly harm oil companies by carrying over into many areas of company operation. Areas that could be particularly vulnerable would be all petroleum transportation, offshore oil terminals, and offshore drilling and exploration.

Evaluating Trends

As discussed at the outset of this Chapter, a company's perspective about trends will be affected by two considerations: the level of value which the trend represents to the company; and the amount of control which the company has over the trend. It is important for companies to realize that planning which concerns prospective changes, like planning based on existing alternatives, is likely to produce different strategies depending on company size.

Value of Trends to Companies

It has already been shown in Chapter XII that small companies and large companies have different alternatives available for dealing with consequences of spills; and even where common alternatives exist, a smaller company may derive a different level of benefit from the alternative than a larger company.

These differences apply also to prospective changes in the range of alternatives. Table 44, at page 407, includes a column for a small and large company indicating the degree of value of each trend to these companies. For the insurance oriented trends, it can be seen that for a large company, changes in P&I levels are of high value, because higher P&I ceilings translate directly into lower NET EXP. See Chapter XII. For the smaller company, however, the value of P&I insurance changing may only be moderate, because a small company may not be able to gain access to a P&I club.

In contrast, for a small company, prospective increases in TOVALOP and CRISTAL, and the possibility of expanded compensation funds to cover damages from spills, are of extremely high value. A smaller company, if it cannot gain access to a P&I club, must fall back on other insurance and on TOVALOP and CRISTAL. Therefore, expanded coverage under TOVALOP and CRISTAL are certain to be of use to a small company. Similarly, compensation funds represent a form of insurance to which the small company is assured access (i.e., because of the reciprocal obligation to pay the $0.013/bbl. tax). For TOVALOP, CRISTAL and compensation funds, it is the larger company which may not experience as great a benefit. Because a large company has extensive P&I coverage, increases in TOVALOP, CRISTAL or compensation funds are only a shift from P&I coverage to these other insurance programs.

Among the cleanup oriented alternatives, it can be seen that both large and small companies experience the same value from alternatives. Both experience high, direct benefits from enhancements to cleanup capability, and both experience uncertain levels of benefits from the

TABLE 44

EVALUATING TRENDS FROM PERSPECTIVES OF SMALL COMPANY, LARGE COMPANY, AND PUBLIC

Alternative/ Trend	Small Company		Large Company		Public Perception
	Value to Company	Degree of Control	Value to Company	Degree of Control	
Insurance:					
P&I Level Increase	MODERATE	LOW	HIGH	HIGH	FAVORABLE
TOVALOP-CRISTAL Increase	HIGH	LOW	MODERATE/	HIGH	FAVORABLE
Legislative Compensation Funds	HIGH	LOW	MODERATE	HIGH	FAVORABLE
Cleanup:					
Cleanup Capability	HIGH	HIGH	HIGH	HIGH	HIGHLY FAVORABLE
Cleanup Training	UNKNOWN	HIGH	UNKNOWN	HIGH	HIGHLY FAVORABLE
Vessel Nav-igation Aids	UNKNOWN	HIGH	UNKNOWN	HIGH	HIGHLY FAVORABLE
Vessel Retrofit	UNKNOWN	HIGH	UNKNOWN	HIGH	HIGHLY FAVORABLE
Limits to Damages:					
Damage and Cleanup Ceilings	MODERATE	LOW	HIGH	HIGH	UN-FAVORABLE

FACTOR and EFF oriented alternatives such as crew and management training and vessel equipment purchases.

Changes associated with setting liability ceilings produce a slightly different benefit for small and large companies. While both sizes of company benefit from a downward movement of liability ceilings it is the large company, with its large NET EXP potential, which derives the highest level of benefit. A small company also experiences an improvement in NET EXP, but on a much lower scale.

Degree of Control Over Trends

A company must also evaluate what role it should attempt to play in bringing about those trends which it finds valuable. The important question is whether the company acts as a spokesman for the industry. A review of organizations such as the American Petroleum Institute, OCIMF, and other industry interest groups produces a small number of the largest companies whose employees are the most active representatives and spokesmen. The congressional hearings in which API and others testify consistently produce industry witnesses who are high management and policy employees of companies such as Exxon, Shell, Mobil, Texaco, and other large companies.

The question of control in bringing about trends, therefore, can be modified to ask whether the trend is one which requires an industry level or institutional effort to achieve, or whether instead the effort is one that can be realized by a single company acting in a single company capacity. See Table 44, at page 407.

The insurance oriented trends are all developments which require an industry level effort. Negotiations with London P&I clubs, the multinational and industry negotiations which will take place in 1984, all require industry level involvement. Similarly, legislative changes such as H.R. 2115, H.R. 2222 and H.R. 2368, which include trends in the area of compensation funds and liability ceilings, require industry level witness testimony and persuasion.

In contrast, the alternatives directly related to controlling spill frequency and severity are within the direct control of an individual company. A single company can make the decision to acquire a piece of equipment, to train a crew, or to plan a cleanup effort.

Planning for Company Role In Seeking Changes

The dual considerations of value of the trend and opportunity to participate in bringing about the trend permit a final set of suggestions for small and large companies and their pursuit of these trends.

Largest Companies: The large companies in the oil industry can be expected to concentrate primarily on enhancing their level of P&I coverage and on seeking legislative limits to liability. As noted in Chapter XII, these two alternatives provide the greatest impact on NET EXP. Further, because the largest companies are themselves able to speak on behalf of the industry at congressional hearings, negotiations and conferences, the large company interest and the industry interest are very similar. The large companies will also, but secondarily, be expected to focus on cleanup capabilities, because this alternative is within their individual company control to effect, there is a direct value to improvements in cleanup (see Chapter XII), and the public views such efforts with approval.

The large companies will probably not concentrate their efforts on present efforts to improve EFF and

FACTOR, for while these alternatives are within their direct power to implement, the value of the alternatives is unknown.

Small Companies: Smaller companies face a different situation in confronting trends. First, because the small company is not likely to be an influential voice at the industry level, the small company will play a relatively passive role in industry level trends such as insurance changes and legislative changes. A second difference is that the industry perspective on alternatives may not reflect the individual company's needs. For example, concentration of industry resources on negotiation of more favorable P&I coverage will not benefit a company which cannot join a P&I club.

The small company should therefore approach the trends discussed with three different strategies. For the small company, there is one alternative over which the individual company has high control and which is also of high value: enhancement of cleanup capability. As noted in Chapter XII, a small company may prefer a cooperative arrangement to individual action; however, a cooperative can be a highly flexible arrangement, and does not have to include every member of the industry.

In pursuing this cleanup capability objective, a small company should also focus on the particular geographic area of its activity. This permits the highest value per dollar expended to be achieved, and assures that while the company cannot exert control over spills worldwide, it can significantly control spill damage for its immediate area. Thus, participation in cooperatives similar to the Corpus Christi spill cleanup cooperative serves the double objective of direct action on the part of the small company and also a concentration of effort in the immediate area of concern.

The second strategy of a small company deals with trends which have a high value for the company, but which require industry level action. For these, including legislative changes and TOVALOP, CRISTAL, CLC and FC negotiations, the small company's role will be limited to supplying its share of financial and resource contributions to the industry representatives. The small company thus views any benefit arising from these trends as a windfall.

Finally, because the small company is limited in terms of its control over alternatives, the small company may wish to turn to those remaining alternatives over which it has high control but whose value is uncertain. The drawback of management and crew training, vessel equipment and other similar alternatives is the unknown utility of the measures. Small companies can and should become more active in their efforts to learn about the real value of these alternatives by conducting studies and data gathering. Note that a small company can also perform its research and development in a cooperative fashion, so that this cost can be shared.

Conclusion

This work has reviewed the important considerations that must be examined and assessed by a company in planning a strategy for dealing with the consequences of catastrophic oil spills. The methodology proposed in Chapter II attempts to assist this evaluation process, using data that is presently available.

Companies must consider their planning alternatives in light of the cost-effectiveness of the strategy, and also in light of public opinion of the strategy. In terms of a purely cost-effective analysis, insurance and legislative ceilings on damage liability are the alternatives having the greatest effect on a company's net exposure. It has also been shown, however, that the public preference is for measures that reduce spill frequency and severity, followed by insurance measures, and only reluctantly consideration of liability ceilings.

This work has also demonstrated that companies will be expected to gravitate to differing alternatives depending on company size and level of activity in an area. Finally, there can be expected to be a number of changes in the coming years which will require a reconsideration of company strategies, and which will again produce different degrees of benefit for small and large companies facing consequences from spills.

NOTES

1. Oil Companies International Marine Forum, and Oil Companies Institute for Marine Pollution Compensation Limited, Oil Spill Pollution Liability and Compensation: A Position Statement Concerning Revisions to the Civil Liabilities Convention, 1969, and the Fund Convention, 1976 (OCIMF, 1982), 4.

2. Ibid., 3-4.

3. Ibid., 5.

4. Ibid., 3; and John I. Jacobs, World Tanker Fleet Review (July-December, 1981): 3-4.

5. OCIMF and OCIMPCL, Oil Spill Pollution Liability and Compensation: A Position Statement, 12.

6. U.S. Congress. House of Representatives. "Comprehensive Oil Pollution Liability and Compensation Act", H.R. 2222, 98th Congress, 1st Sess., Sec. 104(d)(1); and U.S. Congress. House of Representatives. "Comprehensive Oil Pollution Liability and Compensation Act", H.R. 2115, 98th Congress, 1st Sess., Sec. 104(g)(1).

7. U.S. Congress. House of Representatives. "Comprehensive Oil Pollution Liability and Compensation Act", H.R. 2368, 98th Congress, 1st Sess., Sec. 204(c).

8. H.R. 2222, Sec. 207; H.R. 2115, Sec. 206; and H.R. 2368, Sec. 202.

9. American Petroleum Institute, American Petroleum Institute Testimony on H.R. 2222, the Comprehensive Oil Pollution Liability and Compensation Act, April 20, 1983 (Washington: API, 1983), 3-4.

10. U.S. Congress, House Committee on Merchant Marine and Fisheries, Subcommittee on Coast Guard and Navigation, Hearings of March 11, 1981 on Oil Pollution Liability - H.R. 85, 97th Cong., 1st Sess. (1981); and U.S. Congress, Senate Committee on Environment and Public Works, Subcommittee on Environmental Pollution and Resource Protection, Hearings of March 25, 1981 on S. 681 - Oil Spill Liability and Compensation Act of 1981, unpublished stenographic transcript, 97th Cong., 1st Sess. (1981).

These hearings on H.R. 85 and S. 681 were held to address the specific concerns that had been expressed by those groups who would be most directly affected by the legislation. The majority of witnesses, except for the Reagan Administration, favored revision of current legislation to meet current and future needs of oil spill cleanup and compensation.

11. Senate Hearings of March 25, 1981 on S. 681, 6.

12. Ibid., 7.

13. Interview with William Dahl, Advisor, Operations Coordinator, Exxon Corporation.

14. Interview with Mr. Sky-Eagle, Corpus Christi Area Oil Spill Cooperative.

15. Interview with U.S. Coast Guard personnel.

16. H.R. 2115, Sec. 110(a)(2); H.R. 2222, sec. 110(a)(3)(b); and H.R. 2368, Sec. 110(b).

17. House Hearings of March 11, 1981 on Oil Pollution Liability - H.R. 85. See Mr. McPherson's remarks at p. 131, Mr. Griffith's remarks at 131, Mr. Giardina's remarks at 131, and Mr. Stellato's remarks at 130.

18. Senate Hearings of March 25, 1981 - S. 681: See Mr. Buckley's testimony at 7-8; and House Hearings of March 11, 1981 on Oil Pollution Liability - H.R. 85: See Mr. Corrado's testimony at 75-76, Mrs. E. Bruce Calvert's statement at 145, and testimony given by the insurance panel, 174-184.

19. House Hearings of March 11, 1981 on Oil Pollution Liability - H.R. 85. See testimony given by Mrs. Calvert and Mr. Harrison, 154-156.

20. Ibid., 176. Statement by Mr. Hobbie.

21. See H.R. 2222, Sec. 104(b)(2).

22. House Hearings of March 11, 1981 on Oil Pollution Liability - H.R. 85. See Mr. Smith's testimony at 75, Mr. Corrado's testimony at 75-76, Mrs. E. Bruce Calvert's statement at 145, Mr. McPherson's remarks at 131, and testimony given by the insurance panel, 174-184. See also Senate Hearings of March 25, 1981 - S. 681. See Mr. Buckley's testimony at 7-8.

23. H.R. 2222, Sec. 110; H.R. 2115, Sec. 110; and H.R. 2368, sec. 110.

24. U.S. General Accounting Office, International Oil Pollution: Current Alternative Liability and Compensation Arrangements Affecting the United States (Washington: GAO, 1983), 15.

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APPENDIX A

LIST OF INDIVIDUALS CONSULTED

Name/Affiliation (Subject)

Robert Anderson, Policy Analysis, American Petroleum Institute (damages).

William Ayers, Clean Gulf Coordinator, Halliburton Services (cleanup).

Dan Basta, Office of Ocean Resources Coordination and Assessment, National Oceanic and Atmospheric Administration, U.S. Dept. of Commerce (damages, spill frequency).

Michael Bennett, Engineering and Planning, Exxon Corp. (cleanup).

Robert Blackburn, American Petroleum Institute (policy).

Lt. Jerry Brown, Marine Environmental Protection, Pollution Incident Reporting System, U.S. Coast Guard (spill frequency).

John Burdbacher, Clean Gulf Representative, Engineer, Shell Oil (cleanup).

Barbara Burke, American Institute of Merchant Shipping (tanker safety standards, insurance).

Elizabeth Carnahan, Office of Ocean Resources Coordination and Assessment, National Oceanic and Atmospheric Administration, U.S. Dept. of Commerce (damages, liabilities, spill frequency).

Don Casey, Spill Technology, American Petroleum Institute (cleanup).

Lt. Michael Christensen, Marine Environmental Protection, U.S. Coast Guard (contingency planning).

Jon Conrad, Associate Professor of Resource Economics, Department of Agricultural Economics, Cornell University (modeling oil spill risk).

Capt. Charles Corbett, Marine Environmental Protection, U.S. Coast Guard (Coast Guard spill response).

APPENDIX A, Continued

Name/Affiliation (Subject)

Ernest Corrado, Counsel, American Institute of Merchant Shipping, formerly Chief Counsel for Civil Liablities Convention and former Chief Counsel, House Committee on Merchant Marine and Fisheries (liabilities, insurance).

Vincent Covello, National Science Foundation (technological risk).

William Dahl, Advisor, Operations Coordinator, Exxon Corp. (policy, cleanup).

Charles N. Ehler, Director, Office of Research Coordination and Assessment, National Oceanic and Atmospheric Administration, U.S. Dept. of Commerce (damages, spill frequency, resources).

J. P. Fraser, Senior Staff Engineer, Environmental Conservation and Operations, Shell Oil (cleanup).

Lt. Paul Fulton, Marine Environmental Protection, U.S. Coast Guard (spill frequency).

Donald T. Gantz, Associate Professor of Mathematics, George Mason University (modeling).

Peter Ghee, Senior Marine Counsel, Middle East Transportation and Supply, Mobil Oil Co. (insurance, liabilities, policy).

Tim Goodspeed, Office of Research Coordination and Assessment, National Oceanic and Atmospheric Administration, U.S. Dept. of Commerce (resources).

Jack Gould, Environmental Affairs, American Petroleum Institute (damages).

Alan Grafe, Assistant Professor, Recreation and Parks Department, University of Maryland (recreational fishing).

Lt. Hall, Regional Response Center, Marine Environmental Protection, New Orleans, U.S. Coast Guard (Coast Guard response, cleanup).

Walt Hajek, Finance Treasurer, Insurance, Shell Oil (insurance).

Roy Hann, Professor, Environmental Engineering,

APPENDIX A, Continued

Name/Affiliation (Subject)

Texas A&M University (damages, cleanup).

James Helis, Engineering, Mobil Oil Co. (cleanup).

Roy Hogan, Engineering, Phillips Petroleum (cleanup).

Robert Hooker, Manager, Marine Transportation, Champlin Oil Co. (insurance).

William Koerth, Vice President, Finance and Head, Insurance Dept., Coastal Corp. (insurance).

Sherry Kirchoff, National Spill Control School (spill control training).

Robert Lagatolla, President, Water Quality Insurance Syndicate (insurance).

Alan Mendelsohn, Partner, Ward and Mendelsohn (insurance, liability, damages).

Robert Meyers, Oil Spill Coordinator for the U.S., Exxon Corp. (cleanup).

Richard Miller, Bureau of Land Management, U.S. Department of Interior (resources).

John N. Moore, Professor, Center for Ocean Law and Policy, University of Virginia Law School (liabilities, damages).

Alan Moghissi, Society for Risk Analysis (risk issues).

Sarah Morrison, Environmental Policy/Governmental Affairs, Conoco (policy).

Lt. Paul Murphy, Marine Environmental Protection, U.S. Coast Guard (spill frequency).

Cmdr. Norse, Legal Counsel Office, U.S. Coast Guard (spill damage).

Robert Phillips, Attorney, Texaco (insurance, liabilities).

Fred Pressley, Attorney, Legal Division, U.S. Department of State (liabilities).

APPENDIX A, Continued

Name/Affiliation (Subject)

Harold Reinstra, Information Transfer Specialist, National Coastal EcoSystem Team, U.S. Department of Interior (resources).

William Rowe, Professor, Director of Institute for Risk Analysis, American University (risk issues).

Dan Shipman, Clean Gulf Representative, Engineer, Chevron (cleanup).

June Linstedt-Siva, Biologist, Environmental Division, ARCO (MIRG, damages).

Mr. Sky-Eagle, General Manager, Corpus Christi Area Oil Spill Control Association (cleanup, training).

Staff, Information and Analysis, Office of Merchant Marine Safety, U.S. Department of Transportation (vessel traffic).

Staff, Massachusetts Institute of Technology, Marine Industry Collegium (modeling).

Staff, U.S. Congress, Senate Committee on Environment and Public Works (liabilities, damages, costs).

Staff, U.S.Congress, House Committee on Merchant Marine and Fisheries (liabilities, damages, costs).

Robert Stewart, Finance and Accounting Director, American Petroleum Institute (insurance).

G. J. Sullivan, Attorney, Law Office of John B. Culp, Jr. (insurance, liability, crew training, shipping, vessel safety standards).

William Wyland, Office of Biological Services, Fisheries and Wildlife Service, U.S. Department of Interior (resources).

Elizabeth Wylie, Public Affairs, American Institute of Merchant Shipping (policy).

Capt. Kenneth Wyman, Marine Environmental Protection, U.S. Coast Guard (vessel movement).

Harry Young, Environmental Engineering, Texas A&M University (cleanup).

APPENDIX B

THE INTERVENTION CONVENTION

Three important subjects underlie the Intervention Convention:

- Defining the "incident" justifying intervention;
- Defining the obligations and safeguards which would apply to the intervening nation; and
- Defining the obligations between coastal nations and shipowners during a maritime casualty. See: M. M'Gonigle and M. Zacher, Pollution, Politics and International Law: Tankers at Sea (Berkeley, CA: University of California Press, 1979), 160.

All three subjects are areas where the coastal nations sought greater latitude for action to prevent or minimize the consequences of an oil spill. In contrast, the maritime nations wished to carefully limit the intervention rights of the coastal nations. The Convention defines "maritime casualty" as:

> A collision of ships, stranding or other incident of navigation, or other occurrence on board a ship or external to it resulting in material damage or imminent threat of material damage to a ship or cargo.

See: International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties, 1969, International Legal Materials 9 (1970), 25, Article II(1).

The inclusion of the term "material damage or imminent threat of material damage" meant that simply establishing the occurrance of a collision or other incident alone would be insufficient to constitute a "maritime casualty". This definition therefore favored the interests of the shippers above the interests of the coastal nations, by limiting the coastal nations' intervention rights through the additional requirement of proving "damage".

A further definition of an incident justifying intervention was set forth in Article I (1) of the Convention. This provision allowed nations to intervene: "on the high seas as may be necessary to prevent, mitigate or eliminate grave and imminent danger to their coastline or related interests". The "grave and imminent danger" refers to the threat of oil pollution and must follow a "maritime casualty or acts related to such casualty which may reasonably be expected to result in major harmful consequences."

This Article recogizes the coastal nations' right to intervention and also acknowledges that the coastal nations have certain interests which would be affected by

APPENDIX B, Continued

oil pollution. At the same time, the Article continues to favor the maritime nations through the inclusion of such wording as "grave and imminent danger" and "major harmful consequences", because these phrases restricted intervention only to incidents of major impact.

The coastal nations do, however, benefit from the very broad definition of those "related interests" whose protection justifies intervention:

> Maritime coastal, port or estuarine activities including fisheries activities, constituting an essential means of livelihood of the persons concerned;
>
> Tourist attractions of the area concerned;
>
> The health of the coastal population and the well-being of the area concerned, including conservation of living marine resources and of wildlife. See: Intervention Convention, Article II 4(a),(b), and (c).

The above definition of "related interests" is an important acknowledgement that the coastal nations' interests are extensive, and also recognizes that the protection of the economic and natural resources of these nations is at least equal to the economic interests of the maritime nations.

The second major feature of the Convention centers on the act of intervention, and in particular the obligations of the coastal nations to the shipowners and flag nations. The Convention balances the interests of the coastal nations and the flag nations. The convention draft required that before action was taken all parties who might be affected by the action be notified, and that any action taken consider the views of these affected parties. There is a provision, Article III(d), for cases of "extreme urgency" allowing the coastal nation to proceed without notification to affected parties.

The draft also required that any actions taken be proportionate to the damage threatened, and further stated that if any measures taken proved excessive in terms of the provisions of the convention, the intervening nation was required to pay compensation for damages due to this excessive action. See: Intervention Convention, Articles III, V, and VI.

The coastal nations are given the right to intervene, but are required, if possible, to consider the views of involved shipowners and maritime states. Excessive action on the part of the coastal nation will result in compensation to those persons damaged by the

APPENDIX B, Continued

coastal state. Therefore, although neither group was accorded complete latitude of action, the coastal nations are put in the position of being able to rapidly respond through intervention, with the attendant risk of liability for excessive acts of intervention.

The third aspect of the Convention is the question of obligations between the coastal nation and the private shipowner. This question was not resolved to the satisfaction of the coastal nations. In fact, the Convention embodies a definite bias in favor of the shipowner interests, because the obligations, particularly with regard to notification and compensation, are not reciprocal in nature.

The coastal nation has the obligation to inform the shipowner of intended action to be taken by the coastal nation or of action already taken. Further, the coastal nation has the additional burden of paying compensation for damages caused by excessive acts while intervening.

In contrast, there is no corresponding obligation on the part of the shipowner. See Intervention Convention, Articles III and VI. For example, there is no requirement that the shipowner notify a coastal nation about a maritime casualty that might cause oil pollution damage to the coastal nation. There is also no requirement that the payment for damages caused by the shipowner be a prerequisite condition before there will be any obligation by the coastal nation to pay for damages caused by excessive intervention action. And while Article VI provides that the coastal nation pay for damages from actions that were excessive under the terms of the convention, there is no mention of any payment obligation for damages caused to the coastal nation by the shipowner. There does exist a provision for settling disputes over compensation in Artricle VIII of the Convention. It provides a mechanism of conciliation and arbitration for disputes not settled through negotiation. Under this article a coastal nation could challenge a shipowner's claim for damages.

The Intervention Convention clearly codifies the right of a coastal nation to intervene on the high seas in connection with a maritime casualty in order to protect itself from oil pollution damage. The Convention also represents the interests of the maritime nations by requiring that, except in cases of utmost emergency, the views of the maritime nations be considered and properly protected to the extent possible. Therefore, the Convention as a whole is considered well balanced between the various interested parties, even though particular provisions clearly favor one or the other interest.

APPENDIX C

GULF OF MEXICO OUTER CONTINENTAL SHELF SUMMARY (1954-1980)

	Louisiana	Texas	Mississippi/ Alabama/ Florida	Total
Exploration Permits:				
1963-1969	1,417	673	188	2,278
1970-1980	2,323	1,065	332	3,710
Leases:				
Number	2,202	835	143	3,180
Acreage	9,671,637	4,246,220	822,601	14,740,458
Well Status:				
Total Wells	15,868	1,927	234	18,029
Wells Completed	8,618	704	70	9,392
Plugged/Abandoned	6,641	989	126	7,756
Active/Shut-in	7,641	619	66	8,326
Production/Value				
Oil and condensate (million bbls)	5,181	38	0	5,218
Gas (million mcf)	45,816	2,766	0	48,582
Gasoline and LPG (million gal)	14,477	450	0	14,927
Production Value ($ million)	58,265	3,186	0	$61,451
Royalty Value ($ million)	9,486	529	0	$10,015

Source: U.S. Department of Interior. Geologic Survey 1981, Gulf of Mexico OCS Activities Summary. Washington: GPO, 1981.

APPENDIX D

COMPANIES ENGAGED IN OIL AND GAS OPERATIONS IN STATES BORDERING THE GULF OF MEXICO, 1981(*)

(* - includes most primary companies for Gulf states)

ALABAMA

Bow Valley Industries Ltd.
Carless, Capel and leonard, Ltd.
Discovery Oil Ltd.
Energy Resources Corp.
Exchange Oil and Gas Corp.
Freeport McMoRan Inc.
Galaxy Oil Co.
Global Natural Resources Ltd.
Louisiana Land and Expl. Co.
Patrick Petroleum Co.
Peninsula Resources Corp.
Sceptre Resources Ltd.

FLORIDA

Canadian Superior Oil Ltd.
Exchange Oil and Gas Corp.
Louisiana Land and Expl. Co.
Peninsula Resources Corp.

LOUISIANA

Adams Resources and Energy Inc.
Adobe Oil and Gas Corp.
Alaska Interstate Co.
Amax Petroleum Corp.
Amerada Hess Corp.
Aminoil USA Inc.
Apache Corp.
Aran Energy Ltd.
Arkansas Louisiana Gas Co.
Asamera Inc.
Baruch-Foster Corp.
Berkeley-Exploration and Prod. Inc.
Bralorne Resources Inc.
Brock Exploration Corp.
Callon Petroleum CO.
Canadian Occidental Petroleum Ltd.
Challenger Minerals Inc.
Charterhall Ltd.
Cities Services Co.
Cluff Oil Ltd.
Columbia Gas System Inc.
Continental Resources Co.
Coseka Resources Ltd.
Crystal Oil Co.
Damson Oil corp.
Delhi International Oil Corp.
Eason Oil Co.
El Paso Co.
Energy Resources Corp.
Gulf Oil Corp.
Hiran Walker Resources Ltd.
Houston Natural Gas Corp.
Hunting Petroleum Services Ltd.
Inter-City Gas Corp.
Kerr-McGee Corp.
Lear Petroleum Corp.
Leben Oil Corp.
Louisiana Land and Expl. Co.
Maynard Oil Co.
Mesa Petroleum Corp.
Mobil Corp.
Moore McCormack Energy Inc.
Newmont Oil Co.
Norcen Energy Resources Ltd.
Occidental Petroleum Corp.
Paloma Petroleum Ltd.
Panhandle Eastern Corp.
Peninsula Resources Corp..
Pennzoil Co.
Petrol Oil and Gas Co. Ltd.
Pexco NV
Peyto Oils Ltd.
Santa Fe International Corp.
Sceptre Resources Ltd.
Sonat Inc.
Standard Oil Co. of California
Suburban Propane Gas Corp.
Summit Energy Inc.

APPENDIX D, Continued

LOUISIANA
- continued -

El Paso Co.
Energy Resources Corp.
Entex Inc.
Equity Oil Co.
Exchange Oil and Gas Corp.
First Mississippi Corp.
Fluor Corp.
Forest Oil Corp.
Freeport McMoRan Inc.
Galaxy Oil Co.
Global Marine Inc.
Great Basins Petroleum co.
Suburban Propane Gas Corp.
Summit Energy Inc.
Tenneco Inc.
Texas Gas Transmission Corp.
Tomlinson Oil Co. Inc.
TransOcean Oil Inc.
Trimac Ltd.
United Energy Resources Inc.
Stone and Webster Inc.
Weeks Petroleum Ltd.
Woods Petroleum Corp.
Worldwide Energy Corp.

MISSISSIPPI

Agip SpA
Amax Petroleum Corp
Amerada Hess corp.
Bow Valley Industries Inc.
Callon Petroleum co.
Columbia Gas Systems Inc.
Delhi International Oil Corp.
Energy Resources Corp.
Exchange Oil and Gas Corp.
Freeport mcMoRan Inc.
Houston Natural Gas corp.
Lear Petroleum Corp.
Saga Petroleum AS
Sceptre Resources Ltd.
Surburban Peopane Gas Corp.

TEXAS

Adams Resources and Energy Inc.
Adobe Oil and Gas Corp.
AgipSpA
Alaska Interstate Co.
Amax Petroleum Corp.
Amerada Hess Corp.
American Petrofina Inc.
American Quasar Petroleum Co.
Aminoil USA Inc.
Anvil Petroleum plc
Apache Corp.
Argonaut Energy Corp.
Arkansas Louisiana Gas Co.
Baruch-Foster Corp.
Berkeley Exploration and Prod. Ltd.
Bralorne Resources Ltd.
Callon Petroleum Co.
Canadian Occidental Petroleum Ltd.
Challenger Minerals Inc.
Lear Petroleum Corp.
Louisiana Land and Expl. Co.
McFarland Energy Inc.
Mapco Inc.
Marion Corp.
Maynard Oil Co.
Merland Explorations Ltd.
Mesa Petroleum Co.
Metramar Minerals Ltd.
Mitchell Energy and Dev. Corp.
Mobil Corp.
Monsanto Co.
Moore McCormack Energy Inc.
Natomas Co.
Newmont Oil Co.
Norcen Energy Resources Ltd.
Norse Petroleum AS
Oakwood Petroleums Ltd.
Occidental Petroleum Corp.

APPENDIX D, Continued

TEXAS
- continued -

Cities Service Co.
Cluff Oil Ltd.
Coastal Corp.
Columbia Gas System Inc.
Conoco Inc.
Consolidated Oil and Gas Inc.
Continental Resources co.
Crown Central Petroleum Corp.
Crystal Oil Corp.
Cultus Pacific NL
Damson Oil Corp.
Delhi International Oil Corp.
Depco Inc.
Diamond Shamrock Corp.
Discovery Oil Ltd.
Eason Oil Co.
El Paso Co.
Energy Resources Corp.
Entex Inc.
Equity Oil Co.
Exchange Oil and Gas Corp.
Felmont Oil Corp.
First Mississippi Corp.
Fluor Corp.
Forest Oil Corp.
Freeport McMoRan Inc.
Galaxy Oil Co.
Global Marine Inc.
Global Natural Reources Ltd.
Great Basins Petroleum Co.
Gulf Energy and Development Corp.
Gulf Oil Corp.
Hadson Petroleum Corp.
Helmerich and Payne Inc.
Hiran Walker Resources Inc.
Houston Natural Gas Corp.
Hunting Petroleum Services Ltd.
Inter-City Gas Corp.
Kaiser-Francis Oil Co.
Kerr-McGee Corp.
Oklahoma Oil Co.
Oxoco Inc.
Paloma Petroleum Ltd.
Peninsula Resources Corp.
Pennzoil Co.
Petrol Oil and Gas Co. Ltd.
Pexco NV
Peyto Oils Ltd.
Pict Petroleum Ltd.
Pioneer Corp.
Pominex Ltd.
Premier Consolidated Oilfields Ltd.
Ranger Oil Ltd.
Royal Dutch/Shell Group
Santa Fe International Corp.
Sceptre Resources Ltd.
Standard Oil Co of California
Suburban Propane Gas Corp.
Summit Energy Inc.
Sun Co. Inc.
Sundance Oil Co.
Teck Corp.
Tenneco Inc.
Texas American Energy Corp.
Texas Gas Transmission Corp.
Tidewater Inc.
Tipperary Corp.
Tomlinson Oil Co. Inc.
TransOcean Oil Inc.
Trimac Ltd.
United Canso Oil and Gas Ltd.
United Energy Resources Inc.
Stone and Webster Inc.
Weeks Petroleum Inc.
Westburne International Industries Ltd.
Woods Petroleum Corp.
Worldwide Energy Corp.

Source: Financial Times, Oil and Gas International Yearbook, 1982 (London: Gresham Press, 1982).

APPENDIX E

REFINERY CAPACITY STATISTICS FOR GULF OF MEXICO STATES (1982)

(*) - Refinery located on Gulf Coast

Active Gulf Refineries

	Company and Location	Crude Capacity (barrels/ calendar day)
	ALABAMA	
	Hunt Oil Co. - Tuscaloosa	44,220
	Louisiana Land and Expl. Co. - Saraland	43,000
	Marion Corp. - Theodore	25,300
	Mobile Bay Ref. Co. - Chickasaw	28,100
	Vulcan Ref. Co. - Cordova	10,500
	Total:	151,120
	FLORIDA	
	Seminole Asphalt Ref. Inc. - St. Marks	13,000
	LOUISIANA	
*	Atlas Processing Co., Div. of Pennzoil - Shreveport	45,000
	Calumet Ref. Co. - Princeton	(++)
	Canal Ref. Co. - Church Point	7,858
*	Cities Services Co. - Lake Charles	330,000
	Claiborne Gasoline Co. - Lisbon	6,500
	Clark Oil Mt. Airy Ref. - Mt. Airy	(++)
*	Conoco Inc. - Lake Charles	156,500
	Cotton Valley Solvents (Kerr-McGee Ref. Corp.) - Cotton Valley	7,800
*	CPI Refining Inc. - Lake Charles	(++)
	Evangiline Refining CI - Jennings	(++)
*	Exxon Co. - Baton Rouge	474,000
	GHR Energy Corp. - Good Hope	(++)
	Gulf Oil Corp - Belle Chasse	198,900
	Hill Petroleum Co. - Krotz Springs	48,000
	International Processors - St. Rose	32,500
	Kerr McGee Corp. - Dubach	10,780
*	LaJet Inc. - St. James	40,000
*	Lake Charles Refining Co. - Lake Charles	32,000

(++) Barrels/calendar day information not available.

APPENDIX E, Continued

(* - Refinery located on Gulf Coast)

	Company and Location	Crude Capacity (barrels/ calendar day)
	LOUISIANA, continued	
	Mallard Resources Inc. - Gueydon	6,000
*	Marathon Oil Co. - Garyville	255,000
*	Murphy Oil Cpro. - Meraux	92,500
*	Placid Refining Co. - Port Allen	36,000
	Port Petroleum Inc. - Stonewall	3,200
	Schulze Processing Inc. - Talla Bena	1,768
*	Shell Oil Co. - Norco	257,000
	Sooner Refining CI - Egan	8,000
	South Louisiana Production CI - Mermentau	15,000
	T&S Refining Inc. - Jennings	10,200
*	Tenneco Oil Co. - Convent	140,000
	Total:	2,663,856
	MISSISSIPPI	
	Amerada Hess Corp. - Purvis	30,000
*	Chevron U.S.A. Inc. - Pascagoula	280,000
	Ergon Refining Inc. - Vicksburg	20,600
	Natchez Refining Inc. - Natchez	20,000
	Southland Oil Co. - Lumberton	5,800
	Southland Oil Co. - Sandersville	11,000
	Vicksburg Refining Inc. - Vicksburg	5,500
	Total:	372,900
	TEXAS	
	American Petrofina Inc. - Big Spring	60,000
*	American Petrofina Inc. - Port Arthur	90,000
*	Amoco Oil Co. - Texas City	415,000
*	Atlantic Richfield Co. - Houston	222,000
*	Brio Refining Inc. - Houston	16,000
*	Champlin Petroleum Co. - Corpus Christi	173,000
*	Charter International Oil Co. - Houston	(++)
	Chevron U.S.A. Inc. - El Paso	76,000
	Clinton Manges Oil and Ref. Co. - Tucher	9,700
*	Coastal States Petroleum Co. - Corpus Christi	182,000

(++) Barrels/calendar day information not available.

APPENDIX E, Continued

(* - Refinery located on Gulf Coast)

	Company and Location	Crude Capacity (barrels/ calendar day)
	TEXAS, continued	
*	Crown Central Petroleum Corp. - Houston	100,000
	Diamond Shamrock Corp. - Sunray	71,000
	Dorchester Refining Co. - Mt. Pleasant	26,500
*	Eddy Refining Co. - Houston	3,500
*	Erickson Refining Co. - Port Naches	45,000
*	Exxon Co. U.S.A. - Baytown	640,000
	Flint Chemical Co. - San Antonio	1,200
*	Gulf Oil Co. - Port Arthur	335,000
*	Gulf States Oil and Ref. Co. - Corpus Christi	(++)
	Howell Hydrocarbon Inc. - San Antonio	(++)
*	Independent Refining Co. - Winnie	50,000
*	Koch Refining Co. - Corpus Christi	57,000
	La Gloria Oil and Gas Co. - Tyler	65,000
	Liquid Energy Corp. - Bridgeport	10,000
	Listo Petroleum - Donna	3,656
	Longview Ref. Co., Div. of Crystal Oil Co. - Longview	14,000
*	Marathon Oil Co. - Texas City	69,500
*	Mobil Oil Corp. - Beaumont	325,000
	Phillips Petroleum Co. - Borger	95,000
	Phillips Petroleum Co. - Sweeny	175,000
	Pioneer Refining Ltd. - Nixon	15,500
*	Placid Refining Co. - Mont Belvieu	12,400
	Pride Refining Inc. - Abilene	(++)
*	Quintana Petrochemical Co. - Corpus Christi	(++)
	Quitman Refining Co. - Quitman	6,600
*	Ropano Refining - Ingleside	(++)
*	Saber Energy Inc. - Corpus Christi	(++)
*	Sentry Refining Inc. - Corpus Christi	(++)
	Shell Oil Co. - Deer Park	285,000
	Shell Oil Co. - Odessa	30,600
	Sigmore Refining Co. - Three Rivers	37,800
*	South Hampton Refining CO. - Silsbee	19,000
*	Southwestern Refining CI - Corpus Christi	104,000
	Tesoro Petroleum Corp. - Carrizo Springs	26,100
	Texaco Inc. - Amarillo	20,000
	Texaco Inc. - El Paso	17,000
*	Texaco Inc. - Port Arthur	402,000
*	Texaco Inc. - Port Neches	31,000

(++) Barrels/calendar day information not available.

APPENDIX E, Continued

(* - Refinery located on Gulf Coast)

	Company and Location	Crude Capacity (barrels/ calendar day)
	TEXAS, continued	
	Texas Armada Refining CO. - Ft. Worth	5,000
*	Texas City Refining Inc. - Texas City	119,600
*	Texas Oil and Chemical Terminal - Vidor	(++)
	Thriftway Inc. - Graham	2,400
*	Tipperary corp. - Ingleside	10,400
*	Uni Refining Inc. - Ingleside	(++)
*	Union Oil Co. of California - (Beaumont) Nederland	120,000
	Winston Refining Co. - Ft. Worth	20,000
	Total:	4,881,981

TOTAL CAPACITY, ACTIVE GULF REFINERIES 8,082,857

Inactive Gulf Refineries

Company and Location	Crude Capacity (barrels/ calendar day)
Adobe Refining Co. - LaBlanca, TX	5,000
Bayou State Oil Corp. - Hosston, LA	3,000
Bruin Refining Inc. - St. James, LA	19,300
Carbonit Refining Inc. - Hearne, TX	11,000
Dow: Oyster Creek Refining - Freeport, TX	190,000 (on standby)
Gulf Oil Co. - Venice, LA	28,700
Manatee Energy CO. - Palmetto, FL	28,400
Sheperd Oil Inc. - Mermentau, LA	10,000
Southland Oil Co. - Yazoo City MS	5,500
Vedette Oil Refining - Brownsville, TX	10,000

TOTAL CAPACITY, INACTIVE GULF REFINERIES: 310,900

(++) Barrels/calendar day information not available.

Source: John McCasun (ed.), International Petroleum Encyclopedia, 1982 (Tulsa: Penwell Publishing Co., 1982): 380-384.

APPENDIX F

TANKER FLEETS OF COMPANIES IMPORTING INTO GULF OF MEXICO IN 1982
(by Flag of Registry, 1980)

	Owned		Chartered	
	No.	Flag of Registry	No.	Flag of Registry
Amerada Hess	n/a	n/a	40 (owned or chartered)	n/a
Arco	10 3	U.S. n/a (foreign)	6	n/a
Ashland	6	U.S.		
Atlantic Richfield	10 3	U.S. n/a (foreign)	6	n/a
Charter Oil Company	1	Liberia	9	n/a
Chevron	9 2 4 37	U.S. U.K. Netherlands Liberia	n/a (owns and charters 3% of world fleet)	n/a
Clark Oil & Refining Co.			1 47	Liberia (time charter) n/a (spot charters)
The Coastal Corporation	2 1 2	U.S. Liberia U.K.	5 12	n/a (bareboat charter) n/a (time charter)
Coastal States Gas Corp.	8	U.S.		
Conoco Inc.	10	n/a (foreign	n/a (large charter fleet)	n/a
Exxon Corporation	19 121 3 (on order)	U.S. n/a (foreign) 43,000 dwt at $100 million each	n/a (large charter fleet average daily capacity of 8.6 million dwt	n/a

APPENDIX F, Continued

	Owned		Chartered	
	No.	Flag of Registry	No.	Flag of Registry
Gulf Oil Corporation	12	U.S.		
	19	Liberia	n/a	n/a
	1	Denmark		
	1	Belgium		
Mobil Corporation	6	U.S.	49	n/a
	41	n/a (foreign)		
	7	3 at 32,500 dwt; 3 at 80,000 dwt; 1 at 145,000 dwt		
Phillips Petroleum Co.	1	U.S.	2	Liberia (bareboat)
	8	Liberia	3	U.S.(time charter)
			5	Liberian, Ital., Greek, Japanese(time charter)
Sabine Towing & Transportation Co, Inc.	13	U.S.		
Standard Oil Co. Indiana	2	U.S.	9	n/a (time charter)
(AMOCO)	15	n/a (foreign)		
Sun Company Inc.	8	U.S.	1	U.S.
Texaco	14	U.S.	64	n/a
	52	n/a (foreign		
Union	8	U.S.	n/a	Most U.S.

Sources:
Seatrade U.S.A. Yearbook, 1981 (3d Ed.) (Colchester, UK: Seatrade Publications, Ltd., 1981).
Lloyds of London, Lloyds List of Shipowners, 1981-1982 (London: Lloyds of London, 1982).
Financial Times, Oil and Gas International Yearbook, 1982 (London: Gresham Press, 1982).

APPENDIX G

INCOME AND REFINERY STATISTICS FOR OIL COMPANIES IMPORTING/REFINING IN THE GULF STATES (FY 1980)

Company	Net Income ($ million)	Refinery Capacity (b/d in thousands)	Total Revenue ($ million)
Amerada Hess	540	n/a	7,955
Amoco	1,915	1,468	27,832
Arco	1,651	826	24,156
Ashland Oil Co.	205	475(*)	8,365
Champlin Petroleum Co.	191	270(*)	2,602
Charter Oil Co.	243	70(*)	4,397(**)
Chevron	2,401	n/a	42,919
Cities Service Co.	448	191(*)	7,898(+)
Clark Oil and Ref. Co.	75	135(*)	1,658
Coastal Corp.	110	400(*)	5,120
Coral Petroleum (sub. Vulcan Asphalt)	n/a	n/a	1,540
Conoco Inc.	1,026	448(*)	18,766
Continental Oil	n/a	n/a	521
Crown Central Petro.	19	100	1,274
Diamond Shamrock	201	n/a	3,181
El Paso Co.	109	n/a	3,543
Exxon Corp.	5,650	6,000(*)	100,381
Getty	877	n/a	10,266
Gulf Oil Corp.	1,407	1,640(*)	28,790
Gulf States Oil and Ref	n/a	n/a	2(+)
Houston Natural Gas	197	n/a	2,358
International Petroleum	n/a	n/a	626(+)
Kerr-McGee	182	181	3,478(+)
Koch Oil International	n/a	n/a	7,000(+)
La Gloria Oil and Gas (sub Texas Eastern Corp.)	n/a	n/a	3,940(+)

(*) - 1979 figures
(**) - figure refers to oil group only
(+) - sales

APPENDIX G, Continued

Company	Net Income ($ million)	Refinery Capacity (b/d in thousands)	Total Revenue ($ million)
Marathon Oil Co.	379	588	8,754
Mobil Oil Corp.	3,272	891	63,726
Murphy Oil Corp.	151	n/a	12,726
Phillips Petroleum Co.	1,069	425	13,713
Placid Ref. (sub. Placid Oil Co. USA)	n/a	n/a	80(**)
Royal Dutch Shell	5,650	n/a	81,805
Shell Oil Co.	1,542	1,136	19,959
Sigmore Corp.	48	32	1,328
Standard Oil - Ohio	1,811	452	11,379
Summit Energy Inc.	2	n/a	6(+)
Sun Company	732	611	13,242
Superior Oil	334	n/a	1,497
Tenneco Oil Co.	940	100	13,624
Tesoro Petroleum Corp.	104	n/a	3,588
Texaco Inc.	2,643	n/a	52,485
Texas City Ref. (sub. Agway Petroleum)	n/a	n/a	1(+)
Tosco Corp.	46	262	2,387
Total Petroleum, N.A.	48	150	1,500
Union Oil of Cal.	647	490	10,100

(*) - 1979 figures
(**) - figure refers to oil group only
(+) - sales

Sources:

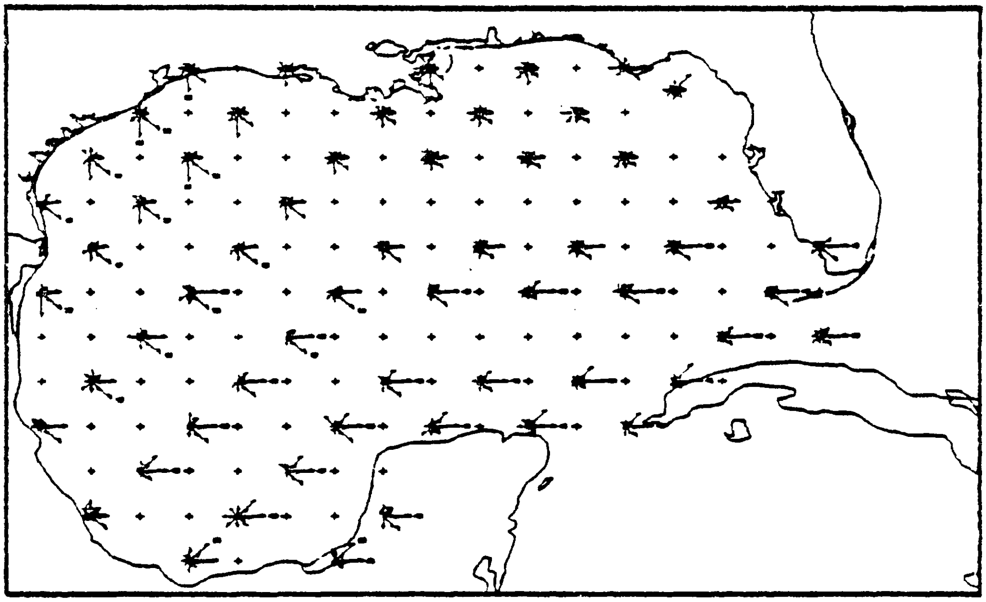
Oil Daily. Oil Industry U.S.A., 1981-1982. New York: Whitney Communication Corp., 1981.

Dun and Bradstreet, ed. Million Dollar Directory, 1983. New York: Dun and Bradstreet, 1983.

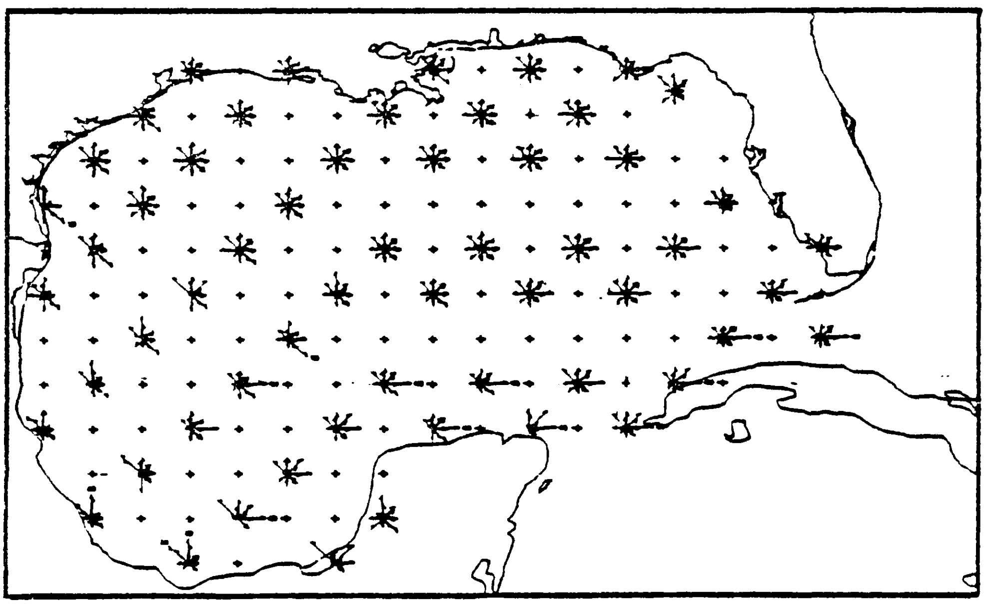
Financial Times, Oil and Gas International Yearbook, 1982 (London: Gresham Press, 1982).

APPENDIX H
GULF OF MEXICO SURFACE WINDS,
GEOSTROPHIC AND COASTAL CURRENTS

Surface Winds



a. WIND ROSES FOR JULY

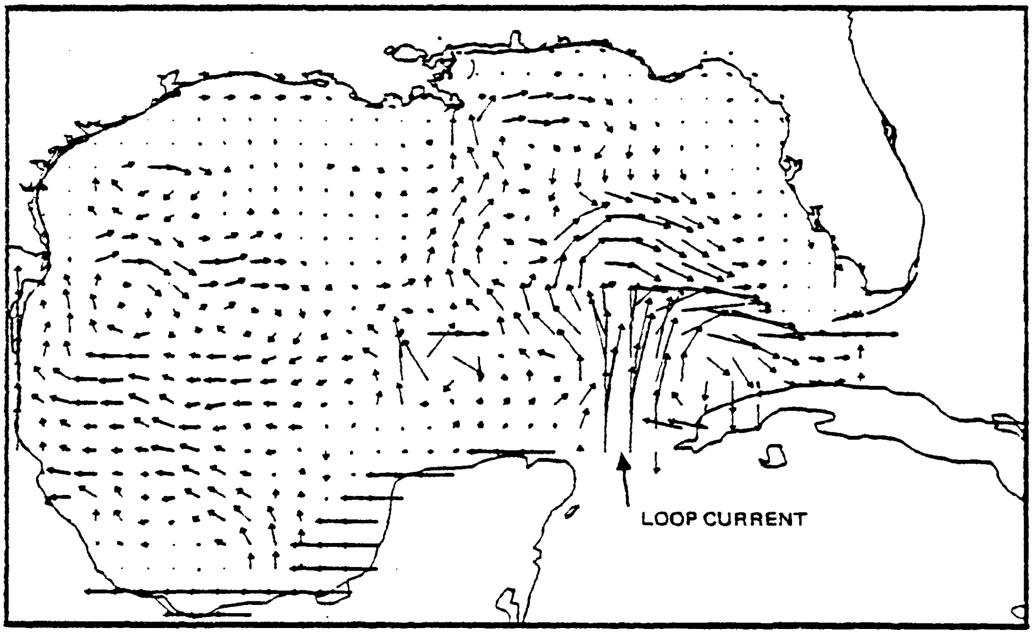


b. WIND ROSES FOR JANUARY

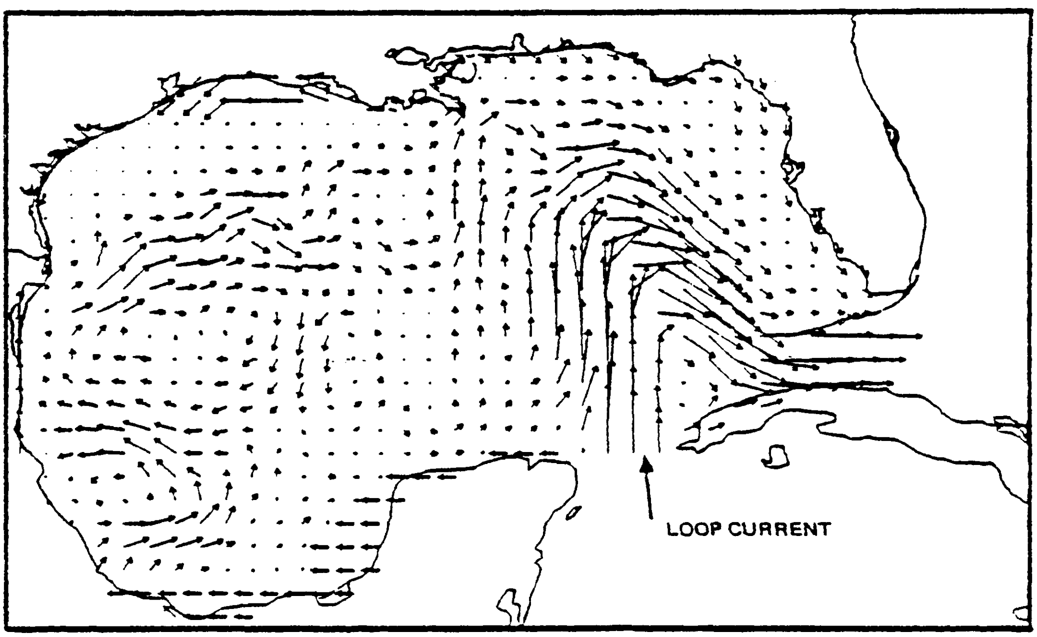
SOURCE: MARINE ENVIRONMENTAL ASSESSMENT DIVISION
NOAA, DEPT. OF COMMERCE

APPENDIX H, Continued

Geostrophic and Coastal Currents



a. JULY



b. JANUARY

SOURCE: MARINE ENVIRONMENTAL ASSESSMENT DIVISION
NOAA, DEPT. OF COMMERCE

APPENDIX I

POPULATION STUDIES, GULF OF MEXICO REGION COASTAL COUNTIES

Population Data, Gulf Region, Coastal Counties
(population figures in thousands)

Area	1960	1970	% Change 1960-70	1980	% Change 1070-80	Compound Annual Growth Rate
Florida	2,522.4	3,423.3	35.7%	4,810.1	40.5%	3.5%
Alabama	363.4	376.7	3.7%	442.8	17.5%	1.6%
Mississippi	182.0	248.0	36.3%	309.9	25.0%	2.5%
Louisiana	1,780.0	2,141.9	20.3%	2,477.3	15.7%	1.5%
Texas	2,501.3	3,104.4	24.1%	4,250.0	35.5%	3.1%
Gulf Region	7,349.1	9,294.3	26.5%	12,245.1	31.7%	2.8%
United States	179,323.0	203,312.0	13.3%	226,504.8	11.5%	1.1%

Net Migration Data, Gulf Region Coastal Counties
(net migration 1970-1978) (*)

Area	Number (000)	Rate(**)	Migration as a Percent of Gulf Region
Florida	791.3	23.1%	61.4%
Alabama	26.5	7.0%	2.0%
Mississippi	15.3	6.2%	1.2%
Louisiana	78.9	3.7%	6.1%
Texas	377.6	12.2%	29.3%
Gulf Region	1,289.6	13.9%	100.0%

(*) - This is the latest year for which data is available.

(**) - Rate is expressed as a percentage of the 1970 total population from Appendix Ch. VIII, Table 5.

Sources:

U.S. Department of Commerce, Bureau of the Census, 1980 Census of Population and Housing, Advance Reports (Washington: GPO, 1981), Environmental and Socioeconomic Baseline on the Gulf of Mexico Coastal Zone and Outer Continental Shelf.

U.S. Department of Commerce. Bureau of the Census. Current Population Reports. Series P-25, No. 873. Washington: Bureau of the Census, 1981.

APPENDIX J

SHIPMENTS INTO GULF OF MEXICO BY TWO GULF OF MEXICO OIL IMPORTERS, JANUARY-OCTOBER 1982

Large Company Example: Mobil Oil Company

	(tons)		(tons)
Jan:	18,471	July:	20,264
	41,269		84,278
	41,439		135,371
	179,154		121,537
			82,650
Feb:	19,330		71,581
	67,767		140,102
	73,851		280,432
	77,616		
		Aug:	19,646
			99,159
Mar:	64,889		76,069
	65,418		68,336
	47,997		
	48,736	Sep:	22,543
			42,643
Apr:	38,915		84,260
	82,079		213,409
	84,395		
	49,274	Oct:	62,094
	75,296		63,160
May:	53,421		
	35,898		
	45,812		
June:	135,371		
	121,537		
	71,581		
	140,102		

TOTAL NUMBER OF SHIPMENTS: 42
TOTAL VOLUME
SHIPPED: 3,367,082 tons

Small Company Example: Charter Oil Co.

	(tons)		(tons)
Jan:	0	July:	27,618
			36,610
Feb:	0		
		Aug:	72,687
Mar:	0		
		Sep:	0
Apr:	0		
		Oct:	77,041
May:	30,249		
	61,243		
June:	47,226		
	75,628		

TOTAL NUMBER OF SHIPMENTS: 8
TOTAL VOLUME
SHIPPED: 428,302 tons

Source:
American Petroleum Institute. Imported Crude Oil and Petroleum Products. Washington: API, 1982.

APPENDIX K

GULF OF MEXICO UNINTENTIONAL BARGE SPILLS, 1976-1980, OF 3.4 TONS (= 1,000 GALLONS) AND ABOVE

Barge Operation - "Underway", "Unknown Operation" or "No Operation Reported"

Volume (tons)	Cause	Barge (thous- and tons)	Operation	Location: (lat/long/)
1976:				
28.6	Collision	B(.5-1)	Underway	2958/9246(east Lake Charles,LA)
142.9	Collision	B(20-35)	Underway	2958/9351(Beaumont,TX)
57.1	Grounding	B(1-10)	Underway	2825/9626(north Corpus Christi,TX)
18.9	Unknown	B(.3-.5)	Unknown	2923/9453(Galveston,TX)
1977:				
275.6	Collision	B(10-20)	Underway	2756/8223(Tampa Bay,FL)
142.9	Collision	B(1-10)	Underway	2921/9448(Galveston Bay,TX)
3.6	Grounding	B(10-20)	None	2750/9704(Pt. Aransas,TX)
13.6	Grounding	B(10-20)	Underway	3010/8913(off Gulfport,MS)
1978:				
859.1	Collision	B(1-10)	None	2914/9130(Lafayette/Grand Isle,LA)
171.4	Collision	B(1-10)	Underway	2930/9452(Galveston Bay,TX)
7.9	Collision	B(.5-1)	Underway	2919/9447(Galveston Bay,TX)
5.1	Collision	B(10-20)	Underway	2805/9320(off Pt. Arthur,TX)
14,285.7	Grounding	B(.3-.5)	Underway	2916/8958(approach New Orleans,LA)
153.1	Grounding	B(.15-.3)	Underway	2927/8915(Venice,LA)
13.6	Grounding	B(1-10)	Underway	2826/9624(north Corpus Christi,TX)
128.6	Grounding	B(1-10)	Underway	2945/9505(Houston Channel,TX)
21.4	Grounding	B(1-10)	None	2943/9515(Houston Channel,TX)
8.5	Grounding	B(1-10)	None	2944/9511(Houston Channel,TX)
1979:				
571.4	Collision	B(1-10)	Underway	2922/9451(Galveston,TX)
2,285.7	Grounding	B(1-10)	Unknown	2922/8911(Venice,LA)
1,857.1	Grounding	B(1-10)	Underway	2922/9448(Galveston Bay,TX)
2,571.4	Grounding	B(1-10)	Underway	2922/9449(Galveston Bay,TX)
6,142.9	Grounding	B(1-10)	Underway	2922/9448(Galveston Bay,TX)
2,857.1	Grounding	B(1-10)	Underway	2922/9452(Galveston Bay,TX)
7,142.9	PE-Unknown	B(50-100)	None	2921/9448(Galveston Bay,TX)
1980:				
714.3	Collision	B(35-50)	Underway	2717/9240(off Corpus Christi,TX)
10.2	Sinking	B(0-.15)	Unknown	2912/8903(Venice,LA)
185.7	Unknown	B(1-10)	Underway	2948/9210(Lafayette,LA)
571.4	Unknown	B(1-10)	None	2943/9501(Houston Channel,TX)
4,357.1	PE-Inattent.	B(20-35)	Underway	3017/8830(off Gulfport,MS)

APPENDIX K, Continued

Barge Operation - "All Other Operations"

Volume (tons)	Cause	Barge (thousand tons)	Operation	Location (lat/long/)
1976:				
11.7	Collision	B(.3-.5)	Loading	2830/9016(north Corpus Christi,TX)
16.7	Collision	B(.5-1)	Unloading	2944/9505(Galveston Bay,TX)
199.6	Fire/Explos.	B(1-10)	Loading	2938/9056(Gramercy,LA)
46.3	Minor Damage	B(10-20)	Unloading	2749/9725(Corpus Christi,TX)
4.3	Mat'l Fault	B(10-20)	Unloading	2922/9452(Galveston Bay,TX)
4.3	PE-Flanges	B(1-10)	Unloading	3000/9359(Beaumont,TX)
4.3	PE-Other	B(35-50)	Loading	2749/9726(Corpus Christi,TX)
1977:				
7.1	PE-Inattent.	B(.5-1)	Transfer	2750/9731(Corpus Christi,TX)
3.6	PE-Inattent.	B(1-10)	Unloading	2922/9454(Galveston Bay,TX)
6.8	PE-Inattent.	B(1-10)	Loading	2913/9427(off Galveston,TX)
4.3	PE-Inattent.	B(10-20)	Unloading	2944/9505(Houston Channel,TX)
16.4	PE-Valve Op.	B(1-10)	Loading	2943/9507(Houston Channel,TX)
1978:				
21.4	Collision	B(20-35)	Unloading	2943/9512(Houston Channel,TX)
10.7	Grounding	B(.5-1)	Transfer	2811/9651(Aransas Pass,TX)
13.6	Corrosion	B(1-10)	Loading	2749/9729(Corpus Christi,TX)
4.3	PE-Valve Op.	B(.5-1)	Unloading	2923/9454(Galveston Bay,TX)
3.4	PE-Training	B(.5-1)	Loading	3008/8814(off Gulfport,MS)
6.8	PE-Other	B(.3-.5)	Other	2754/8226(Tampa Bay,FL)
1979:				
10.2	Collision	B(1-10)	Moored	2922/9453(Galveston Bay,TX)
10.0	Minor Damage	B(1-10)	Other	2944/9506(Houston Channel,TX)
18.6	Unknown	B(10-20)	Loading	2959/9353(Beaumont,TX)
5.1	PE-Inattent.	B(1-10)	Unloading	2922/9454(Galveston Bay,TX)
14.3	PE-Inattent.	B(.5-1)	Loading	2950/9357(Pt. Arthur,TX)
7.1	PE-Hose Twist	B(35-50)	Fueling	2922/9453(Galveston Bay,TX)
14.2	PE-Loading	B(1-10)	Loading	2749/9729(Corpus Christi,TX)
7.1	PE-Other	B(1-10)	Transfer	2922/9454(Galveston Bay,TX)
1980:				
3.4	Corrosion	B(1-10)	Loading	2749/9729(Corpus Christi,TX)
10.7	Unknown	B(1-10)	Unloading	2923/9454(Galveston,TX)
3.4	PE-Inattent.	B(1-10)	Loading	2922/9453(Galveston,TX)
21.4	PE-Inattent.	B(1-10)	Loading	2943/9507(Houston Channel,TX)
5.1	PE-Inattent.	B(.5-1)	Loading	2950/9358(Pt. Arthur,TX)
5.1	PE-Valve Op.	B(1-10)	Unloading	2752/8224(Tampa Bay,FL)
14.3	PE-Valve Op.	B(1-10)	Unloading	3010/9318(Lake Charles,LA)
11.4	PE-Hose Cut	B(1-10)	Unloading	2749/9728(Corpus Christi,TX)
471.4	PE-Loading	B(10-20)	Loading	3002/9402(Beaumont,TX)
28.6	PE-Overfill	B(10-20)	Loading	2943/9501(Houston Channel,TX)
3.6	PE-Loading	B(.3-.5)	Loading	2951/9350(Pt. Arthur,TX)
14.3	PE-Unknown	B(.5-1)	Loading	2749/9728(Corpus Christi,TX)

Source: U.S. Coast Guard Pollution Incident Reporting System computer data base, 1982.

APPENDIX L

U.S. COAST GUARD MAJOR U.S. PORT AREAS RANKED BY SPILL POTENTIAL: PROJECTED FOR YEAR 1985

(Based on crude and heavy oil flows and spills larger than 50,000 gallons (170 tons) from 1974-1977, adjusted to 1985)

Major Port	Constitutent Ports	Spills/Year
NEW ORLEANS, LA	Port of New Orleans, LA; Bay Marchand, LA; Eugene Island, LA; Grand Island, LA; Main Pass, LA; Ship Shoal, LA; South Pass, LA; Timbalier Bay, LA; West Delta, LA.	2.7052
PASCAGOULA, MS	Mobile Harbor, AL; Pascagoula Harbor, MS; Biloxi Harbor, MS; Gulfport Harbor, MS; Eastern Gulf, Mobile, AL region.	1.1205
BATON ROUGE, LA		1.0660
TEXAS CITY, TX	Houston Ship Channel, TX; Texas City Channel, TX; Galveston Channel, TX; Freeport Harbor, TX.	1.0250
PORT ARTHUR, TX	Sabine-Neches Waterway, TX; Beaumont, TX; Orange, TX; Pt. Arthur, TX.	0.8801
CORPUS CHRISTI, TX		0.7417
LAKE CHARLES, LA	Calcasieu River and Pass, LA.	0.4160
TAMPA, FL	St. Petersburg Harbor, FL; Tampa Harbor, FL; Weedon Island, FL; Eastern Gulf, Tampa, FL region.	0.0885
TOTAL		8.0430

Source: A. O. Brien, et. al., Deployment Requirements for U.S. Coast Guard Pollution Response Equipment, Vol. 1 (Washington: U.S. Department of Transportation, 1979).

APPENDIX M

REPRESENTATIVE LIST OF TANKER SAFETY PROGRAMS

United States

Organization: National Spill Control School, Corpus Christi, TX; Subject: Oil Spill Prevention and Control; Duration and Cost: 5 days, $550.

Organization: World Trade Institute, New York, NY; Subject: Petroleum Tankship Operation; Duration and Cost: 5 days, $890.

Organization: Oil and Hazardous Material Control Training Division (Inland),Texas A&M University, College Station, TX; Subject: Oil and Hazardous Material Control (Inland); Duration and cost: 5 days, $575.

Maine Maritime Academy, Castine, ME; Subject: Petroleum Tanker Safety Course; Duration and cost: 5 days, $750-$1,000.

Outside United States

Organization: Leith Nautical College, Edinburgh, Scotland; Subject: Petroleum Tanker Safety, Crude Oil Washing; Duration and Cost: 5 days, $950-$1,175.

Organization: Institute of Petroleum, London, England; Subject: Tanker Safety; Duration and Cost: 5 days, 490 pounds (approx. $750 U.S.);

Grenoble, Switzerland; Subject: Training school for piloting/captaining VLCC's (very large crude carriers); Duration and cost: unknown. Note: this program is a prerequisite of most U.S. companies for piloting VLCC's.

Source: Oil Spill Intelligence Report, February 4, 1983, 4.

APPENDIX N

MAJOR CLEANUP EQUIPMENT AVAILABLE IN GULF OF MEXICO

U.S. Coast Guard

Open Water Containment and Recovery System (OWOCRS)
4 Adapts Salvage Pumps
2 Units (612 ft.) high seas boom
1 JBF 1001 skimmer
1 Mobile command post
Communications equipment
Dracone barges
Zodiac inflatable boats
Viscous oil pumping systems

Companies
(Equipment Based on Lightering Vessels)

Chevron:
Dispersing equipment and small boat for applying dispersant
10 drums Corexit 9527
1 drum Shell Oil Herder
1600 3M sorbent boom (8 inch)
400 3M sorbent pads

Coastal States:
1 support boat used to transport fenders and oil spill control gear
1500 ft. Slickbar Mark V Boom
1 Mantaray Aluminum Head Skimmer
1 pollution pump and hoses
320 ft. Sorboil sorbent boom
Sorboil mats (no dispersants)

Conoco:
1 supply vessel (180 ft.)
2,000 gallons Corexit dispersant
1,500 ft. Uniroyal 18" boom

Exxon:
On each lightering vessel (2 in use) are:
1,000 ft. Bennet Zoom Boom
1 Clean Channel Industries 24 ft. skimmer
260 gallons Corexit 7664
2,400 gallons Corexit 7664 on each lightering ship
1 Utility boat 26x9x4 ft. with 15 hp. diesel engine

APPENDIX N, Continued

Companies, continued
(Equipment Based on Lightering Vessels)

Gulf:
150 ft. service boat "Pike"
5,000 gallons BP 1100 WD dispersant
Permanently mounted WSL spray equipment to apply dispersant
2 rolls 3M sorbent, 3 ft. x 200 ft.
30 gallons Shell Oil Herder and applicator

On lightering vessel - 220 gallons BP 1100 WD

Marathon:
500 ft. Slickbar boom
Small amount of dispersant

Mobil:
2,000 ft. Slickbar Boom
1,500 gallons PC 65 dispersant
110 gallons Nalfleet 9-090

Texaco:
1 supply vessel "ENDEAVOR" (185 ft.)
1 Vikoma Seapack
1,100 gallons Corexit 9527 dispersant
1 pump and hand-held nozzle to dispense dispersant

Shell International Marine:
1,300 gallons Shell LTX dispersant
1 pump, manifold, and hand-held nozzle to dispense dispersant

Contractors
(due to numerous equipment items, only main items such as skimmers, boom, dispersant, etc. are listed)

Oil Mop (New Orleans, Mobile, Houston):
Skimmers:
1 self-propelled skimmer vessel (30 ft.)
Numerous oil mop skimming devices
Containment Boom:
( ) ft. 18" containment boom
( ) ft. 36" containment boom

APPENDIX N, Continued

Contractors

(due to numerous equipment items, only main items such as skimmers, boom, dispersant, etc. are listed)

Clean Channel Industries:
Skimmers:
2 independent vacuum skimming systems onboard "Lady Alice"
3 self-propelled skimming barges
Containment Boom:
3,000 ft. 18" containment boom

Browning-Ferris Industries (Baton Rouge, New Orleans):
Skimmers:
5 Oil Mop Mark IV
Containment Boom:
9,200 ft. 18" containment boom in road vehicle
5,500 cases sorbent

Clean River Associates (Burnside, Port Allen, New Orleans):
Skimmers:
3 hand wringers and 200 ft. oil mop located at Burnside, LA; Port Allen, LA; and New Orleans, LA
Containment Boom:
3 1,000 ft. 18" continment boom in road tractors located at Burnside, LA; Port Allen, LA; and New Orleans, LA
200 ft. 18" boom located at Lake Charles

Peterson Maritime Services, Inc. (New Orleans, Mobile, Houston):
Skimmers:
1 Swiss Olea skimmer
2 Slurp skimmers
10 hand skimmers
Containment Boom:
15,000 ft. 28" containment boom
10,000 ft. disposable sorbant boom (3M)

APPENDIX N, Continued

Cooperatives

Corpus Christi Area Oil Spill Control Association:
(equipment as of 1982)
Skimmers:
1 9' x 24' Catamoran
2 4' dia. saucers
3 4 x 15 decanters
Containment Boom:
2,000 ft. 16" Kepner Boom
1,500 ft. 20" Marsan Boom
540 ft 36" Uniroyal Boom
300 ft. 14" Slickbar Boom
400 ft. 18" Acme Boom
125 ft. 14" Corpus Christi Boom
100 ft. 10" Sorbant Boom
1,600 ft. rough water boom
1,000 ft. Acme Products boom
Sorbents:
250 bales wheat straw
Other Equipment:
1 75 barrel vacuum truck
Pumps
Light plants
Hoses
1 38' crew boat
Response van

Clean Gulf Associates: (as of May 1, 1978)
Skimmers:
1 High Volume Open Sea (HOSS)
7 Fast Response Units Model I
4 Fast Response Units Model II
Containment Boom:
1,000 ft. Bennett 72"
5,000 ft. Bennett 36"
1,000 ft. Uniroyal 36"
4 helicoptor spraying kits
96 bird scarers
1 waterfowl rehabilitation center
41 absorbant pads (bales)
1 incenerator skid
1 communication system
Boat spraying equipment
Dispersant

Source: A. O. Brien, et. al., Deployment Requirements for U.S. Coast Guard Pollution Response Equipment, Vol. 1 (Washington: U.S. Department of Transportation, 1979).

APPENDIX O

CORPUS CHRISTI AREA OIL SPILL CONTROL ASSOCIATION MEMBERSHIP, 1983

CCAOSCA Contributors

Counties of Aransas, Nueces, and San Patricio
Port of Corpus Christi Authority
Cities of Corpus Christi, Aransas Pass, and Rockport

CCAOSCA Membership

Amerada Hess Corporation
American Petrofina Pipe Line Company
Arco Oil and Gas Company
Arco Pipe Line Company
Bass Enterprises Production Co.
The Belcher Company of Texas, Inc.
Champlin Petroleum
Cities Service Corporation
The Coastal Corporation
Copano Refining Company

Corpus Christi Marine Services Co.
Corpus Christi Petrochemical Company
Edwin L. Cox
Energy Reserves Group, Inc.
Exxon Company, U.S.A.

Exxon Pipeline Company
Getty Oil Company
Gulf Oil Exploration and Production Co.
Gulf States Oil and Refining Co.
Highland Resources, Inc.

Koch Refining Company
EADS Operating Service
McMoRan Exploration Co.
Mobil Pipe Line Company
Mobil Producing Texas and New Mexico, Inc.

Pennzoil Producing Company
Phillips Petroleum Company
Quintana Petrochemical Company
Redfish Bay Terminal, Inc.
Reynolds Metal Company

APPENDIX O, Continued

<u>CCAOSCA Members, continued</u>

Saber Refining Company
Sigmor Pipeline Company
Southwestern Refining Co., Inc.
SunGas Company
The Superior Oil Company

Tenneco Oil Company
Texas Fuel and Asphalt Co., Inc.
The Texas Pipeline Company
TXO Production Corporation
UNI Refining, Inc.

National Marine Service
Sun Marine Terminals

Source: Corpus Christi Area Oil Spill Control Association, brochure of operations (untitled) (Corpus Christi, TX: CCAOSCA, 1982).

APPENDIX P

CLEAN GULF ASSOCIATES MEMBERSHIP EFFECTIVE JANUARY 1, 1978

American Petrofina Co. of Texas
Aminoil U.S.A., Inc.
Amoco Production Company
Anadarko Production Company
Ashland Exploration Inc.
Atlantic Richfield Company
Belco Petroleum Corporation
Chevron U.S.A. Inc.
Cities Service Oil Company
Clark Oil Producing Company
CNG Producing Corporation
Coastal States Gas Corporation
Columbia Gas Development Corp.
Continental Oil Company
Diamond Shamrock Corporation
Dixilyn Corporation
Exchange Oil and Gas Corporation
Exxon Company, U.S.A.
Forrest Oil Corporation
General American Oil Co. of Texas
General Crude Oil Company
Getty Oil Company
Gulf Energy and Minerals Co. U.S.
Hamilton Brothers Oil Company
Home Petroleum Corporation
Houston Oil and Minerals Corp.
Hunt Oil Company
- Hunt Industries
- Hassie Hunt Trust
- Hassie Hunt Trust, et. al.

JFD, Inc.
Kerr-McGee Corporation
Louisiana Land and Exploration Co.
Marathon Oil Company
McMoRan Exploration Company
Mesa Petroleum Company
Mitchell Energy Offshore Corp.
Mobil Oil Corporation
Natomas Exploration, Inc.
Ocean Drilling and Exploration Co.
- Ocean Production Company
- Odeco, Inc.
- Odeco Drilling, Inc.

Oxy Petroleum, Inc.
Pennzoil Producing Company
- Pennzoil Producing - Sohio Petroleum
- Pennzoil Producing Co., et. al.

APPENDIX P, Continued

Phillips Petroleum Company
Placid Oil Company
Placid Oil Company, et. al
Placid Oil Company and Texaco Inc.
Quintana Offshore, Inc.
    Quintana Petroleum Corp.
    Quintana Production Co.
    Quintana Oceanic, Inc.
Samedan Oil Corporation
Shell Oil Company
Southern Natural Gas Company
    Sonat Exploration Company
Sun Production Company
Superior Oil Company
Tenneco, Inc.
Texaco, Inc.
Texas Gas Exploration Corp.
Texas Gulf, Inc.
Texas International Petroleum

Transco Exploration Company
Transocean Oil, Inc.
Union Oil Co. of California
Union Texas Petroleum Division
    Allied Chemical Corporation
Zapata Exploration Company

Source: Information furnished by Clean Gulf Associates.

APPENDIX Q

CONVERSION FACTORS USED IN EVALUATING CLEANUP CAPABILTY

- 42 U.S. gallons = 1 barrel;
- 7 barrels (lt. crude) = 1 ton;
- Evaporation rate = 40% for light crude;
- Spill mass = (oil) x 3.5 ((emulsifacation of 1 part oil to 2.5 parts water));
- Length of boom (ft) to encircle spill =

$$29.1 \sqrt{(\text{Oil volume-barrels})/(\text{oil thickness-inches})};$$

- Length of boom used per skimmer = 3,000 ft.
- Skimmer water:oil recovery ratio = 80% water, 20% oil;
- Large skimmer recovery rate = 2,500 bbls./hr (ie- 2,000 bbls./hr of water and 500 bbls./hr of oil);
- Skimmer operation = 12 hours/day (visibility required to operate);
- 1 drum of dispersant = 55 U.S. gallons;
- Dispersant dosage rate = 1 part dispersant:20 parts oil;
- All dispersants EPA approved (and therefore usable on a U.S. offshore spill);
- All measures employed are 100% effective.

Sources:

Exxon Corporation, Oil Spill Cleanup Manuals, Vol. II Response Guidelines (Exxon Corp., 1979), p. 6-4.

R. Meyers and M. Bennett, "Marine Industry Group (MIRG)", Proceedings, American Petroleum Institute Oil Spill Conference, 1983 (Washington: API, 1983), 191.

APPENDIX R

ESTIMATING THE COST OF A COMPANY SURPRISE TEST OF COMPANY CLEANUP EFFICIENCY

Estimated Daily Salary: $150/day (annual salary of $40,000)

Estimated Personnel Involved on surprise test day: 150 persons x $150/day =	$22,500
Preplanning: 15 days x 3 employees x $150/day =	$ 6,750
Equipment Use and Transporation =	30,000
Post-Test Evaluation: 10 days x 2 employees x $150/day =	3,000
Other Unanticipated Costs =	7,750
TOTAL =	$70,000

ESTIMATED COST: Between $60,000-100,000

Source: Interviews with representatives of oil companies.

APPENDIX S

CONCENTRATIONS FOR SELECTED COASTAL RESOURCES IN THE GULF OF MEXICO, FOR SSMO AREAS, BY COUNTY

SSMO Area/ County	High Marine Productivity (Acres)	High Density Offshore Shellfish (Acres)	Finfish High Abundance (Acres)	Major Shorefront Recreation Beaches (miles)	Coastal Wetlands, forested/ unforested (Acres)	Charterboat/ Headboat Fleet (± boats)
AREA 29						
Cameron	143,601	97,623	200,523	7.8	12,509	22
Willacy	87,599	41,844	90,977	2.9	43,224	6
Kenedy	223,164	157,805	310,141	47.8	116,188	--
Kleeburg	87,993	60,868	130,889	17.6	36,836	--
Nueces	178,101	52,953	133,032	7.4	21,844	*
San Patricio	--	--	--	--	21,824	*75
Aransas	111,358	60,045	133,330	--	54,046	*
Refugio	20,274	--	--	--	--	--
Calhoun	248,627	237,456	237,456	--	58,287	--
Jackson	5,751	--	--	--	--	--
Matagorda	158,218	389,026	403,733	--	65,038	--
Brazoria	29,937	218,562	218,562	2.9	95,501	--
(OCS)						
All of W-1	--	4,646,669	5,256,850	--	--	--
1/3 of W-2	--	1,119,339	2,348,655	--	--	--
AREA 29 TOTAL:	1,292,623	7,079,984	9,464,148	86.4	525,267	103
AREA 28						
Galveston	164,711	355,911	355,911	47.5	68,310	27
Harris	3,582	--	--	--	na	--
Chambers	150,411	7,063	7,063	--	102,370	--
Jefferson	17,384	209,786	224,465	6.3	139,318	--
Orange	--	--	--	--	--	--
Cameron	275,465	186,462	186,462	3.5	843,011	7
Vermillion	151,101	79,510	79,510	--	296,647	3
(OCS)						
2/3 of W-2	--	2,272,597	4,768,482	--	--	--
All of W-3	--	--	441,446	--	--	--
All of C-1	3,279,138	5,267,001	7,938,631	--	--	--
AREA 28 TOTAL:	4,041,792	8,378,330	14,001,970	57.3	1,449,656	37

APPENDIX S, Continued

SSMO Area/ County	High Marine Productivity (Acres)	High Density Offshore Shellfish (Acres)	Finfish High Abundance (Acres)	Major Shorefront Recreation Beaches (miles)	Coastal Wetlands, forested/ unforested (Acres)	Charterboat/ Headboat Fleet (± boats)
AREA 27						
Iberia	219,741	101,735	101,735	--	203,034	--
St. Mary	325,309	57,426	57,426	3.1	234,891	--
Terrebonne	410,416	187,237	187,237	--	565,610	--
Lafourche	176,128	55,460	55,460	7.6	477,427	5
Jefferson	131,156	64,344	64,344	8.7	107,692	13
Plaquemines	995,901	246,120	575,148	--	449,775	18
St. Barnard	1,051,693	--	672,667	--	265,025	--
Orleans	92,768	--	--	--	64,961	--
St. Tammany	96,609	--	--	--	179,332	--
Hancock	43,829	--	37,134	5.1	29,885	--
Harrison	219,082	--	207,527	37.1	8,818	6
(OCS)						
All of C-2	2,007,881	3,328,310	5,778,228	--	--	--
1/2 of C-3	1,054,053	203,641	1,036,520	--	--	--
AREA 27 TOTAL:	7,824,566	4,253,273	8,773,426	61.6	2,586,440	42
AREA 26						
Jackson	204,969	--	180,299	40.8	93,840	31
Mobile	240,017	--	101,203	6.4	65,994	37
Baldwin	253,168	--	71,016	12.8	128,636	--
Escambia	266,654	--	268,647	27.8	37.135	--
Santa Rosa	83,028	--	18,549	2.9	66,847	--
Okaloosa	116,099	--	161,218	23.8	38.134	64
Walton	133,511	119,198	172,700	10.4	59,009	--
(OCS)						
1/2 of C-3	1,054,053	203,641	1,036,520	--	--	--
All of C-4	45,694	--	1,400,011	--	--	--
All of E-1	605,488	683,919	2,498,532	--	--	--
All of E-5	--	--	--	--	--	--
AREA 26 TOTAL:	3,002,681	1,006,758	5,918,695	124.9	489,595	132

APPENDIX S, Continued

SSMO Area/ County	High Marine Productivity (Acres)	High Density Offshore Shellfish (Acres)	Finfish High Abundance (Acres)	Major Shorefront Recreation Beaches (miles)	Coastal Wetlands, forested/ unforested (Acres)	Charterboat/ Headboat Fleet (± boats)
AREA 25						
Bay	210,046	262,000	262,000	15.3	62,567	31
Gulf	220,528	202,566	202,566	10.1	106,731	--
Franklin	338,203	349,762	437,920	14.1	83,354	2
Wakulla	125,004	--	121,886	--	89,343	--
Jefferson	47,096	--	46,891	--	60,690	--
Taylor	268,471	--	284,635	--	190,260	--
Dixie	233,305	--	229,992	--	195,382	--
Levy	312,186	--	304,037	--	212,857	--
Citrus	217,618	--	198,050	--	107,295	--
Hernando	142,759	--	137,532	--	77125	--
Pasco	138,203	--	158,356	--	92,351	--
Pinellas	186,633	--	275,755	45.8	14,413	33
Hillborough	127,820	--	45,768	--	70,367	--
Manatee	57,839	--	91,833	14.4	42,766	5
Sarasota	41,410	--	235,284	27.8	28,090	14
(OCS)						
All of E-2	1,021,267	2,759,266	4,513,198	--	--	--
3/4 of E-3	472,152	1,030,903	7,783,442	--	--	--
AREA 25 TOTAL:	4,160,540	3,790,169	12,296,640	127.5	1,433,591	85
Area 24						
Charlotte	74,823	--	85,604	5.5	67,776	26
Lee	178,815	173,920	173,920	18.8	88,402	28
Collier	127,626	361,484	361,484	16.1	592,844	50
Monroe	2,294,430	2,412,000	2,506,179	308.6	367,550	20
(OCS)						
1/4 of E-3	157,384	343,634	2,594,481	--	--	--
All of E-4	--	2,325,812	5,164,083	--	--	--
All of E-4X	1,407,567	3,133,783	4,499,148	--	--	--
AREA 24 TOTAL:	4,240,645	8,783,633	15,384,899	349	1,116,572	124

APPENDIX S, Continued

SSMO Area/ County	High Marine Productivity (Acres)	High Density Offshore Shellfish (Acres)	Finfish High Abundance (Acres)	Major Shorefront Recreation Beaches (miles)	Coastal Wetlands, forested/ unforested (Acres)	Charterboat/ Headboat Fleet (± boats)
AREA 23						
Dade	151,542	--	133,522	49.7	762,701	144
AREA 23 TOTAL:	151,542	--	133,522	49.7	762,701	144

Sources:

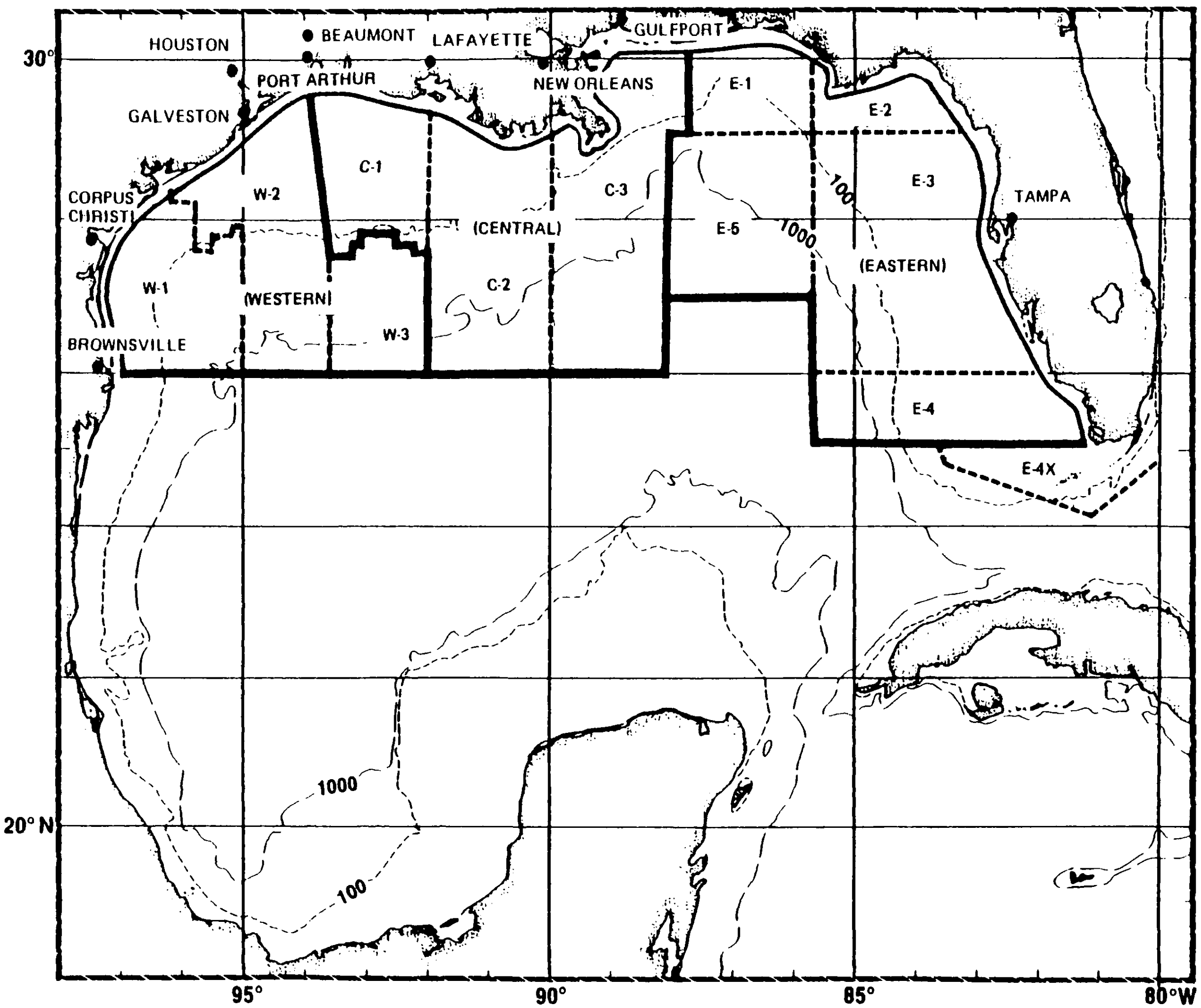
U.S. Department of Interior, Minerals Management Service, Draft Regional Environmental Impact Statement, 1982 (Washington: Minerals Management Service, 1982), "Measurement Tables of Environmental Resources", Visual No. 14;and "Fisheries Resources and Recreation", Visual No. 4 (chart on back of visual)..

D. K. Larson, et. al., Mississippi Deltaic Plain Region Ecological Characterization: A Socioeconomic Study, Vol. I: Synthesis Papers, U.S. Fish and Wildlife Service, Office of Biological Studies, FWS/OBS-79/05 (1980), 153.

E. B. Liebow, K. S. Butler, and T. R. Plaut, et. al., Texas Barrier Islands Region Ecological Characterization: A Socioeconomic Study, Vol. I: Synthesis Papers, U.S. Fish and Wildlife Service, Office of Biological Studies, FWS/OBS-80/19 (1980), 117.

APPENDIX T

GULF OF MEXICO OUTER CONTINENTAL SHELF LEASING DIVISIONS



SOURCE: U.S. DEPARTMENT OF INTERIOR, MINERALS MANAGEMENT SERVICE, DRAFT REGIONAL ENVIRONMENTAL IMPACT STATEMENT, GULF OF MEXICO (WASHINGTON, MINERALS MANAGEMENT SERVICE, 1982)

APPENDIX U

CLAIMS ASSERTED IN AMOCO CADIZ LITIGATION

Claimants	Amount	Parties Claimed Against: Standard Oil Co. (Indiana)	Amoco International Oil Company	Amoco Transport	Claude Phillips
Republic of France	$300,000,000	X	X		
Conseil General des Cotes du Nord	$ 20,000,000			X	
Communes des Cotes du Nord	$ 70,000,000			X	
Communes du Finistere	$ 70,000,000			X	
Unions and Trade Associations	$264,000,000			X	
Societe Pour L'Etude de la Protection de la Nature en Bretagne	$ 8,000,000			X	
Ligue de Protection des Oiseaux	$ 4,000,000			X	
Department of Finistere	$ 600,000	X	X		
Commune of Plougerneau	$ 60,000	X	X		
Bretagne-Angleterre-Irelande, S.A., d/b/a Brittany Ferries, for itself and on behalf of all others similarly situated	$200,000,000	X	X	X	X
Union Departmentale Des Associations Familiales Du Finistere, for itself, its members and on behalf of all others similarly situated	$200,000,000	X	X	X	X

APPENDIX U, Continued

Claimants	Amount	Parties Claimed Against Standard Oil Co. (Indiana)	Amoco International Oil Company	Amoco Transport	Claude Phillips
Chapalain Compagnie, d/b/a Hotel Brittany, in Roscoff, France; Renee cadiou, d/b/a Hotel Des Bains, Roscoff, France, for himself and on behalf of all others similarly situated	$200,000,000	X	X	X	X
Gaby Beganton, for himself and on behalf of all others similarly situated	$200,000,000	X	X	X	X
Alain Bizien, d/b/a/ Establissements Chevalier, for himself and on behalf of all others similarly situated	$200,000,000	X	X	X	X
Yves Craff, d/b/a/ Sarl Quiros, for himself and on behalf of all others similarly situated	$200,000,000	X	X	X	X

TOTAL AMOUNTS CLAIMED:
$1,936,660,000 ($1.937 billion)

Source: In re Oil Spill by the "Amoco Cadiz" Off the Coast of France on March 16, 1978. Civil No. 78 C 3693, MDL Docket No. 376 (U.S. District Court for the Eastern District of Illinois), Pleadings of Plaintiffs Chapalain Compagnie, d/b/a Hotel Brittany, in Roscoff, France; Renee cadiou, d/b/a Hotel Des Bains, Roscoff, France, for himself and on behalf of all others similarly situated. See Schedule A.

APPENDIX V

CALCULATIONS FOR EXAMPLES 1 THROUGH 13

Example 1 Equations
Corpus Christi Area Spill, No Y Investment

EXPOSURE = (D(i) x IMPACT x (V(i) - CLEAN)) + IND + F(k) + (O(i) x V(i))

EXPOSURE(1) = ((32,750) x (.35) x (200,000 - 23,142)) + 250,000 + 730,000 + ((245) x (200,000)) = $2,077,214,825.

EXPOSURE(2) = ((32,750) x (.35) x (55,000 - 23,142)) + 250,000 + 730,000 + ((245) x (55,000)) = $379,627,325.

P(i) = ACTIVITY x SPILLS(i) x FACTOR

Small Company P(1) = (.0125) x (0.16) x (1.0) = 0.002.
Small Company P(2) = (.0125) x (2.0) x (1.0) = 0.025.

Large Company P(1) = (.075) x (0.16) x (1.0) = 0.012.
Large Company P(2) = (.075) x (2.0) x (1.0) = 0.150.

$$\text{NET EXP} = \left(\sum_{1}^{2} P(i) \times (\text{EXPOSURE}(i) - \text{INSURANCE})\right) + Y.$$

Small Company's NET EXP = .002 x (2,077,214,825 - 0) + .025 x (379,627,325 - 0) + 0 = $13,645,118.

Large Company's NET EXP = .012 x (2,077,214,825 - 0) + .150 x (379,627,325 - 0) + 0 = $81,870,703.

APPENDIX V, Continued

Example 2 Equations:
South Florida Area Spill, No Y Investment

DAMAGES(i) = $50,000.

EXPOSURE(1) = ((55,250) x (.35) x (200,000 - 23,142))
+ 250,000 + 730,000 + ((245) x (200,000)) =
$3,469,971,575.

EXPOSURE(2) = ((55,250) x (.35) x (55,000 - 23,142))
+ 250,000 + 730,000 + ((245) x (55,000)) =
$630,509,075.

Small Company P(1) = (.0125) x (0.16) x (1.0) = 0.002.
Small Company P(2) = (.0125) x (2.0) x (1.0) = 0.025.

Large Company P(1) = (.075) x (0.16) x (1.0) = 0.012.
Large Company P(2) = (.075) x (2.0) x (1.0) = 0.150.

Small Company's NET EXP = .002 x (3,469,971,575 - 0)
+ .025 x (630,509,075 - 0) + 0 =
$22,702,670.

Large Company's NET EXP = .012 x (3,469,971,575 - 0)
+ .150 x (630,509,075 - 0) + 0 =
$136,216,020.

APPENDIX V, Continued

Example 3 Equations
Modification of Chapter II Methodology for
Companies Using 2 or More Ports

ACTIVITY(Corpus) = 10/2,000 = 0.005

ACTIVITY(S. FL) = 15/2,000 = 0.0075.

D(Corpus) = $32,750; EXP(Corpus,1) = $2,077,214,825;
EXP(Corpus,2) = $379,627,325.

D(S. FL) = $55,250; EXP(S. FL,1) = $3,469,971,575;
EXP(S. FL,2) = $630,509,075.

INS = 0; Y = 0.

Small* Company NET EXP = "Corpus Christi NET EXP" + "S. Florida NET EXP" =

$5,458,047 + $13,621,602 = $19,079,649.

APPENDIX V, Continued

Example 4 Equations
Insurance: Y Investment in TOVALOP and CRISTAL
(Corpus Christi Area)

EXPOSURE(1) = ((32,750) x (.35) x (200,000 - 23,142)) + 250,000 + 730,000 + ((245) x (200,000)) = $2,077,214,825.

EXPOSURE(2) = ((32,750) x (.35) x (55,000 - 23,142)) + 250,000 + 730,000 + ((245) x (55,000)) = $379,627,325.

Small Company P(1) = (.0125) x (0.16) x (1.0) = 0.002.
Small Company P(2) = (.0125) x (2.0) x (1.0) = 0.025.

Large Company P(1) = (.075) x (0.16) x (1.0) = 0.012.
Large Company P(2) = (.075) x (2.0) x (1.0) = 0.150.

Small Company Y = ($70,000/vessel) x (25 shipments avg. 55,000 tons) / (10 shipments/vessel) = $175,000.

Large Company Y = ($70,000/vessel) x (150 shipments avg. 55,000 tons) / (10 shipments/vessel) = $1,050,000.

Small Company's NET EXP =
.002 x (2,077,214,825 - 36,000,000) +
.025 x (379,627,325 - 36,000,000) + 175,000 =
$12,848,113.

Large Company's NET EXP =
.012 x (2,077,214,825 - 36,000,000) +
.150 x (379,627,325 - 36,000,000) + 1,050,000 =
$77,088,677.

APPENDIX V, Continued

Example 5 Equations
Insurance: Y Investment in P&I Insurance, TOVALOP, and CRISTAL (Corpus Christi Area)

EXPOSURE(1) = ((32,750) x (.35) x (200,000 - 23,142)) + 250,000 + 730,000 + ((245) x (200,000)) = $2,077,214,825.

EXPOSURE(2) = ((32,750) x (.35) x (55,000 - 23,142)) + 250,000 + 730,000 + ((245) x (55,000)) = $379,627,325.

Small Company P(1) = (.0125) x (0.16) x (1.0) = 0.002.
Small Company P(2) = (.0125) x (2.0) x (1.0) = 0.025.

Large Company P(1) = (.075) x (0.16) x (1.0) = 0.012.
Large Company P(2) = (.075) x (2.0) x (1.0) = 0.150.

Small Company Y = ($140,000/vessel) x (25 shipments avg. 55,000 tons) / (10 shipments/vessel) = $350,000.

Large Company Y = ($140,000/vessel) x (150 shipments avg. 55,000 tons) / (10 shipments/vessel) = $2,100,000.

Small Company's NET EXP =
.002 x (2,077,214,825 - 319,200,000) +
.025 x (379,627,325 - 319,200,000) + 350,000 =
$5,376,713.

Large Company's NET EXP =
.012 x (2,077,214,825 - 319,200,000) +
.150 x (379,627,325 - 319,200,000) + 2,100,000 =
$32,260,277.

APPENDIX V, Continued

Example 6 Equations
Insurance: Y Investment in Third Party Insurance Policy
(Corpus Christi Area)

EXPOSURE(1) = ((32,750) x (.35) x (200,000 - 23,142))
+ 250,000 + 730,000 + ((245) x (200,000)) =
$2,077,214,825.

EXPOSURE(2) = ((32,750) x (.35) x (55,000 - 23,142))
+ 250,000 + 730,000 + ((245) x (55,000)) =
$379,627,325.

Small Company P(1) = (.0125) x (0.16) x (1.0) = 0.002.
Small Company P(2) = (.0125) x (2.0) x (1.0) = 0.025.

Large Company P(1) = (.075) x (0.16) x (1.0) = 0.012.
Large Company P(2) = (.075) x (2.0) x (1.0) = 0.150.

Small Company Y = ($210,000/vessel) x (25 shipments
avg. 55,000 tons) / (10 shipments/vessel) =
$525,000.

Large Company Y = ($210,000/vessel) x (150 shipments
avg. 55,000 tons) / (10 shipments/vessel) =
$3,150,000.

Small Company's NET EXP =
.002 x (2,077,214,825 - 119,200,000) +
.025 x (379,627,325 - 119,200,000) + 525,000 =
$10,951,713.

Large Company's NET EXP =
.012 x (2,077,214,825 - 119,200,000) +
.150 x (379,627,325 - 119,200,000) + 3,150,000 =
$65,710,277.

APPENDIX V, Continued

Example 7 Equations
Cleanup Equipment: Y Investment by Single Company in Gulf Cleanup Equipment (Corpus Christi Area)

CAP = (no. skimmers) x (days) x (hrs./day) x (cleanup rate/hr.)

CAP = (10 skimmers) x (6 days) x (12 hours/day) x (71.43 tons/hr.) = 51,430 tons.

CLEAN = (CAP(public) + CAP(private)) x (EFF)

CLEAN = (51,430 tons) x (0.5) = 25,715 tons.

EXPOSURE(1) = ((32,750) x (.35) x (200,000 - 25,715)) + 250,000 + 811,000 + ((245) x (200,000)) = $2,047,802,813.

EXPOSURE(2) = ((32,750) x (.35) x (55,000 - 25,715)) + 250,000 + 811,000 + ((245) x (55,000)) = $350,215,313.

Small Company P(1) = (.0125) x (0.16) x (1.0) = 0.002.
Small Company P(2) = (.0125) x (2.0) x (1.0) = 0.025.

Large Company P(1) = (.075) x (0.16) x (1.0) = 0.012.
Large Company P(2) = (.075) x (2.0) x (1.0) = 0.150.

Small Company Y = $260,000.

Large Company Y = $260,000.

Small Company's NET EXP = .002 x (2,047,802,813 - 0) + .025 x (350,215,313 - 0) + 260,000 = $13,110,989.

Large Company's NET EXP = .012 x (2,047,802,813 - 0) + .150 x (350,215,313 - 0) + 260,000 = $77,365,931.

APPENDIX CH. V, Continued

Example 8 Equations
Cleanup Equipment: Y Investment by Coperative in Gulf Cleanup Equipment (Corpus Christi Area)

CAP = (10 skimmers) x (6 days) x (12 hours/day) x (71.43 tons/hr.) = 51,430 tons.

CLEAN = (51,426 tons) x (0.5) = 25,715 tons.

EXPOSURE(1) = ((32,750) x (.35) x (200,000 - 25,715)) + 250,000 + 811,000 + ((245) x (200,000)) = $2,047,802,813.

EXPOSURE(2) = ((32,750) x (.35) x (55,000 - 25,715)) + 250,000 + 811,000 + ((245) x (55,000)) = $350,215,313.

Small Company P(1) = (.0125) x (0.16) x (1.0) = 0.002.
Small Company P(2) = (.0125) x (2.0) x (1.0) = 0.025.

Large Company P(1) = (.075) x (0.16) x (1.0) = 0.012.
Large Company P(2) = (.075) x (2.0) x (1.0) = 0.150.

Small Company Y = (.05 tonnage among cooperative members) x ($260,000 for additional boom) = $13,000.

Large Company Y = (.30 tonnage among cooperative members) x ($260,000 for additional boom) = $78,000.

Small Company's NET EXP = .002 x (2,047,802,813 - 0) + .025 x (350,215,313 - 0) + 13,000 = $12,863,989.

Large Company's NET EXP = .012 x (2,047,802,813 - 0) + .150 x (350,215,313 - 0) + 78,000 = $77,183,931.

APPENDIX V, Continued

Example 9 Equations
Improving Cleanup Effectiveness: Y Investment in Training, Simulations, and Surprise Tests (Corpus Christi Area)

Alternative A - 10% Improvement in EFF

10% improvement in EFF = (existing Gulf EFF) x (degree of enhancement in EFF)

EFF (10% improvement) = (0.5) x (1.10) = 0.55.

CLEAN (10% improvement in EFF) = (46,287 tons) x (0.55) = 25,458 tons.

EXPOSURE (1) = ((32,750) x (.35) x (200,000 - 25,458)) + 250,000 + 730,000 + ((245) x (200,000)) = $2,050,677,675.

EXPOSURE (2) = ((32,750) x (.35) x (55,000 - 25,458)) + 250,000 + 730,000 + ((245) x (55,000)) = $353,080,175.

Small Company P(1) = (.0125) x (0.16) x (1.0) = 0.002.
Small Company P(2) = (.0125) x (2.0) x (1.0) = 0.025.

Large Company P(1) = (.075) x (0.16) x (1.0) = 0.012.
Large Company P(2) = (.075) x (2.0) x (1.0) = 0.150.

Small Company Y = $210,000
Large Company Y = $210,000

Small Company's NET EXP =
.002 x (2,050,677,675 - 0) +
.025 x (353,080,175 - 0) + 210,000 =
$13,138,359.

Large Company's NET EXP =
.012 x (2,050,677,675 - 0) +
.15 x (353,080,175 - 0) + 210,000 =
$77,780,158.

APPENDIX V, Continued

Example 9 Equations
Improving Cleanup Effectiveness: Y Investment in Training, Simulations, and Surprise Tests
(Corpus Christi Area)

Alternative B - 5% Improvement in EFF

EFF (5% improvement) = (0.5) x (1.05) = 0.525.

CLEAN(5% improvement in EFF) = (46,287 tons) x (0.525) = 24,300 tons.

EXPOSURE(1) = ((32,750) x (.35) x (200,000 - 24,300)) + 250,000 + 730,000 + ((245) x (200,000)) = $2,063,941,250.

EXPOSURE(2) = ((32,750) x (.35) x (55,000 - 24,300)) + 250,000 + 730,000 + ((245) x (55,000)) = $366,353,750.

Small Company P(1) = (.0125) x (0.16) x (1.0) = 0.002.
Small Company P(2) = (.0125) x (2.0) x (1.0) = 0.025.

Large Company P(1) = (.075) x (0.16) x (1.0) = 0.012.
Large Company P(2) = (.075) x (2.0) x (1.0) = 0.150.

Small Company Y = $210,000
Large Company Y = $210,000

Small Company's NET EXP =
.002 x (2,063,941,250 - 0) +
.025 x (366,353,750 - 0) + 210,000 =
$13,496,727.

Large Company's NET EXP =
.012 x (2,063,941,250 - 0) +
.15 x (366,353,750 - 0) + 210,000 =
$79,930,358.

APPENDIX V, Continued

Example 9A Equations
Improving Cleanup Effectiveness
(Corpus Christi Area)

Determining the Degree of Improvement Necessary
Before a Company Will Undertake Y Expenditure

Small Company Example:

Y outlay for EFF training = $210,000.

Management decision: 5:1 ratio of
(reduction in NET EXP):(Y).

NET EXP must be reduced by (210,000) x (5) = 1,050,000.

New NET EXP must be: (13,645,118) - (1,050,000) =
$12,595,118.

New CLEAN required to generate new NET EXP:

(.002) x ((32,750)x(.35)x(200,000-CLEAN)+250,000+730,000+
(245x200,000))
+
(.025) x ((32,750)x(.35)x(55,000-CLEAN)+250,000+730,000+
(245x55,000))
+
210,000 = new NET EXP = 12,595,118.

Therefore, CLEAN = 26,534.5 tons.

Having determined new CLEAN, a new EFF level must be identified:

CLEAN = 26,534.5 = (9 skimmers)x(6 days)x(12 hrs./day)x(71.43 tons/hr.)x(EFF).

Therefore, EFF = 0.588092.

The degree of improvement required from old EFF to new EFF = 17.62%

Thus, the degree of improvement which must be demonstrated by a vendor of cleanup oriented training to induce a company to undertake a Y investment of $210,000 where the company seeks a 5:1 return in reduced NET EXP is 17.62%. That is, the training must be demonstrated to produce a 17.62% improvement in cleanup efficiency and effectiveness.

APPENDIX V, Continued

Example 10
Reducing Probability of a Spill - Crew Training
(Corpus Christi Area)

Determining the Degree of Improvement Necessary
Before a Company Will Undertake Y Expenditure

Small Company Example:

Y outlay for crew training = $37,500.

Management decision: 5:1 ratio of
(reduction in NET EXP):(Y).

NET EXP must be reduced by (37,500) x (5) = 187,000.

New NET EXP must be: (13,645,118) - (187,000) = $13,458,118.

New FACTOR required to generate new NET EXP:

((.0125)x(.16)x(FACTOR)) x (2,077,214,825-0)
+
((.0125)x(2.0)x(FACTOR)) x (379,627,325-0)
+
37,500 = new NET EXP = 13,458,118.

Therefore, FACTOR = 0.984.

The degree of improvement required from old FACTOR to new FACTOR = 1.60%

Thus, the degree of improvement which must be demonstrated by a vendor of crew training to induce a company to undertake a Y investment of $37,500 where the company seeks a 5:1 return in reduced NET EXP is 1.60%. That is, the training must be demonstrated to produce a 1.60% improvement in spill prevention probability.

APPENDIX V, Continued

Example 11 Equations
Reducing Probability of a Spill (Corpus Christi Area)

Determining the Degree of Improvement Necessary
Before a Company Will Undertake Y Expenditure

Alternative A - Navigation Aids

Small Company Example:

Y outlay for vessel navigation aids =
$150,000 per ship x 25 shipments/10 shipments per vessel = $375,000.

Management decision: 5:1 ratio of
(reduction in NET EXP):(Y).

NET EXP must be reduced by (375,000) x (5) = 1,875,000.

New NET EXP must be: (13,645,118) - (1,875,000) =
$11,770,118.

New FACTOR required to generate new NET EXP:

((.0125)x(.16)x(FACTOR)) x (2,077,214,825-0)
+
((.0125)x(2.0)x(FACTOR)) x (379,627,325-0)
+
375,000 = new NET EXP = 11,770,118.

Therefore, FACTOR = 0.835.

The degree of improvement required from old FACTOR to new FACTOR = 16.5%

Thus, the degree of improvement which must be demonstrated by a vendor of navigational aids to induce a company to undertake a Y investment of $375,000 where the company seeks a 5:1 return in reduced NET EXP is 16.5%. That is, the navigational aids must be demonstrated to produce a 16.5% improvement in spill prevention probability.

APPENDIX V, Continued

Example 11 Equations
Reducing Probability of a Spill (Corpus Christi Area)

Determining the Degree of Improvement Necessary
Before a Company Will Undertake Y Expenditure

Alternative B Vessel Retrofitting

Small Company Example:

Y outlay for vessel retrofit =
$1.5 million per ship x 25 shipments/10 shipments per vessel = $3.75 million.

Management decision: 5:1 ratio of (reduction in NET EXP):(Y).

NET EXP must be reduced by (3,750,000) x (5) = 18,750,000.

New NET EXP must be: (13,645,118) - (18,750,000) = $0. (*)

(*) Conclusion: For Small Company, it is not possible to achieve a 5:1 reduction in NET EXP through this level of Y expenditure. NET EXP can only be reduced by $13,645,118, achieving at best a 3.3:1 (reduction in NET EXP):(Y investment) ratio.

APPENDIX V, Continued

Example 12
Reducing Cost Consequnces - Legislation
(Corpus Christi Area)

Alternative A: Limiting Liabilities for Spill Damage

What Y Investment Will A Company Be Willing To Make, Given Its NET EXP?

Objective: Generate legislation setting a limit of $200,000,000 for total liability for damages from a single oil spill event.

Question: What is the change in NET EXP that results from having a $200 million limit rather than the present unlimited liability regime:

A $200 million damage limit means that where DAMAGES(i) x IMPACT x (V(i)-CLEAN) = $200 million, then $200 million is used in place of DAMAGES(i) x IMPACT x (V(i)-CLEAN).

For a catastrophic spill occurring in the Corpus Christi area:

EXPOSURE(1):

DAMAGES(i) x IMPACT x (V(1)-CLEAN) = ($27,500) x (.35) x (200,000-23,142) = $1,702,258,250.

Since $200 million is less than $1,7 billion, $200 million is used instead of $1.7 billion.

Therefore, EXPOSURE(1) = 200,000,000 + (5,250)x(.35)x(200,000-23,142) + 250,000 + 730,000 + (245x200,000) = $574,956,575.

EXPOSURE(2):

DAMAGES(i) x IMPACT x (V(2)-CLEAN) = ($27,500) x (.35) x (55,000-23,142) = $306,633,250.

Since $200 million is less than $306.6 million, $200 million is used instead of $306.6 million.

Therefore, EXPOSURE(2) = 200,000,000 + (5,250)x(.35)x(55,000-23,142) + 250,000 + 730,000 + (245x55,000) = $272,994,075.

APPENDIX V, Continued

Example 12 Equations
Reducing Cost Consequnces - Legislation
(Corpus Christi Area)

Alternative A, continued

Small Company NET EXP and Y:

The new NET EXP(Small) if a $200 million liability ceiling exists:

New NET EXP(Small) = (.002 x 574,956,575) + (.025 x 272,994,075) = $7,974,765.

The improvement in NET EXP(Small) is therefore:
$13,645,118 - 7,974,765 = $5,670,353.

If Small Company wants to receive a 5:1 ratio for (reduction in NET EXP):(Y), then Small Company will be willing to expend:

5 x Y = 5,670,530. Y = $1,134,071.

Large Company NET EXP and Y:

The new NET EXP(Large) if a $200 million liability ceiling exists:

New NET EXP(Large) = (.012 x 574,956,575) + (.15 x 272,994,075) = $47,848,590.

The improvement in NET EXP(Large) is therefore:
$81,870,703 - 47,848,590 = $34,022,113.

If Large Company wants to receive a 5:1 ratio for (reduction in NET EXP):(Y), then Large Company will be willing to expend:

5 x Y = 34,022,113. Y = $6,804,423.

APPENDIX V, Continued

Example 12 Equations
Reducing Cost Consequnces - Legislation
(Corpus Christi Area)

Alternative B: Limiting Cleanup Obligations of Companies
What Y Investment Will A Company Be
Willing To Make, Given Its NET EXP?

Objective: Generate legislation setting a limit of $30,000,000 for total liability for cleanup expenses by third parties and government from a single oil spill event.

Question: What is the change in NET EXP that results from having a $30 million cleanup limit rather than the present unlimited liability regime (note: cleanup liability is presently limited for expenditures by the federal government, but is unlimited for expenditures by states, counties, and private parties)

A $30 million cleanup limit means that where
F(k) + ONSHORE(i) x (V(i)-CLEAN) = $30 million, then $30 million is used in place of F(k) + ONSHORE(i) x IMPACT x (V(i)-CLEAN).

For a catastrophic spill occurring in the Corpus Christi area:

EXPOSURE(1):

F(k) + ONSHORE(i) x IMPACT x (V(i)-CLEAN) = 730,000 + (5,000) x (200,000-23,142) = $310,231,500.

Since $30 million is less than $310.2 million, $30 million is used instead of $310.2 million.

Therefore, EXPOSURE(1) = 30,000,000 + (.35)x(27,750)x(200,000-23,142) + 250,000 + (245x200,000) = $1,796,983,000.

EXPOSURE(2):

F(k) + ONSHORE(i) x IMPACT x (V(i)-CLEAN) = 730,000 + (5,000) x (55,000-23,142) = $56,481,500.

Since $30 million is less than $56.4 million, $30 million is used instead of $56.4 million.

APPENDIX V, Continued

Example 12 Equations
Reducing Cost Consequnces - Legislation
(Corpus Christi Area)

Alternative B, continued

Therefore, EXPOSURE(2) = 30,000,000 + (.35)x(27,750)x(55,000-23,142) + 250,000 + (245x55,000) = $353,145,820.

Small Company NET EXP and Y:

The new NET EXP(Small) if a $30 million cleanup liability ceiling exists:

New NET EXP(Small) = (.002 x 1,796,983,000) + (.025 x 353,145,820) = $12,422,611.

The improvement in NET EXP(Small) is therefore:
$13,645,118 - 12,422,611 = $1,222,507.

If Small Company wants to receive a 5:1 ratio for (reduction in NET EXP):(Y), then Small Company will be willing to expend:

5 x Y = 1,222,507. Y = $ 244,501.

Large Company NET EXP and Y:

The new NET EXP(Large) if a $30 million cleanup liability ceiling exists:

New NET EXP(Large) = (.012 x 1,796,983,000) + (.15 x 353,145,820) = $74,535,669.

The improvement in NET EXP(Large) is therefore:
$81,870,703 - 74,535,669 = $7,335,034.

If Large Company wants to receive a 5:1 ratio for (reduction in NET EXP):(Y), then Large Company will be willing to expend:

5 x Y = 7,335,034. Y = $1,467,007.

APPENDIX CH. V, Continued

Example 13 Equations
Combining Alternatives

Large Company Example

Large Company elects the following three alternatives:
- P&I Coverage (plus TOVALOP-CRISTAL);
- Large Company purchase of 2,000 ft. boom;

- Large Company then wishes to know what level of improvement in vessel safety would be required to justify spending $225,000 on crew training, where Large Company wishes a 5:1 reduction of NET EXP for its Y(crew training) investment.

Step 1: P&I Insurance (See Example 5 Equations) and CLEAN Improvements (See Example 7 Equations):

INSURANCE = $319,200,000

CLEAN = (51,426 tons) x (0.5) = 25,715 tons.

Y(insurance) = $140,000/vessel x 15 vessels = $2,100,000.

Y(cleanup) = $260,000

EXPOSURE(1) = ((32,750) x (.35) x (200,000 - 25,715)) + 250,000 + 811,000 + ((245) x (200,000)) = $2,047,802,813.

EXPOSURE(2) = ((32,750) x (.35) x (55,000 - 25,715)) + 250,000 + 811,000 + ((245) x (55,000)) = $350,215,313.

Large Company NET EXP = .012 x (2,047,802,813 - 319,200,000) + .150 x (350,215,313 - 319,200,000) + 2,100,000 + 260,000 = $27,755,529.

APPENDIX CH. V, Continued

Example 13 Equations
Combining Alternatives

Large Company Example, continued

Step 2: Evaluation of additional Y expenditure on crew training (See Example 10 Equations):

Y(crew training) = $225,000.

Management decision: 5:1 ratio of
(reduction in NET EXP):(Y).

NET EXP must be reduced by (225,000) x (5) = 1,125,000.

New NET EXP must be: (27,755,529) - (1,125,000) = $26,630,529.

New FACTOR required to generate new NET EXP:

FACTOR = 0.951

The degree of improvement required from old FACTOR to new FACTOR = 4.9%

Therefore, the company, having undertaken Y(insurance) and Y(cleanup capability) expenditures, will require that a further Y expenditure on crew training will require a reduction in company exposure to spill events of 4.9%.