SCOPING RISK ASSESSMENT
PROTECTION AGAINST OIL SPILLS IN THE MARINE WATERS OF NORTHWEST WASHINGTON STATE

TECHNICAL APPENDICES

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16. Abstract

On April 28, 1996 the White House issued the Department of Transportation (DOT) Action Plan to Address Vessel and Environmental Safety in Puget Sound-Area Waters. The Action Plan outlines several related tasks, the first stage of which was to report to Congress on the development and implementation of a plan for a private sector international tug-of-opportunity system (ITOS) to provide emergency response in the waters off of the Olympic Coast and the Strait of Juan de Fuca. The second stage is the Secretary's review of the overall marine safety regime to determine whether other hazards--beyond those examined in the development of ITOS--warrant consideration of specific mitigation measures. This report has been prepared to facilitate the Secretary's review.

This report is the Technical Appendices to the main report, which was intended to provide information relevant to possible actions to increase safety of the waterways of northwest Washington State, including Puget Sound, Strait of Juan de Fuca, passages around and through the San Juan Islands, and the offshore waters of the Olympic Coast National Marine Sanctuary. This scoping risk assessment is an initial characterization of the hazards which can cause oil spills by ships underway and the environmental sensitivity to such spills; deaths, injuries, and property losses are not accounted for. This study also served as a pilot application of the Commandant (G-M) Risk Based Decision Making Guidelines. The insights gained from this study will be used for refining and expanding those Guidelines.

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Appendix A
Chapter 1

Contents

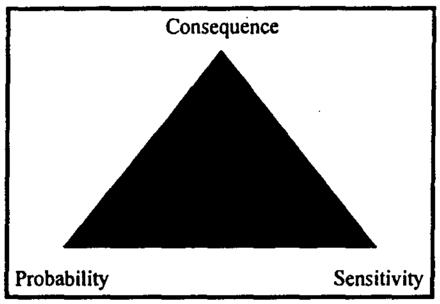
- Details relating to Section 1.3 "Approach"

APPENDIX A
CHAPTER 1

DETAILS RELATING TO SECTION 1.3 "APPROACH"

In order to best support decision-making for the concern of oil spills in Puget Sound area waters, a risk-based approach similar to that recently promulgated in the Coast Guard's Risk Based Decision Making (RBDM) Guidelines was utilized. By systematically decomposing the system, analyzing it and using probabilistic techniques to characterize potential accidents and causal events, a detailed picture of the system can be developed. The three primary characteristics of risk are shown in Figure A-1.

Fig A-1
Risk Characteristics



One of the first concepts that must be understood before undertaking risk-based decision making is that most fundamental notion- "What is risk?". Given the relatively recent development of the field of risk analysis and risk management, there has not been time to reach a consensus on the exact definition of this term. Here, we will define risk as the exposure to the chance of loss, or the combination of the probability of a hazard occurring and the significance of the consequence of the hazard occurring. Mathematically, this is can be interpreted as shown in Equation 1-1.

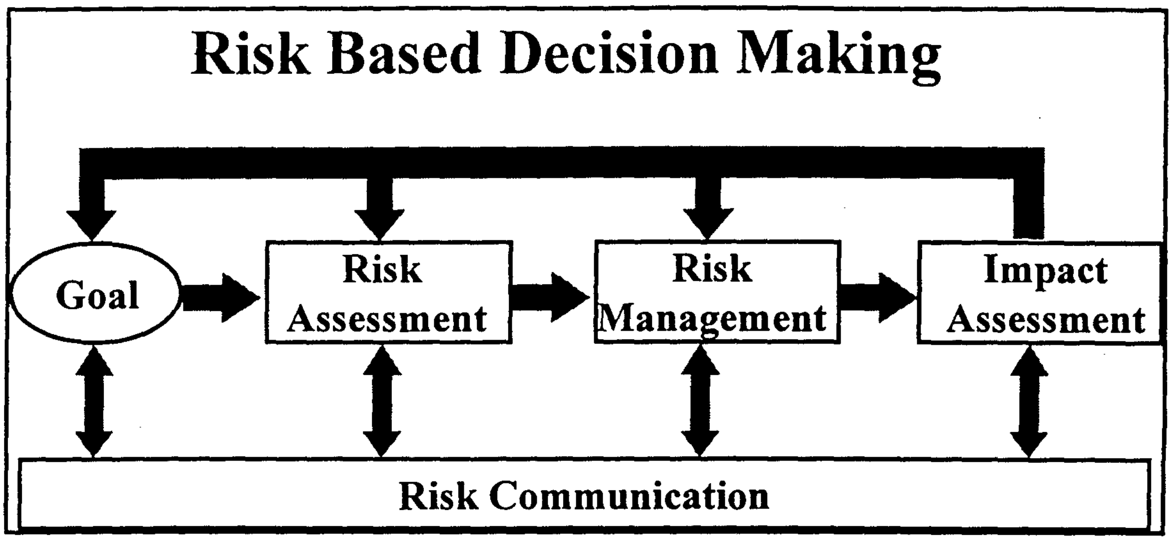
$$\text{Risk of a specific Hazard} \equiv \text{Probability of that Hazard} * \text{Consequence of that Hazard} \quad 1\text{-}1$$

Hazards are potential undesirable events in a given system along with their associated consequences and are characterized in terms of their associated consequence (dollars spent, lives lost, etc.). Risks incorporate the likelihood of experiencing that hazard. In attempting to prevent and mitigate hazards within the maritime system, we define and rank their associated risks.

Risk characteristics can be rated either qualitatively (e.g., low, medium or high) or quantitatively (e.g., dollar amounts or numerical probabilities). Quantitative ranking systems are easier to utilize, if the risk characteristics can be naturally derived from available data. Qualitative ranking systems are useful in comparing dissimilar risks or risks for which reliable data is not available. For this study, qualitative techniques were utilized due to the relatively small data set. As described in Chapter 2, we have combined results from expert elicitation and data using weighting factors to allow manual selection of the relative weights for local data and expert judgment. For this report, a weighting of 1:1 was utilized between local data and expert opinion. National and international data were not utilized in this study, although allowance was made in the worksheets for the inclusion of national data in future efforts by the Captain of the Port.

As described in the RBDM Guidelines, the risk based decision making process is composed of five major components, as shown in Figure A-2. This is intended to be an iterative process of continuous improvement.

Fig A-2
Risk-based Decision Making Process



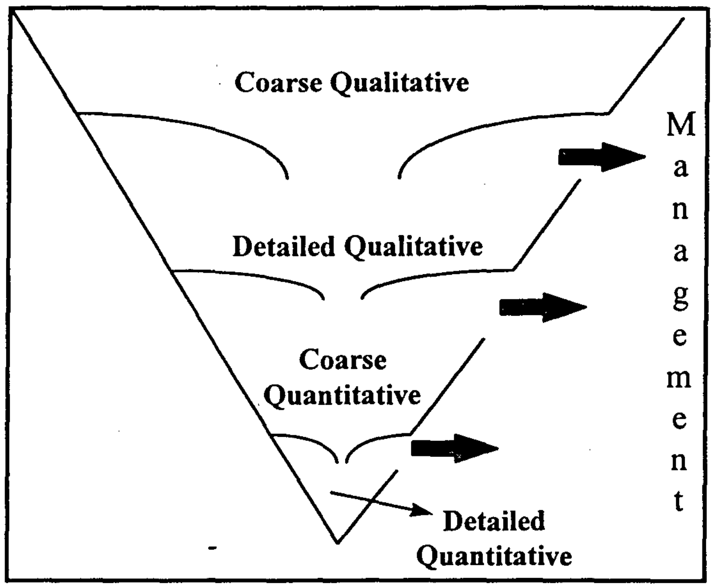
The first step in this decision making process is the identification and delineation of a set of goals for the group. With goals set, the risk assessment process can begin to focus on what, if any, areas for improvement are available.. As such, it attempts to provide answers to the following questions.

- What can go wrong?
- What is the likelihood that it will go wrong?
- What are the consequences?

The end result of the risk assessment process is a list of hazards ranked by risk. The goal of this phase, then, is to dissect the potential hazards to the system so that ready identification of risk management activities is possible.

In order to keep the process manageable, use of a hierarchical screening process as shown in Figure A-3 has been found to be well suited for the maritime industry. Here, high risk items (which would be relatively few in number) identified in a given stage will be evaluated in terms of manageability; those items for which hazard control measures are not readily available are then analyzed in greater detail. This is done using more detailed and complex methodologies in the subsequent assessment phase to determine the sub-components (e.g., causes, contributing factors) which contribute the most to the identified risk. This added "cost" would be offset somewhat by the reduction in the number of risks (reduced scope) provided by the progressive screening.

Figure A-3
Risk Assessment Schematic



Two aspects of Figure A-3 make subtle but very important points about the Risk Assessment process. First and foremost of these is the reduction in the area allocated for each phase. This inverted and divided triangle illustrates the different levels of time spent and number of items considered at each stage of the assessment. Specifically, the majority of the hazards should be screened out utilizing simple techniques, with the most involved techniques being reserved for only one or two of the hazard sub-components that do not lend themselves to effective management by less involved techniques. Second, this diagram shows that the assessment process can stop after any stage; you do not have to go through all stages of the analysis. If effective and efficient management measures can be developed after a given stage, or if the risks are low, then the shift from the Risk Assessment phase to the Risk Management stage should take place.

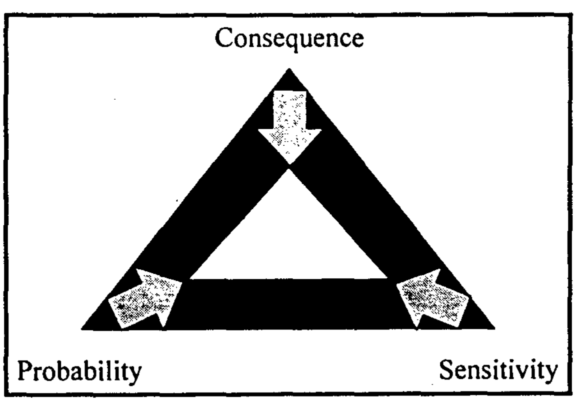
Once a screened and prioritized list of risks has been developed, a risk management action plan can be developed. Risk management is the process of evaluating alternative risk minimization/mitigation actions, selecting preferable countermeasures, and implementing them in an integrated fashion to optimize risk reduction efforts. As the risk countermeasures will vary widely for different situations, no comprehensive list of potential management actions is possible. However, by using a mix of prescriptive (typically detailed to account for/prevent specific situations) and performance based (typically flexible to manage a wide range of hazard scenarios) can be used to improve system performance. Furthermore, special emphasis must be placed on the risk management measures being an integrated package, with both existing measures and other new measures. With increasing integration between measures comes greater coherence and synergy between individual measures, and conflicts and confusion are avoided. Generally, risk management attempts to provide answers to the following questions.

- What can be done?
- What options are available and what are their associated tradeoffs?
- What are the effects of current decisions on future options?

The risk management phase uses the risk descriptions (consequence and probability) developed during the risk assessment phase. The three key characteristics of risk for management are probability, consequence and sensitivity, as was shown in Figure A-1. With information in these three areas, those involved in risk management can develop an integrated approach to risk control. In this manner, Figure A-4 can be used in a manner somewhat similar to the fire triangle, the goal being to move risks to lower likelihood and/or decreased consequence or until their sensitivity to risk management is low. For example, if a risk is considered high due to a high likelihood, then countermeasures must be developed to prevent the mishap from occurring. This would be done by tracing back through the causal chain (described next) and implementing countermeasures to prevent accident precursors (e.g., safe life design, where the system/component is designed to not fail during its rated lifetime).

Similarly, if a risk is considered high due to a high consequence, then measures must be developed to minimize the potential effect (e.g., fail safe design, where the system is designed to remain in a safe state even if individual components fail). Sensitivity is used as an indicator of the potential efficiency and effectiveness of risk management (i.e., hazards with high sensitivity are more manageable than those with low). In Figure A-2, the precept is that risk management is applied to the hazard until the sensitivity decreases to a point where further risk management is not attractive as an option. The sensitivity of a risk to these countermeasures is thus an important factor in prioritizing management activities. After all, why allocate all your resources to risks which do not have the potential to respond well to management?

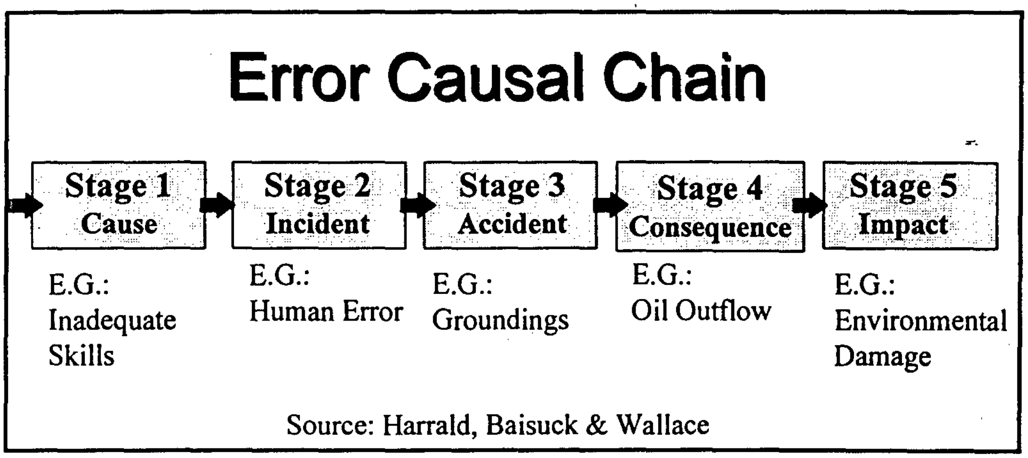
Figure A-4
Management of Risk Characteristics



The causal chain is a description of how mishaps are generated, propagate, and develop. A hypothetical error chain is shown in Figure A-5. Here, the chain is subdivided into five stages.

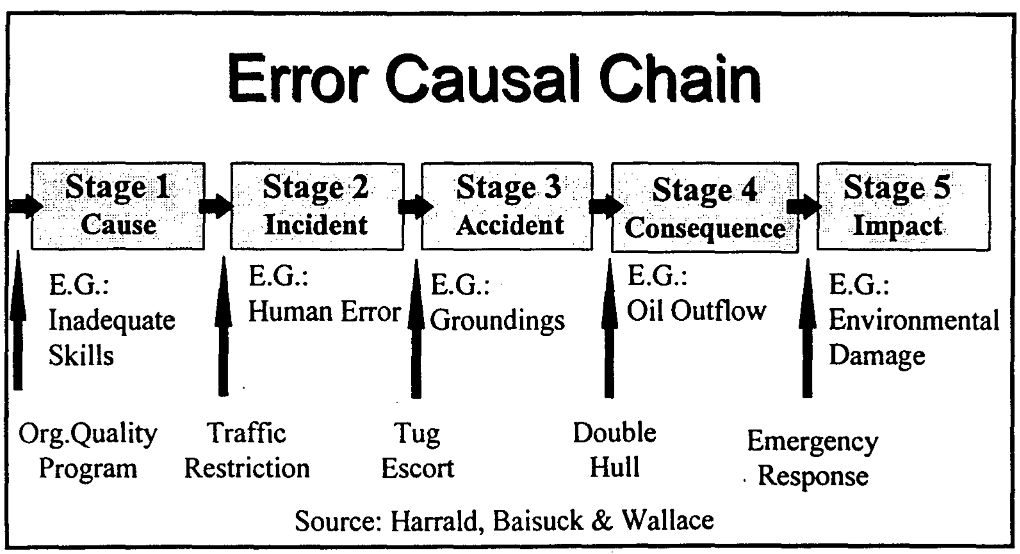
Examples for each stage are shown below each individual box. While the diagram shows the growth of a mishap from left to right, investigation and analysis follow the reverse path, from right to left.

Figure A-5
Error Causal Chain Schematic



Causal chains provide a powerful tool for developing risk management actions, through their graphical description of how mishaps develop. Countermeasures for various risks can then be seen as interruptions in the growth of the potential mishap, placing a break between stages. Figure A-6 shows an example of how risk management measures can be introduced at various points along the error chain to interrupt the disaster. It can readily be seen that the earlier countermeasures are enacted in the error chain (e.g., prevent error causes versus minimize accident impact), the more effective and efficient they will be.

Figure A-6
Introduction of Countermeasures to Interrupt Error Chain



As shown, risk management measures can take many forms and can be enacted throughout the life cycle of the system. To generally categorize risk management measures, we use the taxonomy shown in Table A-1. Included in Table A-1 are examples of risk management measures for a potential fishing derby.

Table A-1
Risk Management Categories

Category	Description	Example
S	Spread Out	Require port partnerships allocate funds for spill prevention, response
T	Transfer	Relocate port facilities
A	Accept	Do nothing
A	Avoid	Find alternative energy supply/source.
R	Reduce	Require masters to participate in yearly waterway familiarization refresher course

Potential risk management measures are often difficult to compare and contrast, due to their wide range of effects. Three general measures by which risk management techniques can be assessed are identified and defined in Table A-2.

Table A-2
Risk Management Measurement Criteria

Criterion	Description
Efficacy	The degree to which the risk will either be eliminated or minimized by the proposed action
Feasibility	The acceptability of implementing the proposed preventative action (economic, legal, physical, political, social, technical, etc.) as well as the technical feasibility.
Efficiency	The cost-effectiveness of the proposed action in terms of potential dollars lost if no action is taken versus the cost of the action.

After the risk management plan has been developed and implemented, an assessment of the effect of the countermeasures used must be conducted. As with all the data collection and analysis in this process, both subjective and objective means should be used to identify and rank the changes in risk resulting from Risk Management activities.

As shown in Figure A-2, effective Risk Communication is a two-way process that must take place throughout the risk-based decision making process. For this study, it started in the development of goals for the project, with which some stakeholders were very involved. This participation was fostered and encouraged throughout the process. Work with the stakeholders continued with three Public Workshops and docket, which collected concerns about the hazards inherent in the system as well as potential additional measures, which was used by both Volpe researchers and the Expert Panel. The final workshop communicated a prioritized list of risks to the stakeholders. Once the stakeholders have had time to review and discuss the assessment results, the communication will continue by way of them providing input for determining appropriate management actions. Finally, reports on the results should be made to stakeholders and to senior policy personnel.

For this project, the goals as put forth by the Administration and DOT were clear; perform a risk assessment to look into the risks of oil spills in Puget Sound area waters. As directed by OST, the deliverable for this project was the development of a risk-ranked list of hazards, the typical result of the risk assessment phase. With this listing and the characterizations of the waterway, determinations concerning the effectiveness of the current and planned risk management system can be made. Additionally, given that this study was but one step in a longer process, great pains were taken to make the process and results of this study as exportable as possible to subsequent risk management and risk assessment efforts.

In conducting the analysis, we have endeavored to obtain and utilize the best sources of information available, both objective and subjective. While the primary source sought was always an objective one (e.g., accident databases, traffic data), acknowledged gaps and weaknesses in the data precluded reliance solely on these sources. In these instances, expert judgment was sought and obtained to fill in gaps and buttress areas of concern. For this report, an equal weighting between objective data and subjective data was used, although provisions have been made in the Microsoft Excel files to allow modifications in subsequent analyses by the District/COTP. Specific data sources utilized are shown in Table A-3.

Table A-3
Data Sources

Data Need	Objective Source	Subjective Source
Traffic	USCG VTS, Canadian VTS, Army Corps of Engineers	Checked by USCG and Canadian VTS, Marine Exchange, Public Workshops
Accidents	USCG, WA State DOE, WA State OMS	Public Workshops, Expert Panel, Docket
Weather	Coast Pilot, Captain Jack's	Checked by VTS, Pilots
Environmental Sensitivity	NRDM, DOE	Public Workshops, Docket, Expert Panel

Further details on this process can be found in the Risk Based Decision Making Guidelines developed by the Coast Guard and other technical references. The goal here was to provide an overview of this process and describe how this study fits within the framework of a larger, continuous improvement process. It should be noted that this report significantly advances efforts by the local Captain of the Port (COTP) by performing the first step on the road to continuous improvement of the local waterway management system.

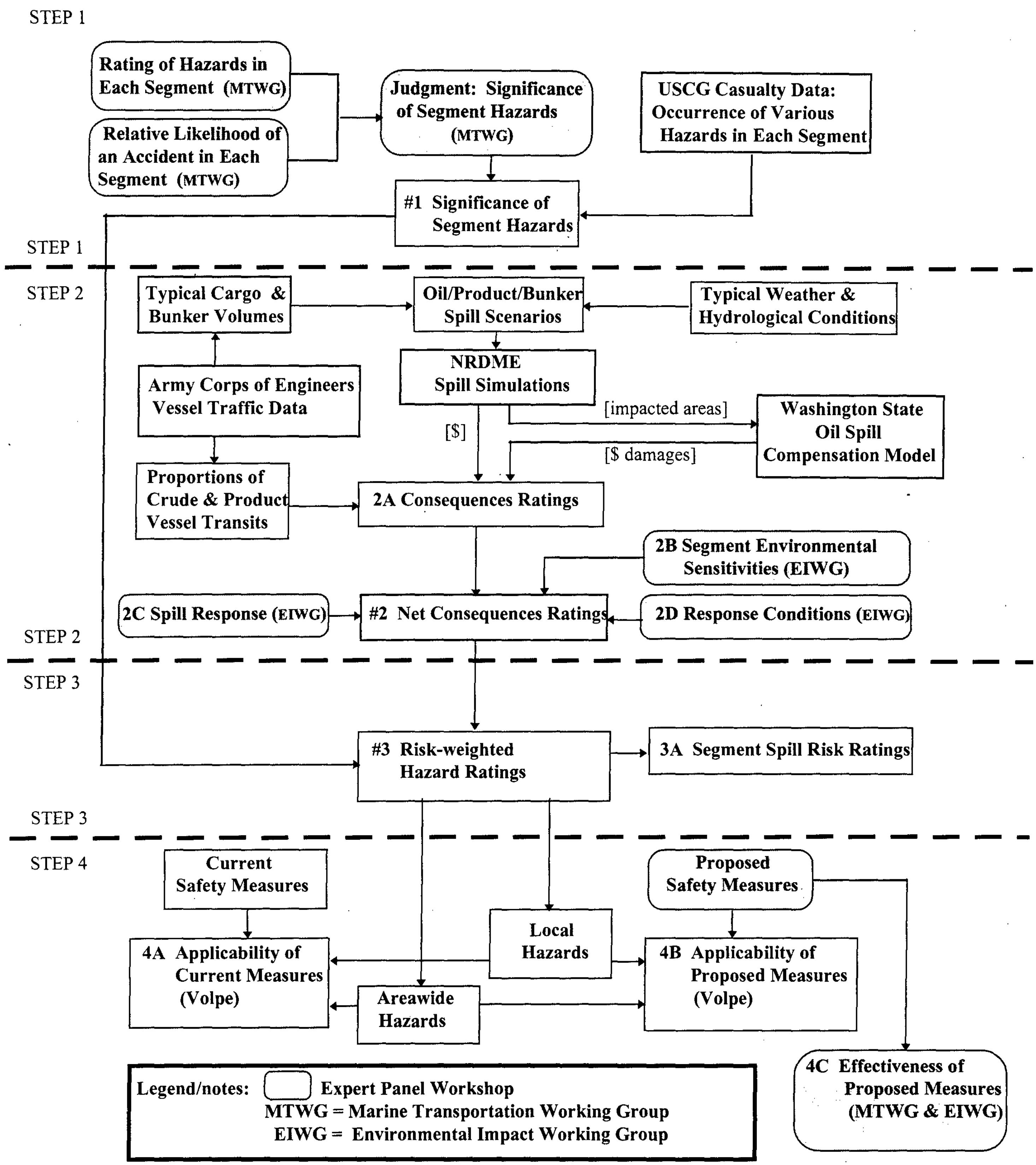
APPENDIX B
CHAPTER 2

DETAILS OF STUDY METHODOLOGY

NOTE:

This appendix contains all of the forms/tables developed to assess the significance of hazards and net consequences of spills, create the risk-ranked list of hazards, and evaluate current and proposed safety measures. The order follows the discussion of chapter 2, section 2 Task Flow. Each form can be found on the overview task flow diagram below, by corresponding number. Note that some of the forms for evaluating current and proposed safety measures (step 4) were not used in this assessment of risk. These forms and the methodology they support would, however, be appropriate for subsequent risk management efforts by waterway managers.

METHODOLOGY FOR ASSESSING MARITIME HAZARDS & SAFETY MEASURES 6/20//97



#1 SIGNIFICANCE OF SEGMENT HAZARDS

6/20/97

Segment No. __ Relative Liklihood of a Spillage Accident: USCG data = ___ (A_U) MTWG judgement = ___ (A_M) Hazard	Frequency of Occurrence in Segment Casualties (USCG: 1986-96) Count	Rating (R_U)	Significance of Segment Hazards (USCG data) $[R_U * A_U = HS_U]$	Rating of Hazards in Segment (MTWG) (R_M)	Significance of Segment Hazards (MTWG judgement) $[R_M * A_M] = HS_M$	Overall Significance of Segment Hazards (HS) $[(HS_U + HS_M)/2]$	Rating
FACTORS IN COLLISIONS (C)							
C1 Poor Positional Information							
C2 Vessel Control and Other Deficiencies & Failures							
C3 Human and Organizational Deficiencies							
C4 Conflicting Vessel Operations	~~low~~		~~high~~				
C5 Physical Features							
FACTORS IN POWERED GROUNDINGS (P)							
P1 Poor Positional Information							
P2 Vessel Control and Other Deficiencies							
....							

Based on the USCG casualty and spill data for the study area for the years 1986-1996. The number of accidents in the CG database for each segment are used to derive a rating of relative probability of an accident, on a proportional, 0-1, scale where the number occurring in the segment is divided by the total for the study area. A rating for relative probability of a spill in the segment is similarly derived. A_U is the arithmetic average of the accident probability and spill probability ratings for the segment.

Based on results of MTWG voting in answer to the question, "What is the relative likelihood that an accident resulting in a spill of 10,000 gals would happen in this segment." where - low $\longrightarrow$ high

1 2 3 4 5

Voting results were converted from this (Likert) scale to a proportional 0-1 scale by the formula: y = (x-1)/4 in order to perform arithmetic operations.

Number of times this hazard was a factor in a segment accident recorded in the USCG casualty databases (VCAS & MINMOD) for the years 1986-96. More than one hazard may have been a factor in a given accident (i.e., a combination of hazards/conditions may have been responsible for an accident)

Count for this hazard divided by the total hazard count for the segment (i.e., overall number of hazard occurrances for the segment). Results lie on a proportional, 0-1, scale where a higher decimal means the hazard is more often a factor in segment accidents.

Combined results of MTWG voting on the relative likelihood of certain accident types in this segment and the relative likelihood that an accident of each type would be caused by this hazard. Results of the multiplication of the respective (Likert scale) votes are then rescaled from a 1-25 range to a 0-1 basis. Yields a rating of the significance of this hazard relative to other hazards for the segment.

Significance of a segment hazard with respect to the entire waterway (HS_U). This is done by weighting (multiplying) the within-segment rating (R_U) by the segment's rating for the liklihood of an accident, compared to other segments (A_U). A similar procedure is followed for the results of expert judgement (R_M, A_M) and then the two significance ratings are averaged to arrive at an overall figure, again a decimal on a 0-1 scale.

#1 SIGNIFICANCE OF SEGMENT HAZARDS

6/20/97

Hazards		Overall Significance of Segment Hazards (HS)								
		1	2	3	4	5	6	7	8	9
FACTORS IN COLLISIONS (C)										
C1	Poor Positional Information -									
C2	Vessel Control and Other Deficiencies & Failures									
C3	Human and Organizational Deficiencies-									
C4	Conflicting Vessel Operations -									
C5	Physical Features -									
FACTORS IN POWERED GROUNDINGS (P)										
P1	Poor Positional Information -									
P2	Vessel Control and Other Deficiencies & Failures									
P3	Human and Organizational Deficiencies-									
P4	Conflicting Vessel Operations -									
P5	Physical Features -									
FACTORS IN DRIFT GROUNDING (D)										
D1	Poor Positional Information -									
D2	Vessel Control and Other Deficiencies & Failures									
D3	Human and Organizational Deficiencies-									
D4	Conflicting Vessel Operations -									
D5	Physical Features -									
ALLISION										
FIRE/EXPLOSION										
STABILITY FAILURE										
STRUCTURAL FAILURE										
OTHER										

Arithmetic average of the Significance of Segment Hazards based on (1) USCG casualty data and (2) the voting of the Marine Transportation Working Group. Results from the preceding worksheet are presented on a proportional (0-1) scale where the higher the decimal, the higher the significance.

2A Consequence Rating (NRDME; WA State Oil Spill Compensation Model)

Segment	Crude (C)				Product (P)				Bunker Fuel (B)				Consequences	
	Damages ($000)		Portion	Weighted	Damages ($000)		Portion	Weighted	Damages ($000)		Portion	Weighted	Overall	Rating
	winter (W)	spring (S)	transits (T)	Damage [(W+S)/2*T]	winter (W)	spring (S)	transits (T)	Damage [(W+S)/2*T]	winter (W)	spring (S)	Transits (T)	Damage [(W+S)/2*T]	Damages [C+P+B]	
1														
2														
3														
4														
5														
6														
7														
8														
9														
average														

Damages calculated by the NRDME or the WA Oil Spill Compensation model for a spill of crude in this segment in winter.

Portion of all transits of large vessels that are laden crude tank vessels. "Large vessels" includes all tankers and tank barges plus other commercial and military vessels that typically carry substantial amounts of bunker fuel, including ferries and tow vessels (note that a tug towing a tank barge are counted as two transits). This factor incorporates the relative exposure (to spill accidents) of crude carriers.

Damage estimates are converted to ratings on a Likert scale (1-5) so the results may be combined with expert judgement of environmental sensitivity. A rating of 1.0 is given to the segment with the lowest consequence and 5.0 to the one with the highest. The following conversion algorithm maintains proportionality:

$Y = 4((X-X_{MIN})/(X_{MAX}-X_{MIN})) +1$

2B Segment Environmental Sensitivities (Environmental Impact Working Group) 6/20/97

Segment	Fin Fish (F)	Aquaculture/ Shellfish (A)	Marine Mammals (M)	Recreational Areas & Parks (R)	Cultural & Archeological Resources (C)	Birds (B)	Shoreline Habitats (H)	Overall Score [(F+A+M+R +C+B+H)/7]	Adjusted Panel Ratings
1									
2									
4									
5									
6									
7									
8									
9									
average									

Relative sensitivity of this factor in each of the segments, using a 1-5 scale where -
1 2 3 4 5
lower → higher

Ratings for the seven factors are averaged to obtain the overall score.

Ratings for the 9 segments, derived as the average of the ratings for the 7 factors, ranged from a low of 3.4 to a high of 4.4. The EIWG rescaled these results on a 3-5 scale to improve the discrimination between segments.

2C Spill Response

Rating of the capability of equipment and personnel and the time it takes for them to reach the scene and the ability to take defensive measures to protect particularly sensitive areas.

Rating assigned by the EIWG based upon average scores.

6/20/97

Segment	Containment & Recovery (R)		Defensive Measures (D)		Cleanup (C)	Salvage (S)		Spill Response Rating	
	Assets	Time	Assets	Time	(Assets only)	Assets	Time	Overall Average $[(R_{ave}+D_{ave}+C+S_{ave})/4]$	EIWG Rating
1									
2									
4									
5									
6									
7									
8									
9									
average									

Rating of the relative quality and quantity of assets that can be brought into play in a timely fashion, on a 1-5 scale where-
1 2 3 4 5
lower —— wwy ave → higher

Rating of the relative quickness with which assets can be brought to bear, on a 1-5 scale where -
1 2 3 4 5
slower —— wwy ave → faster

Only the capability of assets are evaluated as quick response time is not an issue for clean up.

The EIWG felt that assets were a more significant determinant of response capability than response time. Accordingly, those ratings were given a weight of two when calculating the average rating for a response category.

2D Response Conditions

Segment	Rating
1	
2	
3	
4	
5	
6	
7	
8	
9	
average	

Rating of the weather and hydrological conditions (winds, seas state, current, tides, visibility) likely to be encountered during response operations. Ratings reflect typical conditions for the segment compared the the waterway as a whole on a 1-5 scale where -

1 2 3 4 5

worse ——— wwy ———→ better

ave

Segment	2A Consequence Ratings: NRDME (C_1)	2A Consequence Ratings: WA Model (C_2)	2A Consequence Ratings: Composite Rating $[(C_1 + C_2)/2 = C_C]$	2B Environmental Sensitivity (ES)	2C Spill Response ($<SR>$)	2D Response Conditions ($<RC>$)	Net Consequence Rating $[(3(C_C+ES)/2 + <SR> + <RC>)/5 = C_N]$
1							
2							
3							
4							
5							
6							
7							
8							
9							
average							

The rating from the worksheet is inverted about the mean for all segments to align the scale's orientation with those of 2A and 2B in which the higher the number, the worse the consequences. Note: The symbol <> denotes the inverted values.

A weighted average is used to obtain the overall rating in which the average of 2A and 2B, the consequences and sensitivity ratings, is deemed most significant. This is given a weight of 3. The effects of 2C and 2D are to somewhat increase or decrease the consequences of a spill and are each weighted 1.

Range of allowable values is from 1.0 to 5.0, where the higher the score, the higher the relative net consequences.

3A Segment Spill Risk Rating

Segment	Relative likelihood of Accident (LA)	Net Consequence Rating (C_N)	Interim result [$LA*C_N$]	Spill Risk Rating (SR)
1				
2				
3				
4				
5				
6				
7				
8				
9				
average				

Interim results for all 9 segments are converted to a Likert scale (1-5) where the segment with the highest risk is given a 5 and the one with the lowest is given a 1.

Risk is the product of the likelihood of a spill and the consequences should it occur. Here the ratings from steps 1 & 2 are multiplied to obtain a rating for the relative risk of a spill

Ratings from table #2 are converted proportionally to a decimal where the sum of all the ratings is 1.0:

$$Y_I = ((X_I-1)/4))/\sum_{1}^{9} I_i \text{ where } I_i = (X_i-1)/4$$

Arithmetic average of segment's ratings for accident likelihood based on (1) USCG casualty data, parameter A_U from table #1 and (2) MTWG judgement, parameter A_M from table #1.

Hazard	Segment 1 ($C_{N1} =$) Hazard Significance (HS_1)	Segment 1 ($C_{N1} =$) Weighted Hazard Significance [$WHS_1=HS_1*C_{N1}$]	Segment 2 ($C_{N2} =$) Hazard Significance (HS_2)	Segment 2 ($C_{N2} =$) Weighted Hazard Significance [$WHS_2=HS_2*C_{N2}$]		Waterway Total Weighted Hazard Significance [$WHS_1+WHS_2+...$]
FACTORS IN COLLISONS (C)						
C1 Poor Positional Information						
C2 Vessel Control and Other Deficiencies....						
C3 Human and Organizational Deficiencies						
C4 Conflicting Vessel Operations						
C5 Physical Features						
FACTORS IN POWERED GROUNDINGS (P)						
P1 Poor Positional Information						
P2 Vessel Control and Other Deficiencies						
...						

HS_1 is the rating for the significance of this particular hazard in segment 1, from table #1. Since this already incorporates relative accident probability for the segment, risk-weighting is done using the Net Consequences rating (C_N), not the Segment Spill Risk rating. Using the latter would "double count accident probability.

Results are used to produce a risk-ranked list of **area-wide** hazards.

C_N is the Net Consequences Rating for a segment from table #2 (C_{N1} would be the rating for segment 1).
WHS results are used to produce a risk-ranked list of **local** hazards. For example -
#1 C2 (collisions caused by vessel control or other deficiencies) in segment 4
#2 D1 (drift grounding caused by poor positional information) in segment 7
#...

Risk-ranked Hazards	Universal Safety Measures (UM)								
Area-wide	1	2	3	4	5	6	7	8	11
1									
20									
Local									
1									
10									

UM1 Crew proficiency and vessel manning
UM2 System requirements
UM3 Vessel screening
UM4 Systems status, testing/inspection & checks
UM5 Vessel operations
UM6 Positional information
UM7 Central vessel locational monitoring and control
UM8 Emergency procedures
UM9 Outflow mitigation [consequence mitigation only]
UM10 Spill Response planning & capability [" " "]
UM11 Financial responsibility/liability

In each cell is indicated the applicability of this (set of) measures to this hazard whereby -
■ = applicable
□ = not applicable
CP = counter productive (increases hazard)

Ratings in this section replicate corresponding cells of the section above.

Risk-ranked Hazards	Universal Safety Measures (UM)									
Area-wide	1	2	3	4	5	6	7	8	10	11
1										
20										
Local										
1										
10										

NM1 Bridge manning: crew & pilot
NM2 Traffic controls: TSS, one-way traffic
NM3 Special Areas (excluding ABTA)
NM4 Activity restrictions
NM5 Speed limits
NM6 Operator SOPs
NM7 VTS
NM8 AtoN
NM9 Tanker size limit [consequence mitigation only]
NM10 Tug escorts
NM11 ITOS

In each cell is indicated the applicability of this (set of) measures to this hazard whereby -
■ = applicable
□ = not applicable
CP = counter productive (increases hazard)
Applicability is without regard to the degree of implementation of these measures in various segments of the waterway. Use results in conjunction with NM implementation matrix.

Rating of effect of this measure on segment-specific hazard.

4A-3 Applicability of Current Safety Measures to Mitigation of Consequences

	Safety Measures				
Consequence Factors	**UM9**	**UM10**	**UM11**	**NM 3**	**NM9**
Amount Spilled					
Proximity of Spill to Sensitive Resources					
Amount Recovered					
Defensive Protection					
Restoration					

UM9 - Outflow mitigation
UM10 - Spill response planning & capability
UM11 - Financial responsibility/liability
NM3 - ABTA
NM9 - Tanker size limit

In each cell, the applicability of this (set of) measures to this factor which affects spill consequences whereby -
■ = applicable
□ = not applicable
CP = counter productive (increases hazard)

4B-1 Applicability of Proposed Safety Measures for Accident Prevention

Risk-ranked Hazards	Proposed Safety Measures (PM)								
Area-wide	1	2	3	4	5	6	7	8	9
1									
20									
Local									
1									
10									

PM1 Equipment
PM2 Emergency response
PM3 Crew enhancement
PM4 Public involvement
PM5 Port State control enhancement
PM6 Data issues
PM7 Systems analysis
PM8 Operational modifications
PM9 Other training & qualifications

In each cell is indicated the applicability of this (set of) measures to this hazard whereby -
■ = applicable
□ = not applicable
CP = counter productive (increases hazard)

4B-2 Applicability of Proposed Safety Measures for Mitigation of Consequences

	Consequence Factors			
Proposed Safety Measures	Amount Spilled	Amount Recovered	Defensive Protection	Restoration
Better coastal response capabilities (e.g. spill response vessel in Neah Bay, Gray's Harbor)				
Station a spill response vessel at other critical environmentally sensitive location(s)				
Local rapid-salvage capability in sensitive areas				
Dedicated vessel for deploying prepositioned skimmers, booms and other equipment				
Outflow mitigation systems on tank/freight vessels (e.g. quick closure valves for tank vents)				
Vessel fittings to speed transfer of contents to other spaces & connect to offloading equipment				
Establish international training standards for response to additional types of incidents				
Response plans for all vessel types				
Facilitate salvage contracting to minimize delays (e.g., COTP or open forum contracting)				
Increased consideration of alternative response technologies (e.g., dispersants, in situ burning)				
AC review GRP response strategies for shallow-water areas				

In each cell is indicated the applicability of this (set of) measures to this hazard whereby

- [shaded box] = applicable
- [empty box] = not applicable
- CP = counter productive (increases hazard)

4C-1 Effectiveness of Proposed Safety Measures for Accident Prevention (Marine Transportation Working Group) 6/4/97

	Segment									Waterway	
Proposed Safety Measure (category)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Total**	**Score**
Equipment											
Emergency Procedures											
Crew Enhancement											
Public Involvement											
Port State Contrl Enhancement											
Data Issues											
Systems Analysis											
Operational Modifications											
Other Training and Qualifications											

Each of the panel members and advisors allocated nine votes for the most effective measures for each of the waterway segments. Votes could be distributed in any manner among the nine categories Thus, if one felt that one category was much more effective in preventing accidents than the others, most, or all, 9 votes could be assigned to it; conversely, if there was little discrconseirable difference, all categories could be given a single vote.

The vote totals were converted into a 1-5 scoring scale, approximating a normal distribution, where -

1	2	3	4	5
low effectiveness	$\longrightarrow$			high effectiveness

4C-2 Effectiveness of Proposed Safety Measures for Consequence Mitigation (Environmental Impact Working Group) **6/4/97**

Proposed Safety Measures	Consequence Factors				
	Amount Spilled	Amount Recovered	Defensive Protection	Restoration	Overall Effectiveness
Better coastal response capabilities (e.g. spill response vessel in Neah Bay, Gray's Harbor)					
Station a spill response vessel at other critical environmentally sensitive location(s)					
Local rapid-salvage capability in sensitive areas					
Dedicated vessel for deploying prepositioned skimmers, booms and other equipment					
Outflow mitigation systems on tank/freight vessels (e.g. quick closure valves for tank vents)					
Vessel fittings to speed transfer of contents to other spaces & connect to offloading equipment					
Establish international training standards for response to additional types of incidents					
Response plans for all vessel types					
Facilitate salvage contracting to minimize delays (e.g., COTP or open forum contracting)					
Increased consideration of alternative response technologies (e.g., dispersants, in situ burning)					
AC review GRP response strategies for shallow-water areas					

Score as follows:
1 2 3 4 5
low → high
effectiveness effectiveness
N/A = not applicable
CP = counter productive

Maximum score for all consequence factors, plus 1 if there is a second score greater than 3.

APPENDIX C
CHAPTER 3

Contents

- Text excerpts from the United States Coast Pilot 7, Pacific Coast: California, Oregon, Washington, and Hawaii
- Coast Pilot meteorological table
- Excerpts from Captn Jack's Tide and Current Almanac
- Weather, tide and current data tables developed by Volpe Center
- Segment traffic tables by Volpe Center

Excerpts from the *United States Coast Pilot 7*, descriptive text for Segments 1-9

SEGMENTS 1 AND 2

Tatoosh Island, 0.4 mile NW of Cape Flattery, is about 0.2 mile in diameter, 108 feet high, flat-topped, and bare. It is the largest of the group of rocks and reefs making out about 0.9 mile NW from the cape.

SEGMENT 3

The Strait of Juan de Fuca comprises most of segment 3. The waters of the strait are typically deep until near the shore with few outlying dangers. The shores on both sides are heavily wooded, rising rapidly to elevations of considerable height, and are bold and rugged.

The navigation of these waters is relatively simple in clear weather. The aids to navigation are numerous. In thick weather, because of strong and irregular currents, extreme caution and vigilance must be exercised.

Slip Point, the east point of the bight, is high and wooded. A reef, extending 0.2 mile west of the point, is marked by a bell buoy.

The entrance between San Juan Point and Owen Point is 1.7 miles wide and 3.5 miles long. The port is open to SW winds, and a heavy sea rolls in when a moderate gale is blowing from that direction.

Cerantes Rocks, about 300 yards SW from San Juan Point, include several high pinnacle rocks with a few trees growing on them. About 800 yards N of these rocks about 300 yards from the shore is another reef partly uncovered.

Race Rocks, 5 miles E of Beechey Head are a cluster of bare low rocks from 0.5 mile to almost 1.5 miles from shore. Foul ground extends for almost 0.5 mile in all directions from the light; dangerous overfalls and races occur during bad weather. The tidal currents in the vicinity of Race Rocks attain a velocity of 4 to 6 knots at times, and dangerous tide rips are formed.

Port Angeles is entered between Ediz Hook, a low, narrow, and bare sandspit 3 miles long, and the main shore to the S. The harbor is protected from all except E winds, which occasionally blow during the winter. During SE winter gales, the wind is not usually felt but some swells roll in. The depths are greatest on the N shore and decrease from 30 to 15 fathoms in the middle of the harbor. A rock covered 19 feet is reported in the approach to the harbor in about $48^{0}07'245''$N., longitude $123^{0}23'00''$W.

Port Angeles is on the S shore of the harbor.

Sound meets that of Hood Canal off the point, and particularly so with the ebb against a strong N or NW wind.

SEGMENT 8

Everett Harbor is on the east end of segment 8.

Tides - The mean range of the tide at Everett is about 7.4 feet and the diurnal range of tide is 11.1 feet.

Pilotage - is compulsory for all vessels except those under enrollment or engaged exclusively in the coasting trade on the W coast of the continental US and/or British Columbia. Licensed pilots can be obtained for Puget Sound from the Port Angeles Pilots Association.

Towage - Tugs up to 900 hp are available at Everett, and larger tugs may be obtained from Seattle.

SEGMENT 9

Olympia Harbor is on the southern branch of segment 9.

Tides - The mean range of the tide at Olympia is about 10.5 feet and the diurnal range of tide is 14.4 feet.

Pilotage - is compulsory for all vessels except those under enrollment or engaged exclusively in the coasting trade on the W coast of the continental US and/or British Columbia. Licensed pilots can be obtained for Puget Sound from the Port Angeles Pilots Association.

Towage - Tugs up to 3,000 hp are available from Tacoma, and up to 5,000 hp from Seattle. No large tugs are stationed in Olympia.

#

Pilotage is compulsory for all vessels except those under enrollment or engaged exclusively in the coasting trade on the W coast of the continental US and/or British Columbia. Licensed pilots can be obtained from the Port Angeles Pilots Assoc.

Towage - Tugs to 1,200 hp are stationed at Port Angeles, and tugs to 5,000 hp are available from Seattle with advance notice.

SEGMENT 5

Trial Islands, 4 miles E of Victoria Harbor, are bare and rocky. Staines Point, the S and larger island, from its S extremity, has a rocky ledge that extends about 100 yards. Severe tide rips form off Staines Point, especially on the flood tidal current, which attains a velocity of 3 to 6 knots.

Discovery Island, 2 miles ENE of Gonzales Point, lies of the junction of Haro Strait and the Strait of Juan de Fuca. The island is wooded and the shores on all sides are fringed with rocks in some places extending as far as 600 yards offshore.

Haro Strait and Boundary Pass form the westernmost of the three main channels leading from the Strait of Juan de Fuca to the SE end of the Strait of Georgia; it is the one most generally used. Vessels bound from the west to ports in Alaska or British Columbia should use Haro Strait or Rosario Strait. No difficulty will be experienced in navigating Haro Strait and Boundary Pass in clear weather.

Tidal Currents - In Haro Strait and Boundary Pass, the flood current sets north, and the ebb current sets in the opposite direction. The ebb usually runs longer and has a greater velocity than the flood. Heavy dangerous tide rips occur between East Point and Patos Island and for 2 miles N in the Strait of Georgia.

Winds - Winds in the Rosario and Haro Straits are usually southwesterlies. Summer breezes are variable and baffling in the San Juan Islands.

Strait of Georgia extends some 115 miles NW from its S end. General depths are great and in many places exceed 200 fathoms.

Currents - The tidal currents in the Strait of Georgia attain a velocity of 3 knots at times. In the middle of the strait N of Patos and Saturna Islands, the velocity of the currents seldom exceed 3 knots.

Winds and Visibility - Winds are usually either northwesterlies or southeasterlies. Close to British Columbia coast they are often deflected and become easterlies. Gales occur three or four times per month. Some are associated with intense winter storms, but the particularly dangerous gales occur in clear weather. These are known as Squamish winds; they come up suddenly and may exceed 50 knots. North of Point Roberts, in the middle of Georgia Strait, the prevailing winds are northwesterlies. Gales are uncommon.

Fog - Georgia Strait is more effected by land fog than sea fogs. These fogs form on cool nights under clear skies and light winds, and usually dissipate by afternoon. These conditions are most prevalent from September through February. Visibility falls below 0.75 mile on about 20 days annually, but this can increase to 60 days in preferred locations where the low water temperatures of the river help produce the fog.

SEGMENT 6

Rosario Strait is the easternmost of the three main channels leading from the Strait of Juan de Fuca to the Strait of Georgia. It is 20 miles long and from 1.5 to 5 miles wide. The water is deep and the most important dangers are marked. A bank covered 10 to 20 fathoms extends across the S entrance to Rosario Strait. A shoal covered 3 ½ fathoms and marked by a lighted bell buoy is in the W part of the bank, 1.6 miles E of Davidson Rock Light. Lawson Reef, small in extent with a least depth of 1 ¾ fathoms and marked by a bell buoy, is in the E part of the bank, 1.7 miles west of Deception Island.

Currents - Passes are reported to attain velocities of 3 to 7 knots. On the ebb of a large tide off the entrance to the passes, a S wind causes tide rips that are dangerous to small craft.

SEGMENT 7

Point Wilson is the W point to Admiralty Inlet and Puget Sound. Shoals extend 0.5 mile NW of Point Wilson to the 5 fathom curve over irregular bottom; these are usually indicated by kelp. The E edge of the shoals rises rather abruptly from deep water. Heavy tide rips extend N of these shoals, being especially heavy with a W wind and ebb current.

Port Townsend, immediately S of Point Wilson, extends in a general SSW direction for 2.5 miles. It is an excellent harbor and is easily entered. The prevailing winds are generally in the SE quadrant.

Anchorage - The usual anchorage is about 0.5 to 0.7 mile S of the Railroad ferry landing in 8 to 10 fathoms, muddy bottom.

Tides - The mean range of tide at Port Townsend is 5.2 feet and the diurnal range of tide is 8.4 feet.

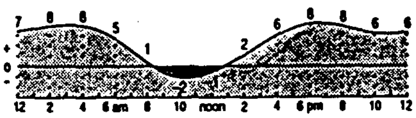
Pilotage - is compulsory for all vessels except those under enrollment or engaged exclusively in the coasting trade on the W coast of the continental US and/or British Columbia. Licensed pilots can be obtained for Puget Sound from the Port Angeles Pilots.

Towage - There are light tugs stationed at Port Townsend. Arrangements should be made in advance through ships' agents.

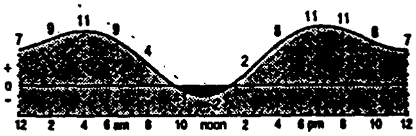
Admiralty Inlet extends from the Strait of Juan de Fuca to Foulweather Bluff. Foulweather Bluff is one of the most prominent cliffs in Puget Sound. It is at the E side of the entrance to Hood Canal. There are several boulders which bare within 100 yards N of the highest part of the bluff, and a shoal covered 2 to 18 feet extends 200 yards E from the extremity and in line with the face of the bluff. At times the tide rips N of and around Foulweather Bluff are sufficiently heavy to be dangerous to small craft and to break up log rafts. This is most dangerous when the ebb current from the main body of Puget

CAPTN. JACK'S DAILY TIDE AND CURRENT DATA, SAMPLE

High & Low Tides (feet)



PORT TOWNSEND				
	8.0 high	-2.2 low	8.4 high	6.2 low
	3:10 am	10:23 am	6:33 pm	10:49 pm
Blaine				
	8.9 high	-2.3 low	9.3 high	6.6 low
	4:06 am	11:52 am	7:29 pm	12:18 am JUNE 21
Bellingham				
	7.9 high	-2.1 low	8.3 high	6.0 low
	3:48 am	11:34 am	7:11 pm	12:00 mid JUNE 21
East Sound				
	7.7 high	-2.1 low	8.1 high	6.0 low
	3:37 am	11:27 am	7:00 pm	11:53 pm
Friday Harbor				
	7.3 high	-2.1 low	7.6 high	5.9 low
	3:38 am	11:13 am	7:01 pm	11:39 pm
Anacortes				
	7.7 high	-2.2 low	8.1 high	6.2 low
	3:32 am	10:56 am	6:55 pm	11:22 pm
Sequim Bay				
	7.5 high	-2.1 low	7.9 high	5.8 low
	2:31 am	10:16 am	5:54 pm	10:42 pm
Port Angeles				
	6.6 high	-1.8 low	7.0 high	5.0 low
	1:22 am	9:05 am	4:45 pm	9:31 pm
Neah Bay				
	7.8 high	-1.7 low	6.4 high	1.5 low
	12:39 am	7:31 am	2:06 pm	7:31 pm



SEATTLE				
	10.8 high	-2.1 low	11.6 high	6.6 low
	4:04 am	11:22 am	6:44 pm	11:55 pm
La Conner				
	9.7 high	-2.0 low	10.4 high	6.3 low
	4:25 am	12:01 pm	7:05 pm	12:34 am JUNE 21
Kayak Point				
	10.7 high	-2.1 low	11.5 high	6.5 low
	4:04 am	11:20 am	6:44 pm	11:53 pm
Everett				
	10.6 high	-2.1 low	11.4 high	6.5 low
	4:04 am	11:21 am	6:44 pm	11:54 pm
Port Ludlow				
	9.4 high	-2.0 low	10.1 high	6.3 low
	3:50 am	11:08 am	6:30 pm	11:41 pm
Pleasant Harbor				
	10.9 high	-2.1 low	11.7 high	6.7 low
	3:50 am	11:21 am	6:30 pm	11:54 pm
Bremerton				
	11.2 high	-2.1 low	12.1 high	6.6 low
	4:13 am	11:35 am	6:53 pm	12:08 am JUNE 21
Tacoma				
	11.2 high	-2.1 low	12.1 high	6.7 low
	4:11 am	11:30 am	6:51 pm	12:03 am JUNE 21
Olympia				
	13.9 high	-2.3 low	15.0 high	7.1 low
	4:49 am	12:19 pm	7:29 pm	12:52 am JUNE 21

Currents (knots)

San Juan Channel
Floods 010°, Ebbs 180° T

1.7	max flood	1:53 am
	slack	4:11 am
3.8	max ebb	8:02 am
	slack	11:23 am
4.5	max flood	2:43 pm
	slack	6:41 pm
2.5	max ebb	9:17 pm

Rosario Strait
Floods 335°, Ebbs 175° T

	slack	1:00 am
0.6	max flood	2:26 am
	slack	3:54 am
3.0	max ebb	9:17 am
	slack	1:01 pm
2.2	max flood	3:38 pm
	slack	8:03 pm
1.2	max ebb	10:35 pm

Deception Pass
Floods 090°, Ebbs 270° T

4.8	max flood	12:39 am
	slack	3:15 am
7.4	max ebb	6:37 am
	slack	9:49 am
6.7	max flood	1:10 pm
	slack	4:47 pm
6.9	max ebb	7:24 pm
	slack	10:55 pm

Juan de Fuca Strait
Floods 115°, Ebbs 290° T

	•	1:51 am
2.1	max ebb	8:02 am
	slack	12:06 pm
1.2	max flood	2:57 pm
	slack	6:01 pm
1.3	max ebb	9:20 pm

Bush Point
Floods 180°, Ebbs 005° T

	slack	12:29 am
0.8	max flood	2:22 am
	slack	4:07 am
3.7	max ebb	8:33 am
	slack	12:17 pm
3.0	max flood	3:28 pm
	slack	6:56 pm
2.1	max ebb	9:50 pm

Tacoma Narrows
Floods 135°, Ebbs 335° T

	slack	12:28 am
2.3	max flood	2:45 am
	slack	5:10 am
4.0	max ebb	8:50 am
	slack	12:28 pm
4.8	max flood	3:35 pm
	slack	7:29 pm
2.3	max ebb	10:13 pm

○
full moon
moon farthest south of equator
sunrise: 5:11 am
sunset: 9:14 pm

Friday
JUNE 20

Additional locations are provided in Appendix A and B.

CAPTN. JACK'S TIDE AND CURRENT CORRECTIONS, SAMPLE

PLACE	POSITION		TIME CORRECTIONS (hours & mins)				SPEED RATIOS		AVERAGE SPEED & DIRECTION			
	Lat ° ' N	Lon ° ' W	Slack before Flood	Flood	Slack before Ebb	Ebb	Maximum Flood	Maximum Ebb	Max Flood knt	Max Flood deg	Max Ebb knt	Max Ebb deg
STRAIT of JUAN DE FUCA			based on STRAIT of JUAN DE FUCA ENT. (1)									
Strait of Juan de Fuca Entrance	48 27	124 35	. . . see daily pages . . .						0.6	115	1.5	290
Pillar Point	48 16	124 04	-0:35	+0:06	+1:27	+0:52	1.2	1.2	1.4	100	0.9	280
			based on BUSH POINT, Admiralty Inlet (1)									
Ediz Hook Light, 1.2 miles north of	48 10	123 25	-0:32	-0:19	-0:05	-0:05	0.5	0.4	0.8	080	1.1	295
Ediz Hook Light, 5.3 miles ENE of	48 11	123 17	+0:39	+0:12	-0:07	-0:14	0.6	0.8	1.0	055	2.0	215
Trial Island, 5.2 miles SSW of	48 19	123 22	-0:08	+0:39	+1:22	+0:55	0.7	0.5	1.1	045	1.4	235
New Dungeness Light, 2.8 miles NNW of	48 14	123 08	+0:57	+0:27	-0:13	+0:16	0.3	0.5	0.5	075	1.2	255
New Dungeness Light, 6 miles NNE of	48 16	123 03	+0:51	+0:55	+0:27	+0:36	0.3	0.4	0.5	050	1.1	255
Discovery Island, 7.6 miles SSE of	48 18	123 10	+0:27	+0:15	+0:51	+0:30	0.4	0.4	0.7	035	1.0	260
Discovery Island, 3 miles SSE of	48 23	123 12	+0:23	+0:15	+0:02	+0:40	0.6	0.9	0.9	025	2.3	250
Cattle Point, 2.8 miles SSW of (2)	48 24	123 00	-1:17	+0:52	+1:04	-0:42	0.4	0.2	0.6	046	0.4	187
Cattle Point, 5 miles SSW of	48 23	123 01	+1:14	+1:11	+1:20	+0:44	0.6	0.3	0.9	120	0.9	210
Violet Point, 3.7 miles north of (3)	48 11	122 55	—	+0:22	-0:36	+0:09	0.2	0.5	0.4	100	1.2	270
Violet Point, 3.2 miles northwest of	48 10	122 58	-0:05	-0:32	-0:08	-0:17	0.3	0.4	0.6	120	1.0	325
Kamen Point, 1.3 miles southwest of	48 06	122 58	-1:10	-0:52	-1:06	-0:34	0.2	0.4	0.3	125	1.0	265
Discovery Bay entrance (4)	48 06	122 54	—	—	—	—	—	—	—	—	—	—
Smith Island, 2 miles east of (5)	48 19	122 48	+1:22	+0:51	—	+0:19	0.2	0.2	0.4	—	0.5	220
Smith Island, 1.4 miles SSW of	48 18	122 51	-0:06	+0:03	+0:29	+0:25	0.4	0.4	0.7	090	1.0	280
Smith Island, 3.7 miles ESE of (6)	48 18	122 45	—	+1:11	—	+1:35	—	0.3	—	—	0.9	225

1997 PUGET SOUND EDITION 427

COAST PILOT METEOROLOGICAL TABLE, SAMPLE

TATOOSH ISLAND, WASHINGTON (48°23'N., 124°44'W.) Elevation 101 ft. (30.8m)

WEATHER ELEMENTS	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	YEAR	YEARS OF RECORD
TEMPERATURE (DEGREES F)														
Mean	42.0	43.1	44.2	47.5	51.1	53.9	55.5	56.0	54.8	51.9	47.2	44.4	49.3	30
Mean Daily Maximum	45.2	46.8	47.9	51.8	55.2	57.8	59.5	60.1	59.2	55.8	50.5	47.6	53.1	30
Mean Daily Minimum	38.8	39.5	40.4	43.3	47.0	50.0	51.5	51.8	50.4	48.0	43.9	41.1	45.5	30
Extreme Highest	64	64	69	75	81	84	88	78	80	77	66	61	88	63
Extreme Lowest	14	16	25	33	36	43	44	45	40	33	19	14	14	63
RELATIVE HUMIDITY														
Average Percentage (1000 l.s.t.)	82	81	80	80	82	86	89	90	87	85	83	83	84	48
Average Percentage (1600 l.s.t.)	82	80	79	79	81	84	87	90	86	85	84	83	83	63
CLOUD COVER														
Average Amount (Tenths)	8.0	7.5	7.4	7.3	7.2	7.2	6.9	7.1	6.5	7.1	8.0	8.1	7.3	59
Mean Number of Days with Clear Skies	4	5	5	5	5	4	6	5	7	6	3	3	58	63
Mean Number of Days with Cloudy Skies	23	19	20	19	18	17	17	18	16	19	22	23	231	63
PRECIPITATION														
Mean Amount (Inches)	10.82	8.70	8.34	5.23	3.00	2.84	2.34	1.96	3.55	8.22	10.51	12.16	77.69	30
Greatest Amount (Inches)	22.57	21.16	14.80	10.79	8.05	7.81	7.73	5.06	7.81	14.54	22.17	16.81	101.64	36
Least Amount (Inches)	1.84	1.64	2.94	0.88	0.64	0.48	0.24	0.18	0.07	2.50	2.85	5.84	58.61	36
Maximum in 24 hrs. (Inches)	3.67	4.57	4.76	3.70	2.22	2.75	3.72	2.30	3.79	5.91	4.38	4.03	5.91	63
Mean Amount of Snow (Inches)	3.5	1.5	1.1	t	t	0.0	0.0	0.0	0.0	t	0.4	1.2	7.7	63
Maximum snowfall in 24 hrs. (Inches)	8.6	12.0	10.8	0.6	0.1	0.0	0.0	0.0	0.0	*	6.8	7.0	12.0	63
Mean Number of Days with Snow (One Inch or More)	1	t	t	0	0	0	0	0	0	0	t	t	3	63
0.01 Inch or More, Mean Number of Days	22	18	20	17	14	12	10	11	11	17	21	23	197	63
WIND														
Mean Wind Speed (Knots)	17.4	15.4	13.6	11.8	10.1	8.7	8.8	8.6	9.9	13.2	15.9	17.1	12.5	33
Prevailing Wind Direction	E	E	E	W	W	SW	S	S	S	E	E	E	E	24
Maximum Wind Speed (Knots)	76	73	79	63	57	63	46	51	59	73	82	74	82	63
VISIBILITY														
Days with Visibility equal to or less than 1/4 mile	1	1	1	2	3	5	11	16	11	6	2	1	59	63

PUGET SOUND MARITIME SAFETY EVALUATION
SEGMENT TRAFFIC TABLES

Segment 1 North Approach to Strait of Juan de Fuca

Commodity		Tonnage	Trips	Tons/Trip
All Other Commodities				
Barge Units				
Dry Cargo Barge Tow		725,920	602	1,206
Tanker Barge Tow		42,565	85	501
	Barge Units Subtotals	**768,485**	**687**	
Self-propelled Units				
Dry Cargo		1,718,375	2,728	630
Tanker		0	247	n/a
	Self-propelled Units Subtotals	**1,718,375**	**2,975**	
Tug/Tow Units				
Tug/Tow Boat		150	560	0
	Tug/Tow Units Subtotals	**150**	**560**	
Other Units				
Passenger		0	77	n/a
Other		0	31	n/a
	Other Units Subtotals	**0**	**108**	
Commodity Group		**2,487,010**	**4,330**	
Crude Petroleum				
Barge Units				
Dry Cargo Barge Tow		524	0	n/a
	Barge Units Subtotals	**524**	**0**	
Self-propelled Units				
Tanker		25,217,594	290	86,957
	Self-propelled Units Subtotals	**25,217,594**	**290**	
Commodity Group		**25,218,118**	**290**	
Refined Petroleum Products				
Barge Units				
Dry Cargo Barge Tow		76,910	10	7,691
Tanker Barge Tow		205,382	217	946
	Barge Units Subtotals	**282,292**	**227**	
Self-propelled Units				
Dry Cargo		16,734	2	8,367
Tanker		550,634	88	6,257
	Self-propelled Units Subtotals	**567,368**	**90**	
Commodity Group		**849,660**	**317**	
SEGMENT 1 TOTAL		***28,554,788***	***4,937***	

Segment 2 South Approach to Strait of Juan de Fuca "J" Buoy

Commodity	Tonnage	Trips	Tons/Trip
All Other Commodities			
Barge Units			
Dry Cargo Barge Tow	494,849	521	950
Tanker Barge Tow	325,569	522	624
Barge Units Subtotals	**820,418**	**1,043**	
Self-propelled Units			
Dry Cargo	24,646,428	4,825	5,108
Tanker	563,285	197	2,859
Self-propelled Units Subtotals	**25,209,713**	**5,022**	
Tug/Tow Units			
Tug/Tow Boat	26,759	1,486	18
Tug/Tow Units Subtotals	**26,759**	**1,486**	
Other Units			
Passenger	0	373	n/a
Other	4,833	46	105
Other Units Subtotals	**4,833**	**419**	
Commodity Group	**26,061,723**	**7,970**	
Crude Petroleum			
Self-propelled Units			
Dry Cargo	89	0	n/a
Tanker	798,130	24	33,255
Self-propelled Units Subtotals	**798,219**	**24**	
Commodity Group	**798,219**	**24**	
Refined Petroleum Products			
Barge Units			
Dry Cargo Barge Tow	13,161	2	6,581
Tanker Barge Tow	428,621	76	5,640
Barge Units Subtotals	**441,782**	**78**	
Self-propelled Units			
Dry Cargo	63,875	0	n/a
Tanker	2,033,433	82	24,798
Self-propelled Units Subtotals	**2,097,308**	**82**	
Tug/Tow Units			
Tug/Tow Boat	3	0	n/a
Tug/Tow Units Subtotals	**3**	**0**	
Other Units			
Other	12	0	n/a
Other Units Subtotals	**12**	**0**	
Commodity Group	**2,539,105**	**160**	
SEGMENT 2 TOTAL	***29,399,047***	***8,154***	

Segment 3 Strait of Juan de Fuca, "J" Buoy to Port Angeles

Commodity	Tonnage	Trips	Tons/Trip
All Other Commodities			
Barge Units			
Dry Cargo Barge Tow	1,391,442	1,486	936
Tanker Barge Tow	368,134	617	597
Barge Units Subtotals	**1,759,576**	**2,103**	
Self-propelled Units			
Dry Cargo	26,397,836	7,599	3,474
Tanker	563,286	445	1,266
Self-propelled Units Subtotals	**26,961,122**	**8,044**	
Tug/Tow Units			
Tug/Tow Boat	26,909	2,469	11
Tug/Tow Units Subtotals	**26,909**	**2,469**	
Other Units			
Passenger	0	450	n/a
Other	4,833	89	54
Other Units Subtotals	**4,833**	**539**	
Commodity Group	**28,752,440**	**13,155**	
Crude Petroleum			
Barge Units			
Dry Cargo Barge Tow	524	0	n/a
Barge Units Subtotals	**524**	**0**	
Self-propelled Units			
Dry Cargo	89	0	n/a
Tanker	26,015,724	314	82,853
Self-propelled Units Subtotals	**26,015,813**	**314**	
Commodity Group	**26,016,337**	**314**	
Refined Petroleum Products			
Barge Units			
Dry Cargo Barge Tow	112,096	12	9,341
Tanker Barge Tow	682,647	301	2,268
Barge Units Subtotals	**794,743**	**313**	
Self-propelled Units			
Dry Cargo	80,609	2	40,305
Tanker	2,584,067	170	15,200
Self-propelled Units Subtotals	**2,664,676**	**172**	
Tug/Tow Units			
Tug/Tow Boat	3	0	n/a
Tug/Tow Units Subtotals	**3**	**0**	
Other Units			
Other	12	0	n/a
Other Units Subtotals	**12**	**0**	
Commodity Group	**3,459,434**	**485**	

SEGMENT 3 TOTAL	*58,228,211*	*13,954*	

Segment 4 Junction Area

Commodity	Tonnage	Trips	Tons/Trip
All Other Commodities			
Barge Units			
Dry Cargo Barge Tow	5,661,567	4,248	1,333
Tanker Barge Tow	430,065	1,266	340
Barge Units Subtotals	**6,091,632**	**5,514**	
Self-propelled Units			
Dry Cargo	26,872,444	5,146	5,222
Tanker	563,287	317	1,777
Self-propelled Units Subtotals	**27,435,731**	**5,463**	
Tug/Tow Units			
Tug/Tow Boat	27,009	11,308	2
Tug/Tow Units Subtotals	**27,009**	**11,308**	
Other Units			
Passenger	0	1,894	n/a
Other	4,833	39	124
Other Units Subtotals	**4,833**	**1,933**	
Commodity Group	**33,559,205**	**24,218**	
Crude Petroleum			
Barge Units			
Dry Cargo Barge Tow	794	0	n/a
Tanker Barge Tow	153,704	34	4,521
Barge Units Subtotals	**154,498**	**34**	
Self-propelled Units			
Dry Cargo	89	0	n/a
Tanker	25,229,655	295	85,524
Self-propelled Units Subtotals	**25,229,744**	**295**	
Commodity Group	**25,384,242**	**329**	
Refined Petroleum Products			
Barge Units			
Dry Cargo Barge Tow	75,824	4	18,956
Tanker Barge Tow	3,612,825	814	4,438
Barge Units Subtotals	**3,688,649**	**818**	
Self-propelled Units			
Dry Cargo	80,963	18	4,498
Tanker	2,206,468	101	21,846
Self-propelled Units Subtotals	**2,287,431**	**119**	
Tug/Tow Units			
Tug/Tow Boat	3	0	n/a
Tug/Tow Units Subtotals	**3**	**0**	
Other Units			
Other	12	0	n/a
Other Units Subtotals	**12**	**0**	
Commodity Group	**5,976,095**	**937**	

SEGMENT 4 TOTAL	***64,919,542***	***25,484***	

Segment 5 Canadian Route via Haro Strait and Strait of Georgia

Commodity	Tonnage	Trips	Tons/Trip
All Other Commodities			
Barge Units			
Dry Cargo Barge Tow	4,868,450	3,322	1,466
Tanker Barge Tow	47,950	721	67
Barge Units Subtotals	**4,916,400**	**4,043**	
Self-propelled Units			
Dry Cargo	593,687	5,264	113
Tanker	2	307	0
Self-propelled Units Subtotals	**593,689**	**5,571**	
Tug/Tow Units			
Tug/Tow Boat	100	4,022	0
Tug/Tow Units Subtotals	**100**	**4,022**	
Other Units			
Passenger	0	1,214	n/a
Other	0	83	n/a
Other Units Subtotals	**0**	**1,297**	
Commodity Group	**5,510,189**	**14,933**	
Crude Petroleum			
Barge Units			
Dry Cargo Barge Tow	270	0	n/a
Tanker Barge Tow	192,130	38	5,056
Barge Units Subtotals	**192,400**	**38**	
Self-propelled Units			
Tanker	786,069	19	41,372
Self-propelled Units Subtotals	**786,069**	**19**	
Commodity Group	**978,469**	**57**	
Refined Petroleum Products			
Barge Units			
Dry Cargo Barge Tow	71,635	8	8,954
Tanker Barge Tow	1,386,177	767	1,807
Barge Units Subtotals	**1,457,812**	**775**	
Self-propelled Units			
Tanker	649,154	117	5,548
Self-propelled Units Subtotals	**649,154**	**117**	
Commodity Group	**2,106,966**	**892**	
SEGMENT 5 TOTAL	***8,595,624***	***15,882***	

Segment 6 San Juan Islands and Oil Terminals

Commodity		Tonnage	Trips	Tons/Trip
All Other Commodities				
Barge Units				
Dry Cargo Barge Tow		1,994,110	309	6,453
Tanker Barge Tow		223,247	761	293
Barge Units	**Subtotals**	**2,217,357**	**1,070**	
Self-propelled Units				
Dry Cargo		671,866	1,321	509
Tanker		303,473	226	1,343
Self-propelled Units	**Subtotals**	**975,339**	**1,547**	
Tug/Tow Units				
Tug/Tow Boat		1	7,312	0
Tug/Tow Units	**Subtotals**	**1**	**7,312**	
Other Units				
Passenger		0	11,326	n/a
Other		4,483	3	1,494
Other Units	**Subtotals**	**4,483**	**11,329**	
Commodity Group		**3,197,180**	**21,258**	
Crude Petroleum				
Barge Units				
Tanker Barge Tow		115,278	30	3,843
Barge Units	**Subtotals**	**115,278**	**30**	
Self-propelled Units				
Tanker		23,683,763	266	89,037
Self-propelled Units	**Subtotals**	**23,683,763**	**266**	
Commodity Group		**23,799,041**	**296**	
Refined Petroleum Products				
Barge Units				
Dry Cargo Barge Tow		3,122	0	n/a
Tanker Barge Tow		2,886,969	575	5,021
Barge Units	**Subtotals**	**2,890,091**	**575**	
Self-propelled Units				
Dry Cargo		765	56	14
Tanker		1,547,891	81	19,110
Self-propelled Units	**Subtotals**	**1,548,656**	**137**	
Commodity Group		**4,438,747**	**712**	
SEGMENT 6 TOTAL		***31,434,968***	***22,266***	

Segment 7 Central/Western Puget Sound: Admiralty Inlet to Tacoma

Commodity		Tonnage	Trips	Tons/Trip
All Other Commodities				
Barge Units				
Dry Cargo Barge Tow		7,623,774	8,174	933
Tanker Barge Tow		303,954	4,172	73
Barge Units	**Subtotals**	**7,927,728**	**12,346**	
Self-propelled Units				
Dry Cargo		25,549,530	6,260	4,081
Tanker		259,813	210	1,237
Self-propelled Units	**Subtotals**	**25,809,343**	**6,470**	
Tug/Tow Units				
Tug/Tow Boat		26,838	49,521	1
Tug/Tow Units	**Subtotals**	**26,838**	**49,521**	
Other Units				
Passenger		0	90,304	n/a
Other		350	22	16
Other Units	**Subtotals**	**350**	**90,326**	
Commodity Group		**33,764,259**	**158,663**	
Crude Petroleum				
Barge Units				
Dry Cargo Barge Tow		794	0	n/a
Tanker Barge Tow		153,704	34	4,521
Barge Units	**Subtotals**	**154,498**	**34**	
Self-propelled Units				
Dry Cargo		89	0	n/a
Tanker		1,545,892	29	53,307
Self-propelled Units	**Subtotals**	**1,545,981**	**29**	
Commodity Group		**1,700,479**	**63**	
Refined Petroleum Products				
Barge Units				
Dry Cargo Barge Tow		53,799	4	13,450
Tanker Barge Tow		4,233,521	1,635	2,589
Barge Units	**Subtotals**	**4,287,320**	**1,639**	
Self-propelled Units				
Dry Cargo		81,553	52	1,568
Tanker		603,677	117	5,160
Self-propelled Units	**Subtotals**	**685,230**	**169**	
Tug/Tow Units				
Tug/Tow Boat		3	0	n/a
Tug/Tow Units	**Subtotals**	**3**	**0**	
Other Units				
Other		12	0	n/a
Other Units	**Subtotals**	**12**	**0**	
Commodity Group		**4,972,565**	**1,808**	

SEGMENT 7 TOTAL	*40,437,303*	*160,534*

Segment 8 Eastern Puget Sound: Skagit River to Edwards Pt.

Commodity	Tonnage	Trips	Tons/Trip
All Other Commodities			
Barge Units			
Dry Cargo Barge Tow	441,270	559	789
Tanker Barge Tow	17,173	105	164
Barge Units Subtotals	**458,443**	**664**	
Self-propelled Units			
Dry Cargo	1,316,706	518	2,542
Tanker	0	3	n/a
Self-propelled Units Subtotals	**1,316,706**	**521**	
Tug/Tow Units			
Tug/Tow Boat	6,250	5,573	1
Tug/Tow Units Subtotals	**6,250**	**5,573**	
Other Units			
Passenger	0	1,751	n/a
Other	0	1	n/a
Other Units Subtotals	**0**	**1,752**	
Commodity Group	**1,781,399**	**8,510**	
Refined Petroleum Products			
Barge Units			
Tanker Barge Tow	35,500	40	888
Barge Units Subtotals	**35,500**	**40**	
Self-propelled Units			
Tanker	25	3	8
Self-propelled Units Subtotals	**25**	**3**	
Commodity Group	**35,525**	**43**	

SEGMENT 8 TOTAL	*1,816,924*	*8,553*

Segment 9 Puget Sound below Tacoma: Olympia and Hammersley Inlet

Commodity		Tonnage	Trips	Tons/Trip
All Other Commodities				
Barge Units				
Dry Cargo Barge Tow		181,263	359	505
Tanker Barge Tow		23,659	23	1,029
Barge Units	**Subtotals**	**204,922**	**382**	
Self-propelled Units				
Dry Cargo		271,825	42	6,472
Self-propelled Units	**Subtotals**	**271,825**	**42**	
Tug/Tow Units				
Tug/Tow Boat		0	988	n/a
Tug/Tow Units	**Subtotals**	**0**	**988**	
Other Units				
Passenger		0	27	n/a
Other Units	**Subtotals**	**0**	**27**	
Commodity Group		**476,747**	**1,439**	
Refined Petroleum Products				
Barge Units				
Tanker Barge Tow		3,744	6	624
Barge Units	**Subtotals**	**3,744**	**6**	
Commodity Group		**3,744**	**6**	
SEGMENT 9 TOTAL		***480,491***	***1,445***	

SEGMENT TRAFFIC TABLES

SEGMENT 1

Factor	Avg. Value	Unit	Data Source	Data Used
Wind	13	knots	USCP	Tatoosh
Tide	xxx	feet	xxx	xxx
Current	0.2	knots	Enviro. Impact	CA/Davidson Current
Fog	5	days(<1/4 mile)	USCP	Tatoosh
Rain	7	inches	USCP	Tatoosh
Temperature	49	^{0}F	USCP	Tatoosh

SEGMENT 2

Factor	Avg. Value	Unit	Data Source	Data Used
Wind	9	knots	USCP/Enviro. Impact	Quillayute/Cape Elizabeth
Tide	9	feet	Captn Jack's	Neah Bay
Current	0.2	knots	Enviro. Impact	CA/Davidson Current
Fog	4	days(<1/4 mile)	USCP	Quillayute
Rain	9	inches	USCP	Quillayute
Temperature	49	^{0}F	USCP	Quillayute

SEGMENT 3

Factor	Avg. Value	Unit	Data Source	Data Used
Wind	11	knots	USCP/Captn Jack's	Tatoosh/Port Angeles
Tide	9	feet	Captn Jack's	Neah Bay
Current	0.9	knots	Captn Jack's	Strait of Juan de Fuca Entrance/Ediz Hook
Fog	4	days(<1/4 mile)	USCP/Captn Jack's	Tatoosh/Port Angeles
Rain	4	inches	USCP/Captn Jack's	Tatoosh/Port Angeles
Temperature	49	^{0}F	USCP/Captn Jack's	Tatoosh/Port Angeles

SEGMENT 4

Factor	Avg. Value	Unit	Data Source	Data Used
Wind	9	knots	Captn Jack's	Port Angeles
Tide	7	feet	Captn Jack's	Port Angeles
Current	0.9	knots	Captn Jack's	New Dungeness/Smith Island/Ediz Hook/ Discovery Island
Fog	3	days(<1/4 mile)	Captn Jack's	Port Angeles
Rain	2	inches	Captn Jack's	Port Angeles
Temperature	49	^{0}F	Captn Jack's	Port Angeles

SEGMENT 5

Factor	Avg. Value	Unit	Data Source	Data Used
Wind	= Segment 6	knots	Coastal Resources	??
Tide	8	feet	Captn Jack's	Friday Harbor
Current	1.3	knots	Captn Jack's	Patos Island/Turn Point/ Discovery Island
Fog	= Segment 6	days(<1/4 mile)	Coastal Resources	Figure 14
Rain	3	inches	Coastal Resources	Figure 16 - Cowichan
Temperature	50	^{0}F	Coastal Resources	Figure 15 - Cowichan

SEGMENT 6

Factor	Avg. Value	Unit	Data Source	Data Used
Wind	5	knots	Captn Jack's	Bellingham
Tide	8	feet	Captn Jack's	Anacortes
Current	2.0	knots	Captn Jack's	Rosario Strait/Clark Island/ Guemes Channel/ Bellingham
Fog	4	days(<1/4 mile)	Captn Jack's	Bellingham
Rain	3	inches	Captn Jack's	Bellingham
Temperature	49	^{0}F	Captn Jack's	Bellingham

SEGMENT 7

Factor	Avg. Value	Unit	Data Source	Data Used
Wind	8	knots	Captn Jack's	Seattle
Tide	11	feet	Captn Jack's	Seattle
Current	1.0	knots	Captn Jack's	Foulweather Bluff/ President Point
Fog	4	days(<1/4 mile)	Captn Jack's	Seattle
Rain	3	inches	Captn Jack's	Seattle
Temperature	51	^{0}F	Captn Jack's	Seattle

SEGMENT 8

Factor	Avg. Value	Unit	Data Source	Data Used
Wind	??	knots	??	??
Tide	11	feet	Captn Jack's	Everett
Current	1.6	knots	Captn Jack's	Possession Sound/ Saratoga Passage/ Skagit Bay (Goat Island)
Fog	= Segment 7	days(<1/4 mile)	= Segment 7	= Segment 7
Rain	= Segment 7	inches	= Segment 7	= Segment 7
Temperature	= Segment 7	^{0}F	= Segment 7	= Segment 7

SEGMENT 9

Factor	Avg. Value	Unit	Data Source	Data Used
Wind	6	knots	Captn Jack's	Olympia
Tide	15	feet	Captn Jack's	Olympia
Current	2.3	knots	Captn Jack's	The Narrows (S. end)/ Nisqually Reach/Olympia
Fog	8	days(<1/4 mile)	Captn Jack's	Olympia
Rain	4	inches	Captn Jack's	Olympia
Temperature	50	^{0}F	Captn Jack's	Olympia

<u>Sources for weather and hydrographic data</u>

1. Coastal Resources - Coastal Resources Oil Spill Response Atlas, Southern Strait of Georgia, B.C Ministry of Environment, Lands, and Parks, 1993.
2. Captn Jack's - Captn. Jack's Tide and Current Alamanac, Puget Sound, 1997.
3. U.S. Coast Pilot, Pacific Coast, 1991.

<u>Notes:</u>

1. Where monthly wind, fog, rain, and temp. data was available, averages were found using a representative month from each season. The months used were January, April, July, and October.
2. Where daily tide data was available, averages were determined using the average tides on the days of the new moon and full moon.
3. Current data was obtained by average maximum flood and ebb values given in Capt. Jack's.

APPENDIX D
CHAPTER 4

Contents

- Catalog of existing safety measures
- Marine Transportation Working Group report
- Accident data comparisons

SAFETY MEASURES

UNIVERSAL

UM1 - CREW PROFICIENCY AND VESSEL MANNING

Mariners' certification & licensing
Removal of master
Manning standards for foreign tank vessels

International Maritime Organization (IMO):

- **IMO Convention on Standards of Training, Certification, and Watchkeeping for Seafarers (STCW)**
- **International Safety Management Code**

Code of Federal Regulations (CFR):

- **33 CFR 164.13 Navigation Underway: Tankers.** Bridge watch requirements.
- **46 CFR (B)** - Merchant Marine Officers and Seamen

Oil Pollution Act of 1990 (OPA):

- **OPA 91-211** Renewal Certificates of Registry, Renewal of Merchant Mariners' Documents, Termination of Existing Licenses, Certificates, and Documents.
- **OPA 91-212** Criminal Record Reviews in Renewals of Licenses and Certificates of Registry; Access to National Driver Register.
- **OPA 91-223** Review of Alcohol and Drug Abuse in Issuing Licenses and Certificates of Registry; and Merchant Mariners' Documents.
- **OPA 94-101** Suspension and Revocation of Licenses, Certificates of Registry, and Merchant Mariners' Documents.

Washington Administrative Code (WAC):

- **WAC 317-21-230 & 317-21-320 Personnel Policies – Training.** (Tankers & Tank Barges) An oil spill prevention plan for a tanker must describe a comprehensive training program that requires training beyond the training necessary to obtain a license or merchant marine document. The program must include instruction on the use of job-specific equipment, installed technology, lifesaving equipment and procedures. The plan must at a minimum contain the following elements:

1) *Crew Training.* A crew member shall complete a comprehensive training program approved by the office.

2) *Vessel Orientation.* Personnel newly assigned to a tanker and maintenance personnel who sail on tankers, shall undergo an orientation that includes: …
3) *Position Specific Requirements.* All personnel newly hired shall complete training specific to their position.
4) *Refresher Training.* Personnel who received training described in subsection (3) shall undergo refresher training at least once every five years.
5) *Shipboard Drills.* The following shipboard drills must be conducted and logged in the vessel's deck log.

- **WAC 317-21-235 & 317-21-325 Personnel Policies – Illicit Drug and Alcohol Use.** (Tankers & Tank Barges)

6) An owner or operator of a tanker shall have policies, procedures, and practices for alcohol and drug testing.
7) State licensed pilots are subject to the alcohol and illicit drug chemical testing policies established by the state board of pilotage commissioners.
8) The testing program must include tests for alcohol and drug use that meet the following objective.
9) The owner or operator shall describe measures employed to ensure quality control of all test samples taken and the accuracy of test results.
10) The owner or operator shall submit a report with annual plan updates. The report must describe testing activity and results for the past calendar year.
11) The owner or operator shall report to the office the name, rating and assigned vessel of any navigation or engineering watchstander after testing positive.
12) For the purposes of this section, the following definitions apply.
13) If one percent or less of the personnel have positive test results for two consecutive calendar years, the owner or operator may reduce the level of random testing.

- **WAC 317-21-245 & 317-21-330 Personnel Policies – Work Hours.** (Tankers & Tank Barges)

14) A member of a tanker's crew may not work more than fifteen hours in twenty-four hours, nor more than thirty-six hours in seventy-two hours except in an emergency.
15) An emergency is an unforeseen situation that poses an imminent threat.
16) A licensed deck officer may not assume duties on a navigation watch when first departing a berth in state waters unless he or she was off duty for at least six hours of the twelve hours prior to departure.

- **WAC 317-21-255 & 317-21-335 Personnel Policies – Record Keeping.** (Tankers & Tank Barges) The owner or operator shall maintain the following records:

17) *Training Records.*
18) *Work Hour Records.*

- **WAC 317-21-260 & 317-21-340 Management.** (Tankers & Tank Barges)

19) *Management Oversight.* Management policies that demonstrate active monitoring of vessel operations and maintenance, personnel training.
20) *Management Program.* Program must meet certification requirements.
21) *Management Program Elements.* Without certified program, shall have a management program containing certain elements.
22) *Vessel Visitation.* Vessel visitation program shall require quarterly visits by company management.
23) *Preventive Maintenance.* Oil spill prevention plan must describe comprehensive maintenance program that contains certain elements.

- **WAC 317-21-315 Crewing.** Oil spill prevention plan for a tank barge must contain policies that demonstrate:

    Two certified tankerman shall be on the tank barge during topping off if receiving oil cargo.

    Three licensed officers or tow vessel operators shall be on tow vessel for tank barge in coastal waters.

    Tow vessel operators shall maintain a list of crew members.

- **WAC 317-21-250 Personnel Policies – Language.** An oil spill prevention plan for a tanker must demonstrate:

    24) proficiency by the master in English and in a language understood and spoken by subordinate officers.
    25) Written instructions shall be printed in language understood and spoken by officers and crew.

<u>Industry Standards (IS):</u>

- **IS: Vessel Crewing.** Vessels are crewed in accordance with the vessels' flag state. Crew members should be certified with STWC for the position.
- **IS: Alcohol and Drug Policy.** Institute policies that conform to 33 and 46 CFR.
- **IS: Work Hours/Fatigue.** Ensure vessel crew members are rested at least 10 hours per day, 6 hours rest consecutive, 70 hours rest per week.
- **IS: Training Programs.** Institute a comprehensive training program for crew members.
- **IS: Orientation.** Orientation training for new crew members.
- **IS: English Proficiency.** Officers who communicate with pilots, vessels proficient in English.
- **IS: Common Language.** Designate a common working language.

UM2 - SYSTEM REQUIREMENTS

Code of Federal Regulations (CFR):

- **33 CFR 26** - Vessel bridge-bridge radiotelephone regulations.
- **46 CFR (D)** - Tank Vessels
  - Inspection and certification
  - Special equipment, hull, and machinery requirements
  - Lifesaving equipment
  - Firefighting equipment
  - Operations
  - Vapor control systems
- **46 CFR (E)** - Load Lines
- **46 CFR (F)** - Marine Engineering
- **46 CFR (G)** - Documentation and Measurement of Vessels
- **46 CFR (S)** - Subdivision and Stability

Oil Pollution Act of 1990 (OPA):

- **OPA 94-020** Navigational Safety Equipment for Towing Vessels.

Washington Administrative Code (WAC):

- **WAC 317-21-265 & 317-21-345 Technology.** (Tankers & Tank Barges)
  1) *Navigation Equipment.* GPS, and two separate radar systems.
  2) *Emergency Towing System.*
  3) The emergency towing system must be deployable...

Industry Standards (IS):

- **IS: Planned Maintenance System.** Ensure planned maintenance system is in place for all major ship systems.
- **IS: Inspection/Survey.** Ensure ballast tanks and cargo holds are inspected annually to detect structural failures, cracks, and excessive corrosion.
- **IS: Ultrasonic Gauging.** Program of ultrasonic gauging and non-destructive testing of vessel hulls and tanks at 3 year intervals.

Code of Federal Regulations (CFR):

- **46 CFR 4** - Marine casualties and Investigations.

Washington Administrative Code (WAC):

- **WAC 317-21-130 & WAC 317-31-240 Event Reporting.**
  1) The owner or operator shall include an event summary of the past five years for each vessel covered by an oil spill prevention plan, or during the time the vessel has been under the control of the owner or operator if less than five years.
  2) The owner or operator shall submit to the office reports of events that occur after a plan is submitted.
  3) For the purposes of this section, "event" means collision, allision, near-miss, marine casualty, disabled vessel, spills.
  4) Penalty for failure to submit an event summary or report: disapproval of owner's plan, penalties assessed under RCW 88.46.090(6), referral for prosecution under RCW 88.46.080.
- **WAC 317-21-540, WAC 317-31-110 & WAC 317-31-130 Advance Notice of Entry and Safety Reports.**
  5) Tank vessel owner shall submit notice of entry to the office 24 hours before enter state waters.
  6) Shall submit the following information in the notice: vessel's name, country, gross tonnage, call sign. Lloyd's number; name and telephone number of local representative; date, time and point of entry into state waters, intended berths or anchorages in WA; last port of call; amount and type of bunker or cargo; whether loaded with cargo; operational deficiencies of vessel's primary and auxiliary navigation, propulsion, or cargo containment and transfer systems; identification of the contingency plan.
  7) Give notice as soon as practicable.
  8) Submit safety report with advance notice of entry if vessel experiences: abnormality or malfunction of steering, navigation, propulsion or safety system; breach of hull or integrity of structure of a cargo, bunker, bilge, or ballast tank causing oil spill or loss of stability; damage from fire or explosion, incomplete engineering or deck complement under US law or regulation; any condition that may adversely affect the safety of a vessel, property, or marine environments.
- **WAC 317-21-550 & WAC 317-31-250 Inspections and Investigations.**
  9) The office may inspect any vessel in port for compliance with the vessel's oil spill prevention plan. Shall have access to the following documents:

deck and engineering logs, voyage plans for the current voyage, charts and other records used to fix the position of the vessel during transit and at anchor, personnel training records, other documents that demonstrate compliance with the vessel's plan.

10) The documents may not be destroyed unless office notifies no inspection.

11) The office may require further information concerning a reported event.

- **WAC 317-21-560 Exceptional Compliance.**

  12) *Compliance Incentives*. If owner achieves best protection standards, the office may: reduce the level of inspection for tank vessels covered by the plan,; waive specific requirements that the owner or operator demonstrates as obsolete because of a new procedure or technology employed on vessels covered by the plan; take other actions as appropriate.

  13) *Exceptional Compliance*. Means the owner or operator: complies with the requirements of this chapter; implements policies, procedures, or practices which may differ from the standards of this chapter, demonstrates a commitment to safe vessel operations verified through inspections by the office of the vessels covered by the plan.

- **WAC 317-31-100 Vessel Screening.** The office may screen any cargo or passenger vessel, to determine potential risk.
- **WAC 317-31-210 Determination of Substantial Risk.**

  14) Shall be determined based on condition of the vessel and crew.

  15) Inspections involve evaluating the following:...

- **WAC 317-31-300 Vessels Posing Substantial Risk.** The office may:

  16) request deny entry

  17) issue an order

- **WAC 317-31-110 Advance Notice of Entry.**

  1) Submit a notice of entry to office 24 hours before entry into State waters.

UM4 - SYSTEMS STATUS, TESTING/INSPECTION AND CHECKS

<u>Washington Administrative Code (WAC):</u>

- **WAC 317-21-210&215 Operating Procedures – Engineering and Pre-arrival Tests and Inspections**. An oil spill prevention plan for a tanker must describe engineering practices, policies, and procedures that meet the following standards:
  1) Tankers without automatic stand-by switching gear for stand-by generators must operate with a stand-by generator running and immediately available to assume the electrical load while underway in state waters.
  2) The steering gear flat must be inspected hourly while in operating in state waters, unless monitored.
  3) If applicable, scoop injection cooling water systems must be secured at least six hours before operating in state waters.

4) If applicable, the main engines must be operating to capacity on fuel used for maneuvering before operating in state waters.
5) Navigation equipment must be inspected.
6) Emergency and stand-by ship service generators must be started and the switch gear proven to be working.
7) All steering systems and local controls of the steering gear at the steering gear flat must be inspected or tested.
8) The main engine, or engines, must be tested ahead and astern.
9) Main lubrication oil pumps must be installed or tested and ready for immediate use.
10) Main heavy oil pumps must be inspected or tested and ready for immediate use.
11) For main engine lubrication and fuel oil systems with fitted duplex strainers, stand-by strainers must be cleaned, purged, and made immediately available.
12) Fuel sufficient to operate the main engine or engines on the transit to berth or anchorage must be transferred to the main engine settler or service tanks, or both.
13) For motor-driven tankers
14) For steam driven tankers

<u>Industry Standards (IS)</u>:

- IS: **Ground Tackle Readiness.** Ensure anchors are clear and ready to drop.
- IS: **Equipment Error Checks.** Ensure all radars, gyrocompasses, magnetic compasses and compass repeaters are checked for errors at least once per watch.
- IS: **Electrical Systems.** Ensure standby and emergency generators are proven operational.
- IS: **Fuel Oil/Lube Oil Pumps.** Ensure primary and back-up fuel and lube oil pumps are proven operational.
- **IS: Oil Strainers.** Ensure all fuel and lube oil strainers are cleaned and ready for use.
- **IS: Cooling Water Systems.** Ensure all cooling water primary and back-up circulating pumps are proven operational and ensure scoop injection cooling water systems are secured.
- **IS: Control/Start Air Systems.** Ensure starting air system tanks are full, all primary and back-up air compressors have been proven operational and condensate in the system has been properly drained.
- **IS: Steering Gear Flat.** Ensure primary and back-up steering systems are tested and steering gear flat should be inspected hourly.
- **IS: Fuel Oil Tanks and Purifiers.** Ensure fuel oil settler and service tanks are filled to 85% capacity. Service tanks should contain only purified oil.

- **IS: Cargo Operation Stability.** Ensure vessel masters and chief officers prepare, update, and monitor stability plans for all cargo loading and unloading operations. Updates prepared daily.
- **IS: Dangerous Hazardous Cargo.** Transporting, loading, or unloading dangerous or hazardous cargo should ensure stowage is pre-verified for IMDG Code.

UM5 - VESSEL OPERATIONS

International Maritime Organization (IMO):

- **STCW - IMO Convention on Standards of Training, Certification, and Watchkeeping for Seafarers** - Navigation Watch
- **Convention on the International Regulations for Preventing Collisions at Sea**

Code of Federal Regulations (CFR):

- **33 CFR 164.13 Navigation underway: Tankers.** Navigation safety regulations: engineering watch, auto pilot allowance, helmsman qualifications.
- **33 CFR (D)** - International Navigation Rules
- **33 CFR (E)** - Inland Navigation Rules

Oil Pollution Act of 1990 (OPA):

- **OPA 91-202** Escorts for Certain Tankers (Prince William Sound, Puget Sound, WA)

Washington Administrative Code (WAC):

- **WAC 317-21-200 & 317-21-300 Operating procedures – Watch Practices** (Tankers & Tank Barges)
  1) *Navigation Watch.* The navigation watch shall consist of at least two licensed deck officers, a helmsman, and a lookout.
  2) *Bridge Resource Management.* The navigation watch shall employ a bridge resource management system.
  3) *Coordination with Pilots.* The bridge resource management system must include a procedure to coordinate interaction of the bridge team and pilot.
  4) *Security Rounds.* The master shall designate spaces on the vessel subject to security rounds to identify and to correct, safety hazards.
  5) *Anchor Watch.* A licensed deck officer shall maintain a watch from the bridge while the tanker is anchored. The officer shall continuously monitor the position of the vessel at anchor and plot its position at least once each hour.

6) *Engineering Watch.* Licensed engineers shall be in the engineering control room and in the immediate vicinity of the machinery space's emergency throttle controls if room is not within machinery spaces, vessel is maneuvering to embark or disembark a pilot, docking or departing a berth, or anchoring or departing anchorage.

- **WAC 317-21-205 & 317-21-305 Operating procedures – Navigation.** (Tankers & Tank Barges) An oil spill prevention plan for a tanker must describe navigation practices, policies and procedures that meet the following standards:
  1) *Fix Intervals.* The position of tankers must be constantly monitored. Positions must be recorded at fifteen minute intervals.
  2) *Voyage Planning.* The vessel master shall ensure that a comprehensive written voyage plan is developed for the tanker's trip through state waters.
  3) *Compass Checks.* While underway in state waters, the vessel master shall establish a schedule for frequent comparisons of the steering gyrocompass with the magnetic compass.
  4) *Port Angeles.* A master of a tanker carrying cargo shall use at least one assist tug for anchoring and departing anchorages in the port of Port Angeles.

Industry Standards (IS):

- **IS: Bridge Watch Procedures.** Shall employ a Bridge Resource Management system.
- **IS: Helmsman and Lookout.** Shall ensure lookouts are assigned no other duties.
- **IS: Pilot Coordination.** Employ a pilot card or checklist to facilitate coordination with state licensed pilots.
- **IS: Security Rounds.** Conducted hourly while in port or at anchor and at least once per watch while underway.
- **IS: Anchor Watch.** Ensure a licensed deck officer is standing watch on bridge and monitoring position.
- **IS: Engine Room Crewing.** Ensure licensed engineer officers are on watch in the engine control room.
- **IS: Voyage Planning.** Employ written voyage planning system.
- **IS: Management Oversight.** Vessels are visited by representative of company management at least quarterly.

UM6 - POSITIONAL INFORMATION

Communications: ship-ship
GPS
Weather reporting
Ship-board radar

Weather reporting by National Weather Service

Aids to navigation by United States and Canadian Coast Guards

Washington State

- **WAC 317-21-265 & 317-21-345 Technology.** (Tankers & Tank Barges)
  1) *Navigation Equipment.* GPS, and two separate radar systems.

Industry Standards (IS):

- **IS: Charts and Publications.** Ensure all charts and navigational publications are correct and current.

UM7 - CENTRAL VESSEL LOCATIONAL MONITORING & CONTROL

VTS
Ship-shore communications
Traffic Separation Scheme

VTS by United States and Canadian Coast Guards: radio communications throughout waterway and radar coverage for most major shipping lanes.

Traffic separation schemes

Code of Federal Regulations (CFR):

- **33 CFR 150.313 Clearances for Tankers.** - Vessel traffic clearance for entrance to safety zone, based upon: separation between tankers, presence of Mooring Master onboard. Also requirements for single-point moorings (if applicable).
- **33 CFR 165.1301 Puget Sound and adjacent waters in northwestern Washington – Regulated Navigation Area.** - Addresses fishing traffic issues and VTS control.
- **33 CFR (P)** - Ports and Waterways Safety

UM8 - EMERGENCY PROCEDURES

Washington Administrative Code (WAC):

- **WAC 317-21-220 & 317-21-310 Operating Procedures – Emergency Procedures.** (Tankers & Tank Barges) An oil spill prevention plan for a tanker must describe practices, policies, and procedures for emergencies that meet the following standards.
  1) The vessel master shall maintain and post station bills clearly stating crew assignments and duties for the following emergencies: fire, abandon ship, man overboard, oil spill response.
  2) The vessel master shall establish written procedures for responding to: collisions/allisions, groundings/strandings, hull breach, loss of propulsion/steering/electrical power, gyrocompass malfunction.
  3) The vessel master shall establish written procedures outlining preparations for: emergency towing, responding to loss of throttle control, weather that poses hazards to personnel.

International tug of opportunity system

Industry Standards (IS):

- **IS: Emergency Procedures.** Establish and maintain station bills outlining crew member responsibilities for fire-fighting, oil spill response, abandon ship.
- **IS: Emergency Towing.** Equip all affected vessels with functional emergency towing equipment.

UM9 - OUTFLOW MITIGATION

Oil Pollution Act of 1990 (OPA):

- **OPA 90-051** Establishment of Double Hull Requirements for Tank Vessels.
- **OPA 91-209** Requirements for Longitudinal Strength, Plating Thickness and Gauging for Certain Tank Vessels.
- **OPA 91-045L** Emergency Lightering Equipment and Advance Notice of Arrival Requirements for Existing Tank Vessels Without Double Hulls.
- **OPA 91-045-O** Operational Measures to Reduce Oil Spills from Existing Tank Vessels Without Double Hulls.
- **OPA 93-081** Designation of Lightering Zones.

UM10 - SPILL RESPONSE PLANNING & CAPABILITY

National Planning & Response System
Area Contingency Plans
Vessel Response Plans
Spill drills

Oil Pollution Act of 1990 (OPA):

- **OPA 90-068 DSC** Discharge Removal Equipment and Inspection for Vessels Carrying Oil - Deck Spill Control.
- **OPA 90-068 SCC** Discharge Removal Equipment and Inspection for Vessels Carrying Oil - Source Control and Containment of Spills other than Deck Spills.
- **OPA 91-034-VRP** National Planning and Response System: Tank Vessel Response Plans (Oil).

Washington Office of Marine Safety (OMS) & Oregon State Department of Environmental Quality (DEQ):

- **Vessel Contingency Plan,** Planning Standards.

Washington Administrative Code (WAC):

- **WAC 317-21-100 Format.** A tank vessel owner or operator shall submit an oil spill prevention plan.
- **WAC 317-21-120 Submittal Agreement.** An oil spill prevention plan must include a submittal agreement that includes the following information:
  1) Information identifying the person submitting the plan.
  2) A statement verifying that the submitted plan describes policies, procedures, and practices of the owner or operator employed on vessels covered by the plan and commits the owner or operator and employees to complying with the policies described in the plan.
  3) For a tanker, an operational summary.
  4) For a tank barge, an operational summary for the barge and a typical tow vessel that contains the information required under subsection (3) of this section.
  5) For a tanker or tank barge that operates entirely in state waters, a written schedule of the vessel's typical operations in state water.
  6) A written schedule submitted under WAC 317-40-050(2) meets the requirement under subsection (5) of this section.

- **WAC 317-21-140 Vessel Specific Information and Documentation.**
  1) Vessel specific information includes each vessel's:
     a) name

b) capacity
c) length
d) arrangement

2) Certification and classification documentation includes: copies of certificates of inspection and other documents.

- **WAC 317-21-225 Operating Procedures – Events.** If the vessel is involved in an event, the position plotting records, and the comprehensive written voyage plan may not be erased, discarded, or altered without permission of the office.
- **WAC 317-21-400 Review Process**. Determine if plan is complete or incomplete.
- **WAC 317-21-410 Plan Approval**. A plan that meets standards will be approved as providing best achievable protection. Approved plan is valid for five years.
- **WAC 317-21-500 Administrative Actions.**
  1) Fail to comply with requirements may be subject to administrative actions.

- **WAC 317-21-510 Administrative Review.**
  1) Owner or operator may request review of administrative action.
  2) Request may be submitted in writing.
  3) While appeal is pending, the office may…

- **WAC 317-21-520 Waivers.**
  1) The office may waive specific requirements.
  2) The office will waive application of this chapter to a vessel certified as a tank vessel if the owner or operator submits waiver application.
  3) Waiver is valid until vessel is used to carry oil in bulk as cargo.
  4) The office may condition a waiver and a waiver extension to ensure protection.

- **WAC 317-21-530 Plan Updates.**
  1) If significant change affects plan, submit amendment.

Industry Standards (IS):

- **IS: Safety/Environmental Management Program.** Implement a safety and environmental management system for disseminating critical safety information.
- **IS: Safety Program.** Ensure that a corporate safety program is implemented. Program should include a system for disseminating critical safety information including accident prevention measures and corrective actions.
- **IS: Shipboard Safety Program.** Ensure shipboard safety program is established with committee meetings at least monthly.

- **IS: Pollution.** Pollution prevention program is implemented for compliance with international and federal regulations.
- **IS: Drills.** Emergency drills conducted every two weeks.

UM11 - FINANCIAL RESPONSIBILITY/LIABILITY

Code of Federal Regulations (CFR):

- **33 CFR (M)** - Marine pollution financial responsibility and compensation.
- **33 CFR (Q)** - Pollution

Oil Pollution Act of 1990 (OPA):

- **OPA 91-005** Financial Responsibility for Water Pollution Civil Penalties (Vessels).

Revised Code of Washington (RCW):

- **RCW 88.40.020** Evidence of financial responsibility for vessels.
  1) Any inland barge that transports hazardous substances in bulk as cargo shall establish evidence of financial responsibility of $1 million or $150 per gross ton.
  2) A tank vessel that carries oil as cargo in bulk: at least $500 million.
  3) Vessel that carries oil as fuel: at least $600 per gross ton or $500,000.
  4) Documentation shall demonstrate the ability to meet state and federal financial liability costs for removal of spills, natural resource damages, and necessary expenses.

- **RCW 88.40.030** Establishing evidence of financial responsibility - Documentation.
  Financial responsibility may be established by any one of the following methods acceptable to the office of marine safety or the department of ecology.
  1) insurance 2)surety bonds
  3)self-insurer 4)other evidence

#

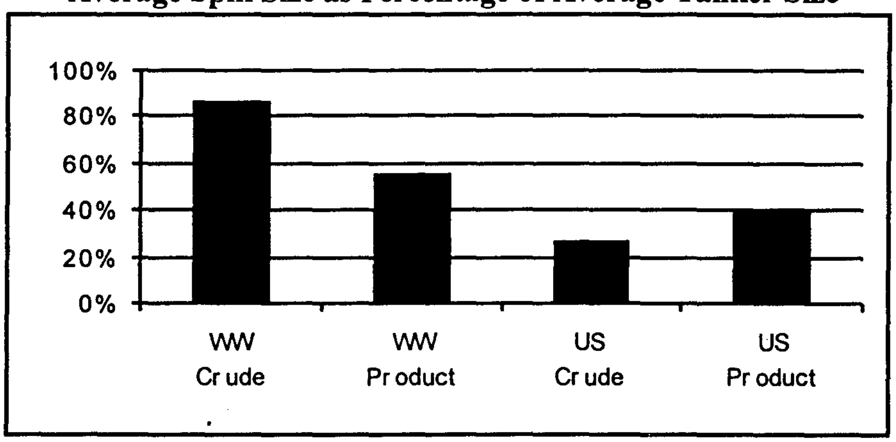
National and Worldwide Spill Statistics Review

In their study of tanker spills, the Minerals Management Service (MMS) looked at accident rates, types and causes of accidents for both the U.S. and worldwide fleets. Table D-1 [MMS, 1994] shows the breakdown of crude oil and refined product spills both worldwide and in U.S. waters for the time period 1974-1992. As shown (Figure D-1), the average spill size in U.S. waters is lower as a percentage of average tanker size than worldwide for both crude oil and refined product. No cause for this trend can be shown empirically.

Table D-1
Worldwide and U.S. Crude Oil and Refined Product Spill Breakdown

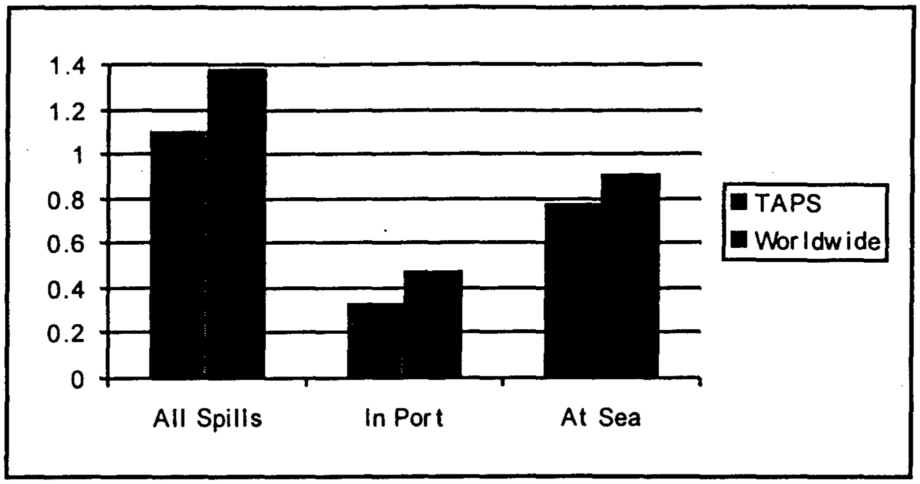
	Worldwide Spills		U.S. Spills	
	Crude Oil	Refined Product	Crude Oil	Refined Product
Number of Spills	203	280	32	46
Ave. Spill Size (barrels)	107,500	22,500	27,500	16,500
Average Tanker Size (DWT)	125,500	40,500	103,000	41,500

Figure D-1
Average Spill Size as Percentage of Average Tanker Size



The MMS study also decomposed the spill rates for TAPS and worldwide tankers for the 1977 to 1992 time period. These results, for spills greater than or equal to 1,000 barrels are provided in Table D-2. Here, two important pieces of information can be gleaned. First, the spill rate for TAPS tankers was 20% less than that for the worldwide average. Secondly, and perhaps more pertinent for this study, was that the spill rates were roughly twice as high at sea as in port for both the TAPS and worldwide tankers.

Table D-2
Comparison of TAPS and Worldwide Tanker Spill Rates (1977-1992)



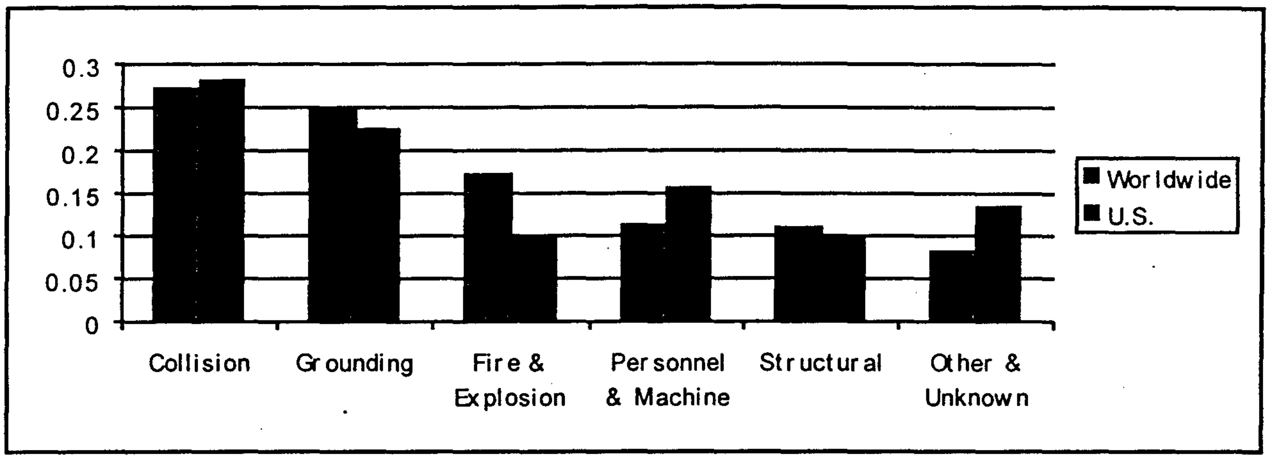
The MMS causes for worldwide and U.S. tanker spills was next reviewed, to compare with the results for this waterway system. Table D-2 breaks down the accident types for these two data sets. It should be noted here that the MMS database combined collisions and allisions, and powered and drift grounding, and did not include loss of stability. Additionally, MMS has included personnel errors/machine failures as an accident category, where we have categorized them as causes and incidents. Furthermore, this data excludes barge and inland spills. However, with those differences aside, several parallels can be drawn. First and foremost among these parallels was the agreement between the MMS results both worldwide and U.S. and the results from this study.

Figure D-3 shows the accident types as a percentage of the total number of accidents for both worldwide and U.S. waters. Both studies showed strong dominance for the collision/allision and grounding scenarios. Furthermore, results for the worldwide and U.S. statistics were remarkably similar, with the exception of fires and explosions, and the non-accident category of personnel error/machine failure. The MMS results also provide support for our findings, particularly for the relative significance of collisions/allisions and groundings. While the MMS results showed collision/contact as being more prevalent than groundings, our study for this specific waterway showed otherwise, although in both cases the differences between the two categories was minor.

Table D-2
Accident Types for Worldwide and U.S. Tanker Spills

Accident Type	Number Worldwide	Number U.S.
Collision/Contact	150	25
Grounding	138	20
Explosion/Fire	94	9
Personnel Error/Machine Failure	62	14
Structural Failure/Leak	61	9
Other/Unknown	45	12

Figure D-3
Accident Types as Percentage of Total Number of Accidents



Additional comparisons are drawn with work by Harrald et al in Puget Sound [1994] and Prince William Sound [1997], Wenk et al in Puget Sound [1982], MIT Sea Grant study [1996], Washington State Office of Marine Safety data, and the results of the Coast Guard Port Needs Study [1991].

In the report "Evaluating and Monitoring Maritime Risk: The Development of a Vessel Risk Model for Puget Sound and the Straits of Juan de Fuca" [Harrald et al, 1994], the primary goal was the development of a port state control evaluation system, including weighting and scaling factors, to screen vessels inbound to Puget Sound area waters. As such, it did not explicitly evaluate accident types, but rather focused on accident causes, in order to restrict the scope and allow detailed development of this screening system. As such, their results cannot be directly compared with ours. However, two findings from that study are worthy of note and will be briefly discussed here.

First, the researchers focused in heavily on human and organizational factors as primary features in vessel risks. Not only were the majority of factors in the screening model directly focused on human and organizational factors, but those with the highest weightings fell into that category as well. Secondly, their findings also highlighted the hazard significance of unregulated vessels, which was an item noted by the expert panel as well. In fact, much of the risks of accidents in eastern waters were attributed in part to these vessels.

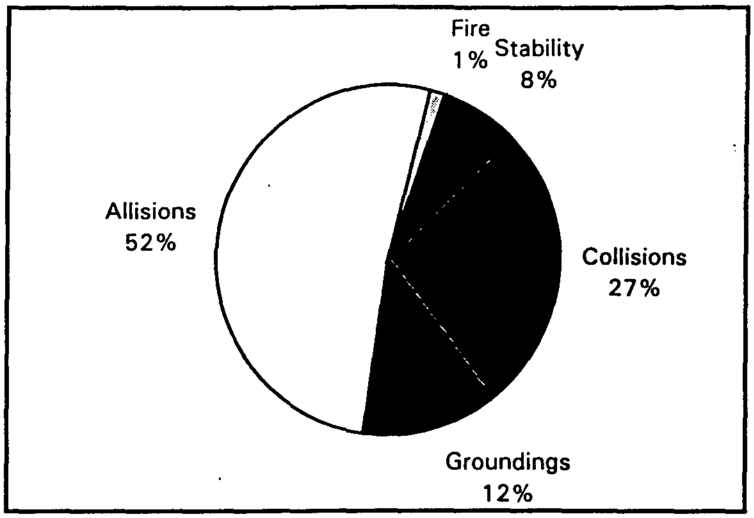
In the report "Improving Maritime Traffic Safety on Puget Sound Waterways" [Wenk et al, 1982], the focus was primarily on preventing the loss of life in Puget Sound area waters; a significant goal not focused on in this study. Here, based on U.S. and Canadian Coast Guard data from 1974 to 1981, they found allisions to represent the single most common accident type, followed by collisions and groundings respectively. Their results are given in Table D-3, and a full representation of their results as mapped into this analytical framework is given in Figure D-4 below.

In our framework, the categories of "Near Miss" and "Wake Damage" were not considered, and "Capsizing" and "Flooding" were combined into "Stability". Furthermore, our taxonomy used "Allisions" versus "Rammings", a minor difference. As can be seen, the accident histories for their study and that which we obtained for ours were slightly different in relative incidence of accident type. While our study our study showed groundings dominating, followed by fires, allisions, collisions and stability, theirs was dominated by allisions and collisions, with the other accident types following at a distance. The causes for these differences are unknown, although should be expected given the relatively sparse nature of the data sets.

Table D-3
Incidents on Puget Sound Area Waters (1974-1981)

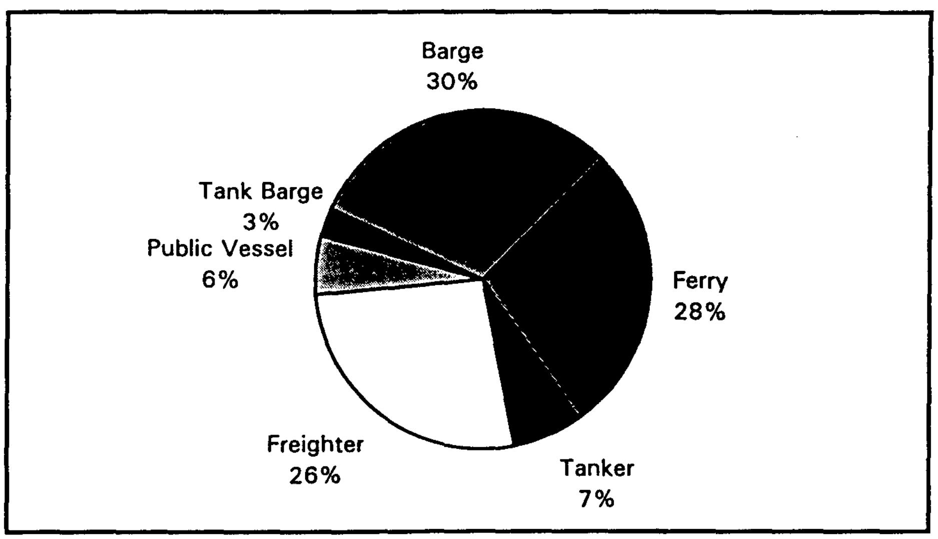
	Ferry	Tanker	Freighter	Public Vessel	Tank Barge	Barge
Collisions	12	5	15	4	0	21
Groundings	10	1	2	3	1	9
Near Miss	23	4	3	2	1	2
Rammings	26	7	40	4	4	28
Wake Damage	1	0	10	0	1	4
Equip. Failure	4	1	0	2	0	2
Fire	0	0	1	1	0	0
Capsizing	0	0	0	0	0	4
Flooding	0	0	0	0	0	12

Figure D-4
Accident history by accident type, Puget Sound (1974-1981)



In addition to this breakdown by accident type, the University of Washington researchers also looked at the differences between vessel types (Figure D-5). Here it can be seen that barges had the single greatest number of accidents, followed by freighters and ferries in that order, then distantly by tankers, public vessels and tank barges. As can be seen, this compares quite well with the results found from our analysis.

Figure D-5
Accident history by vessel type, Puget Sound (1974-1981)



Wenk et al also looked at the causes of mishaps for large vessels, and found similar results to our own. In their results, however, physical environment (current, narrow passage, visibility, wind and waves) was the predominant causal type overall, followed by human and organizational error and equipment failure. While this does conflict with our finding of human and organizational error (HOE) as dominant, it can be at least somewhat attributed to the systemic investigation and database difficulties at the time in regard to HOE. However, the greater significance of physical environment compared to vessel deficiencies was in agreement with our findings. Furthermore, when looking at causal factors by accident type, the results also match up quite well. Their findings showed collisions to be a strong function of HOE, with a more even distribution for groundings, which agrees with our results.

In their analysis as part of the ongoing MIT Sea Grant study "Formulation of a Model for Ship Transit Risk" [Kite-Powell et al, 1996], researchers have started an analysis of vessel groundings (to which they attribute one-third of all U.S. accidents) for five U.S. ports (Boston, New York, Tampa, Houston and San Francisco). While encountering several difficulties which require further work, and finding significant differences in grounding rates between ports, they did find one significant result when causes of these groundings were analyzed.

In their breakdown, they analyzed the effects of vessel size, chart uncertainties, wind speed, visibility, personnel, and channel complexity. However, only one of those factors, vessel size, was found to provide a satisfactory result. As expected based upon maneuverability considerations, they found that "larger ships are consistently more likely to ground than small ships (drafts less than 30 feet)". This supports stakeholders concerns about the trend towards larger vessels in the dry cargo fleet.

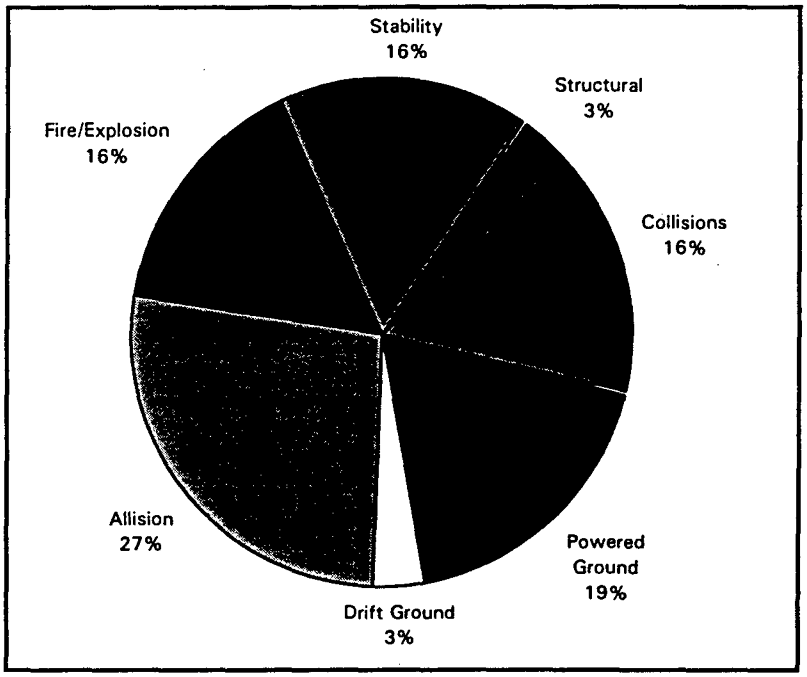
In the recently published "Prince William Sound, Alaska Risk Assessment Study", researchers from The George Washington University, Rensellaer Polytechnic Institute and Det Norske Veritas looked into the likelihood of oil spills in the Valdez area. Several findings of note were made, and will be discussed here. (These results are significant when one considers that the majority of the tanker traffic is moving between Prince William Sound and Puget Sound. However, care should be taken not to over-emphasize their results, as the Prince William Sound waterway system is significantly different than the Puget Sound system. While Puget Sound has greater levels and varieties if traffic, it is also larger, and also enjoys greater tug availability and no ice difficulties among others).

In their findings, researchers found that collisions represented the most likely accident, followed by powered groundings, drift groundings, structural failures, and fires/explosions. However, when considering potential oil outflow (which incorporates both likelihood of accident type and expected oil outflow given accident type), the picture changes somewhat. While collisions still dominate, drift groundings surpass powered groundings in significance.

The Washington State Office of Marine Safety also provided data. As no positional information was provided, these data could not be used to check the segment by segment analysis. However, these results do provide a check on the analysis of accident types, and provide additional information on the number of casualties by vessel type. In their data, propulsion failures were the predominant casualty type, with 30% of the records on file. However, in this analysis, these were considered as incidents, which were not explicitly analyzed. Looking only at the vessel accidents, then, some comparisons and conclusions can be drawn.

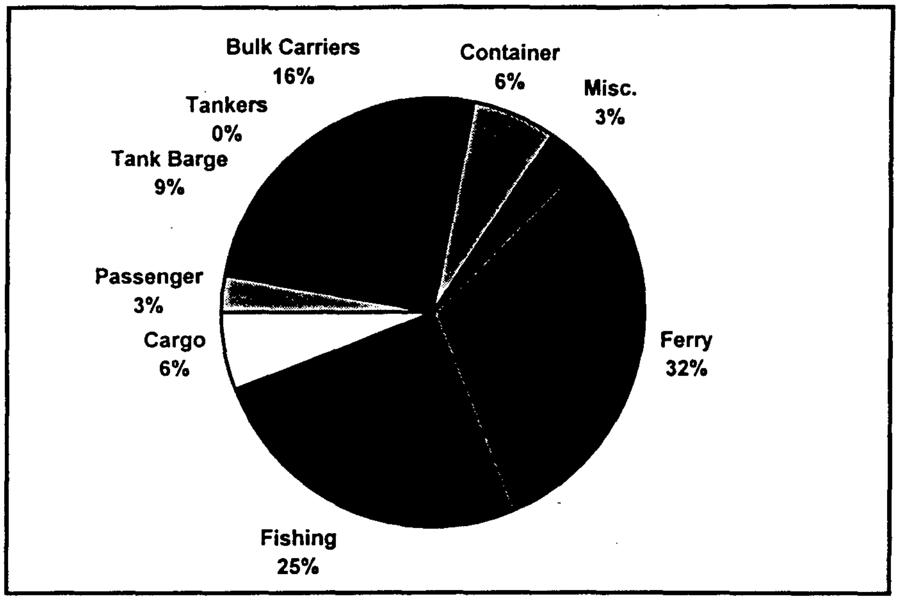
As shown in Figure D-6, the OMS accidents were fairly evenly distributed between allisions, powered groundings, fires/explosions, stability failures and collisions, much as was seen in the Coast Guard data set. These results compare well with the Coast Guard data used herein. While this could be expected (OMS and Coast Guard have similar reporting schemes, and the data covered similar regions and time frame), it by no means was a given (due to the various flaws and biases found in each data set).

Figure D-6
Percent of Accidents by Type (OMS Data)



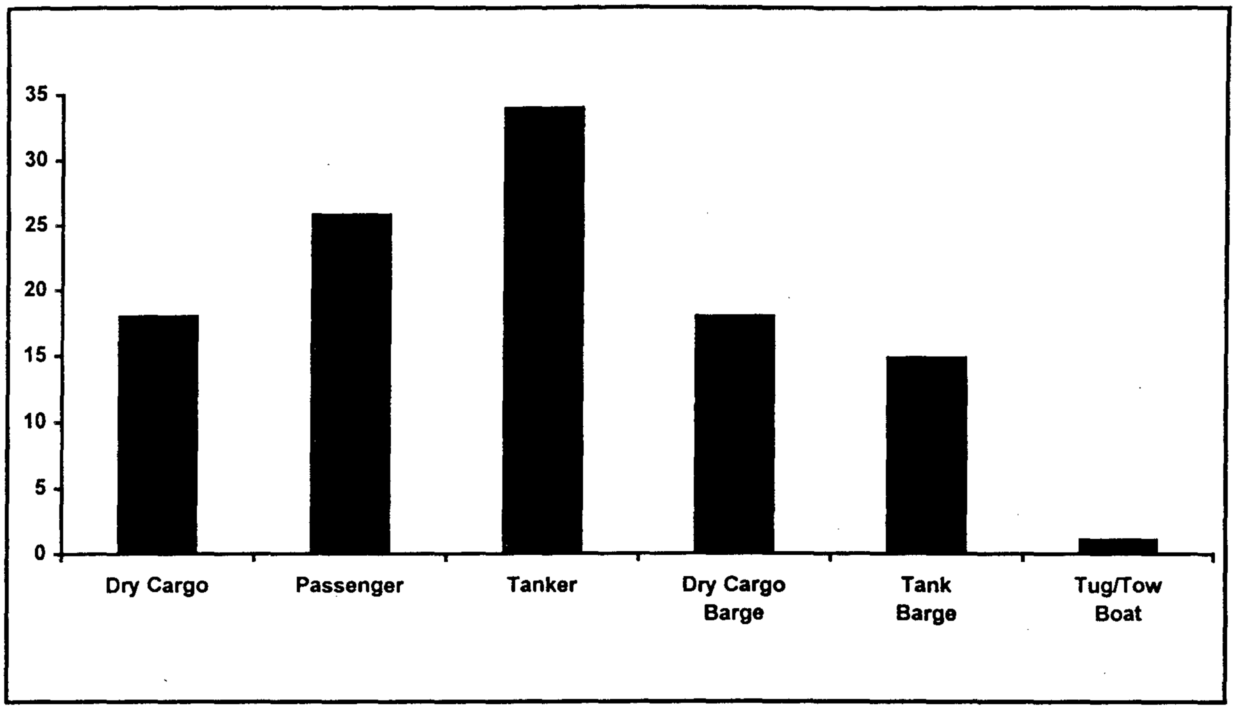
To provide another insight, the OMS vessel type data were examined. While insufficient data points existed for analysis by individual types, the full set of accidents do show some significant insights. Figure D-7 shows the percent of accidents by vessel type. Here, ferry accidents dominate, followed by fishing vessels, bulk carriers, and other vessels. As seen, these results give further support for our findings. While the fact that ferries had the most accidents, this should not have been surprising, given the fact that they represented 40% of all vessel transits during the 10 year time frame of this study. Their casualty rate, therefore, will be lower relatively than what is indicated here. However, the large percentage of fishing vessel and bulk carrier casualties are of interest. These data do show a high incidence for these vessels, although actual casualty rates (which would be the better indicator) are unknown.

Figure D-7
Accidents by vessel type (OMS data)



As part of the research for the Port Needs Study, vessel casualty and traffic statistics were analyzed to determine the baseline casualty rates over 23 port areas, including Puget Sound. These base casualty rates are shown in Figure D-8 through D-10. In Figure D-8, it can be seen that dry cargo barges have the highest accident rate nationwide, followed by tankers and passenger vessels. While these results do not correlate to the results found in the Puget Sound waters (Wenk's data showed barges, freighters and ferries as the three most common vessels in the 1974-1981 accidents, and the OMS data showed ferries, fishing vessels and bulk carriers as the most common vessels in accidents after 1992), such differences can be expected. First, the Port Needs Study data were for accident rates, and thus were normalized by the number of transits, where the Wenk and OMS data were not. Second, the national data were for a longer period of time and, covering 23 port areas, had a greater number of data points (and therefore was a more robust data set). Furthermore, the Port Needs Study [Volpe, 1991] analyzed only collisions, rammings and groundings. Finally, differences between the Puget Sound waterway system and the others studied do exist and should be expected to alter the results somewhat.

Figure D-8
Accident rate per 100,000 Transits



In Figures D-9 and D-10, the base casualty rates by accident and vessel type are shown. As discussed previously, only the three accident types shown were analyzed by Volpe, who were investigating the effectiveness of VTS systems. As shown in Figure D-9, groundings represented the most common accident type of the three types in the period and 23 port areas studied, having a rate almost twice as large as collisions. In Figure D-10, it can be seen that, for groundings, dry cargo barges had the highest accident rate, almost half again as large as that for tankers and passenger vessels, which followed. For collisions a similar relationship is shown, with dry cargo barges having a rate over twice that of tankers and passenger vessels.

Figure D-9
Numbers of accidents by type of accident

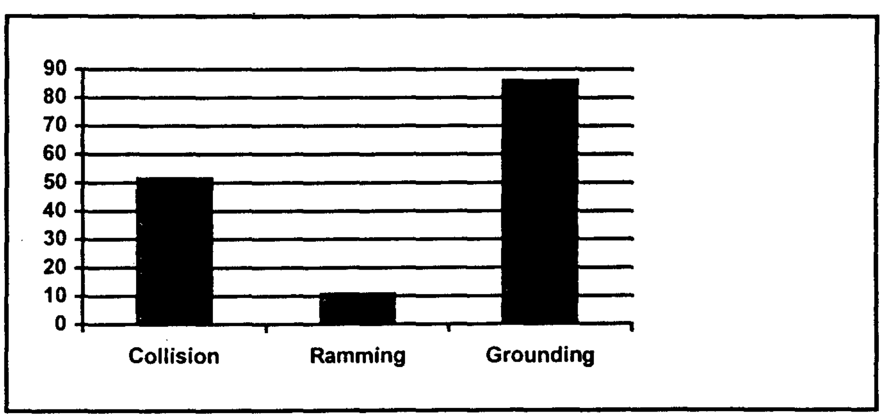
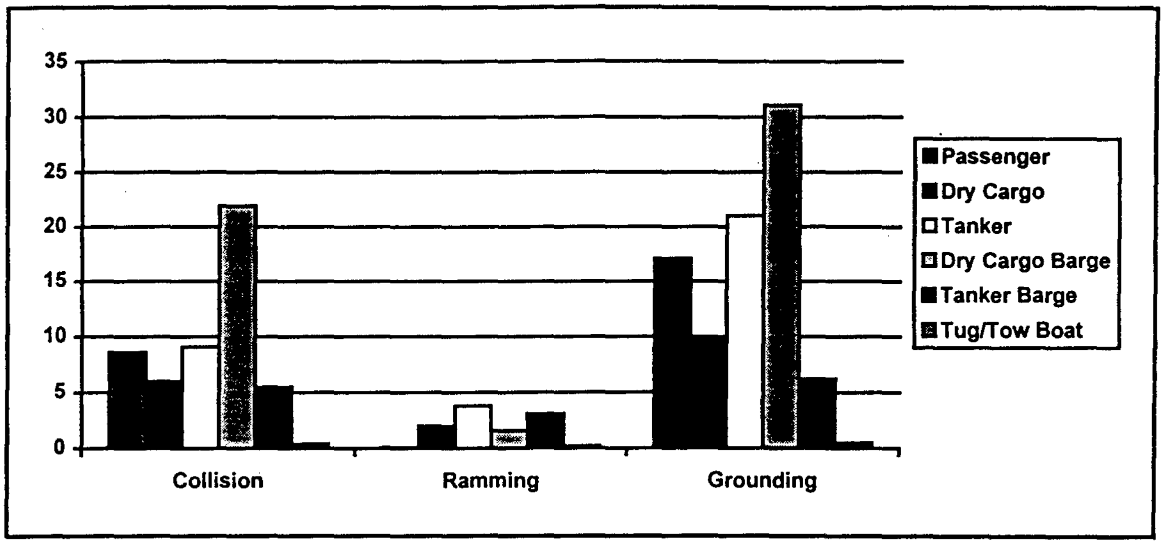


Figure D-10



Changes from these base rates (number of accidents per 100,000 transits) were then determined for a number of sub-zones within each of the areas studied. These differences were captured by risk adjustment factors, which are given for the 9 regions used for the Puget Sound area in Table D-4 [Volpe, 1991]. Here, risk adjustment factors less than one indicate a lower accident rate than the national average, while risk adjustment factors greater than one indicate a higher rate.

Table D-4
Risk Adjustment Factors for Puget Sound Regions [Volpe, 1991]

Region	Risk Adjustment Factor
Western Strait of Juan de Fuca	0.92
Eastern Strait of Juan de Fuca	0.31
Hood Canal	0.64
San Juan Islands	1.05
Strait of Georgia	0.02
Everett	0.10
Lake Washington	0.78
Puget Sound, South of Tacoma	2.90
Central Puget Sound	0.03

SUMMARY

The high hazard significance of Segments 6 and 7 found in this study has been confirmed by Wenk and the Coast Guard Port Needs Study. The Expert Panel for this study highlighted the substantial risk in Segments 1 and 2. Their finding is supported by a study prepared for the Canadian Council of Ministers of the Environment, which found the entrance of the Strait of Juan de Fuca most likely place for spill of 1,000 to 10,000 barrels [Allan and Dickins, 1995] Overall, these four segments were the most significant in terms of the likelihood of an accident which could result in a significant oil spill. For national comparison, the findings of the Port Needs Study indicated an accident likelihood lower than the national average for all but two subzones in the Puget Sound system.

For types of accidents, similar agreement can be found between the results of our study and those of others. The data here show allisions to be the most common accident type, followed by powered groundings, fires and explosions, loss of stability, collisions, drift groundings, and structural failures. These results directly agree with those found in the Washington State Office of Marine Safety results, and are close to what Wenk et al found in their study. While these accident histories do not match exactly the results given by the Expert Panel, it is important to note that the expert panel considered the likelihood of accidents which could result in a significant oil spill. As such, they considered an additional step not provided by the data; the likelihood of a spill given an accident. This additional step thus explains the experts finding collisions, powered groundings and drift groundings to be more significant than the other accident types. Overall, collisions and powered groundings were found to be the dominant accident type, followed by drift groundings, stability failures (which includes flooding), fires and explosions, allisions, and structural failures. This final result is in agreement with the MMS study of tanker casualties and is believed to be representative of the true nature of the waterway system.

PUGET SOUND OIL SPILL RISK ASSESSMENT EXPERT PANEL
MINUTES OF 21-23 APRIL 1997 MEETINGS

Executive Summary

The Panel met over three days in Bellevue, Washington to assess 1) likelihoods of accidents and spill events in the waterway, 2) the consequences of spills, and 3) the efficacy of new safety and response measures for risk reduction. The Panel was, on the whole, successful in reaching these goals. There were some methodology and thought process issues on the part of the Marine Transportation Working Group (MT WG), but they were able to get through the spill hazard characterization and consideration of new measures. The Environmental Impact Working Group (EI WG) completed the sensitivity and response assessment, and met again on May 22nd to work through their investigation of new response measures.

Panel's substantive findings, based on a process which yielded qualitative results, are the following:

- The spill scenarios of importance in this waterway are collisions, and powered and drift groundings. The main contributory causes are human and organizational error (HOE), including many factors such as poor communication, poor training, and lack of maintenance, traffic congestion, particularly as regards non-regulated vessels, and environmental conditions such as wind and waves.
- The highest probability of accidents resulting in spills was seen in Segments 1, 2, and 7. The most likely cause of such an accident was a collision, except in Segments 5 and 6, where powered groundings were seen as the most likely scenario.
- All segments of the waterway were seen as having unique and highly sensitive environmental values and were therefore scored in a narrow high end range. The net consequence of oil spills was considerably more varied after taking account of the feasibility of response in different segments. The net sensitivity ratings are highest for the outer coast areas, Segments 1 and 2, and the areas around the San Juan Islands, Segments 5 and 6.
- The spill risk rating, arrived at by straight multiplication of the relative spill likelihood and net consequence rating (both on a scale of 1-5), turns out the highest in Segments 2, 1, 6, and 5, in that order. The ratings for Segments 1 and 2 are substantially higher than those for 5 and 6; the western coastal area emerged very clearly as that meriting the greatest concern.
- The MT WG found that crew enhancement and port state control enhancement were the most promising areas for risk reduction, as well as improved training and qualifications for operators of fishing and recreational vessels. Operational modifications, including VTS infrastructure and use and TSS improvements, were also seen with significant potential.
- The EI WG concluded that enhanced salvage capability, defined to include fire fighting, patching, ballast adjustments, lightering and towing, is the measure likely to be the most effective in spill mitigation. They identified several options for effecting the enhancement (see Attachment 2B). The Group also found that quick execution of in situ burning and oil dispersion could be effective in Segments 1, 2, and 3.
- The project team had to make several adjustments to the methodology and learned some valuable lessons in the art of port risk assessment. The product report must account for these adjustments and include new sources of data identified during the meeting. The sense of the meeting was that existing accident data do not provide the causal information desired.

This is the final version of these minutes. They are organized in sections, added as attachments. The first of these (1A and 1B) describes the plenary and MT WG sessions. The second (2A and 2B) is the proceedings of the EI WG, executive summaries by Judy Schwenk of the Volpe Center and Chairperson Sharon Christopherson, respectively.

#

Plenary of 4/21 am

Mr. Joe Angelo of Coast Guard Headquarters opened the meeting with greetings to the Panel and a description of Coast Guard programmatic goals and the place of this risk assessment project in the long term approach to safety in the Puget Sound waterway. He was followed by Dr. Edward Wenk, Jr., Chairman of the Marine Transportation Working Group, who set the tone for the meeting by reminding us that the room was full of dedicated professionals sharing a common goal: safety in the waterway. Ed stated that for most intents and purposes there would be no distinction between "experts" and "advisors" on the Panel (project leaders later decided that all members would have full voting powers, both as a matter of practicality and in recognition of the contributions that all could make). Dr. Wenk then introduced the members of his Working Group. Dr. Sharon Christopherson, Chairperson of the Environmental Impact Working Group, then made opening remarks and introduced the members of her Group.

Michael Dyer and Gary Watros of the Volpe Center described the approach of the risk assessment and the particulars of the methodology into which the Panel's findings would go. Dr. Wenk then asked for general comments. Chad Bowechop of the Makah stated that the Federal Government must be held to the highest legal, administrative, and technical standards in safeguarding the treaty rights of the Makah and other tribes, i.e., resource protection for cultural and subsistence purposes. Andy Palmer of Ocean Policy Associates expressed concerns with the data to be used in the study and asked that the Panel comment on its reliability.

Following closing comments by the Chairpersons and a break, the Working Groups went into session.

MARINE TRANSPORTATION WORKING GROUP

4/21 am Puget Sound Marine Transportation Working Group Highlights

The Group spent the morning in general discussions on the "state of the waterway", with focus on identifying the most worrisome hazards and promising solutions. There was also comment on the study methodology and approach to the meeting.

Many felt, in the main, that the waterway is safe, but that improvement is still needed in some areas. The substantive points offered by individuals in their opening comments were the following:

HAZARDS

Universal

- Insufficient crew training
- Unregulated traffic.
- Need for recreational boater ed. and licensing
- Poor capability for locating nearby vessels in poor visibility by ship masters.
- Lack of adequate English language skills on many ships.
- Lack of enforcement of existing regulations, e.g. language, crew fatigue.
- Danger of unintended consequences from introduction of new measures.

Marine Transportation Working Group

Experts

Professor Edward Wenk, Chairman	University of Washington (retired)
Captain Miklos Endrody	Puget Sound Pilots
Professor Robert Bea	University of California, Berkeley
Dr. Jack Harrald	George Washington University
Captain Peter Golden	Canadian Coast Guard
Professor Hal Hendrick	University of Southern California
Captain Myles Boothe	Coast Guard MSO Seattle, COTP

Advisors

Captain James Morgan	ARCO Marine, Inc.
Captain Ian Walker	BP Oil
Doug Ward	American President Lines
Jerry McMahon	American Waterways Operators
Jerry Lucas	Makah Nation
Stan Thurston	Retired tug/tow operator
Fred Felleman	Ocean Advocates
CDR Paul Huscher	Naval Surface Group Pacific Northwest, U.S. Navy
Captain Jim Caspers	Washington State Ferry system
Stan Norman	Washington Office of Marine Safety
LT Dan Precourt	Seattle VTS, U.S. Coast Guard
Ralph Hughes	Vancouver VTS, Canadian Coast Guard

Latent, organizational causes of safety problems. Blame for the Exxon Valdez had origins far and wide (e.g., Houston, Washington, D.C.). Avoid shifting of blame. Importance of a culture of safety.

- Maritime culture---> primacy of Captain. Some positive changes here, but still room for improvement.
- Human factors important, but safeguards must still be in place for those accidents that do occur.

Local

- Traffic at entrance to the Strait of JdF: lack of pilots, strong currents, bad weather and seas, lack of tug escorts.
- VTS gaps, southern Puget Sound and Rich Passage.

NEW MEASURES

Universal

- The importance of a system approach to the waterway, and avoidance of piecemeal measures whose overall effects are not known. Complete waterway management.
- Care to avoid crew paper and procedural burdens. Simplification of bridge procedures, e.g. by integration of U.S./Canada requirements.
- Primacy of training and qualifications for everyone on and concerned with the water: ship crews, inspectors, pleasure boaters, etc. "First class, safety conscious people".
- Transponders for ships
- Improved port state control: improved inspection, more teeth in penalties for non-compliance, e.g. keeping bad ships out.
- Improved data collection: causality, personnel, near miss.
- Systems which provide warnings of impending error.
- High reliability management---> real time response to problems, involvement of people.
- Improved enforcement and compliance.
- Provision of incentive for "green" ships.

Local

- Improve VTS in Rich Passage and south Puget Sound.
- Pilots from Cape Flattery
- Tug escort for double hulled tankers as the fleet is replaced.
- Importance of tug escorts as extra eyes/ears and as "guardian" from J Buoy in.

MAKAH CONCERN

- Government must be held to highest standard in protection of Treaty rights; preservation of environment and tribal way of life.

METHODOLOGY ISSUES AND OTHER COMMENTS

- Need for Panel's confidence in data. Also, the need to use as much local data as possible.
- Desire for a flexible model which can reflect new data.
- The desire for a new start altogether on the safety system, i.e., no more band-aids.
- The need to search for latent underlying causes and "macro" targets for safety improvement.
- Beware that equipment will not fix a people problem.
- Broader public involvement in Coast Guard policy is necessary.
- Coast Guard self-examination needed. Cite of NTSB assertion that CG implements the fewest of its recommendations.
- Available causality data are questionable.

4/21 pm

The afternoon session began with talks on human and organizational error (HOE) by Bea, Harrald, and Hendrick, a revisitation of the EXXON VALDEZ by Wenk, a discussion of NTSB safety recommendations to Coast Guard by Boniface, and a brief discussion of available Coast Guard data by Boniface and Watros. The latter led to the suggestion that oversight and screening should include vessel personnel.

The Group began on Worksheet #1, assessing "universal hazards" and ran into problems with definitions of probabilities and how to deal with hazards across the waterway. By day's end, the worksheet was largely completed.

4/22 Marine Transportation Working Group Session

The project team made adjustments to the approach for the meeting by simplifying the questions and required input. The product of the meeting would be a picture of the waterway hazards and existing measures, with new measures considered in general categories rather than specific items. The Group agreed to approach hazards on the basis of the most likely or worrisome accidents (these turned out be collisions and powered and drift groundings) and major hazard categories for each, segment by segment. This examination was restricted to underway transit events and did not include dock allisions.

The significance of each accident type and the five causal categories were determined by simple 1-5 (low likelihood to high) rating by all Group members (voting was not allocated, but conducted topic by topic). The Group agreed to hear descriptions of operations from members who had operated large ships in the waters of interest. First up was Jim Morgan of ARCO to describe a transit from Alaska into the Strait of Juan de Fuca via the approach to the J Buoy. The first phase of Group voting for accident likelihoods addressed relative likelihood of accident types and hazards in each segment (the Group later assessed the relative probability of accidents causing spills in the nine segments). This process continued later for the landward segments with discussions led by Miklos Endrody (pilot) and Jim Caspers (ferry captain). The Group decided to consider both Segments 5 and 6 and 8 and 9 as similar pairs. The particulars of the discussions on each segment are bulletized in Attachment #1A.

These discussions resulted in likelihoods for each of three types of accident ***within each segment***, and their most likely causes. These results are also given in Attachment #1A.

4/23

LT Boniface presented the data showing the previous day's results. The floor was open for comments, which included 1) the need to break the error chain at a number of points, 2) further discussion on data (see below), 3) the point that Coast Guard can vary some regulatory measures now in place (e.g., temporary regulated navigation areas), 4) the statement that enforcement of operating rules for fishing vessels doesn't help, 5) mention of the State alcohol and drug test program, and 6) a reminder that ITOS would be effective on September 1 with transponders on the tugs.

The data issue was again raised, with concerns that the study does not have adequate amounts of it. It was agreed that Coast Guard data lack sufficiently specific detailed causality information. Washington OSM has some near miss and incident data, but it was agreed that their reports would have to be reconciled with those of the Coast Guard Seattle COTP and "hand analysis" undertaken mutually to best determine causes. Mr. Norman and Captain Boothe agreed that they should do this task, but it is probable that they will not be able to do so in time for this study. LT Boniface added that the risk model resulting from this study could be updated with new data when received.

The Panel also received a new report from the Washington Department of Ecology, "Oil Spills in Washington State: A Historical Analysis". "Major" and "minor" spills since 1970 are cataloged and analyzed; this document will contribute to the Volpe Center accident and spill analysis.

Next, the Group voted on probabilities of accidents resulting in serious spills (agreed as >10,000 gallons). The Group voted (again using 1-5 scale for each segment) on the likelihood of such accidents in each segment. There was discussion and disagreement as to whether the aggregation of segment ratings constituted relative likelihoods across the waterway. These results appear as the figure titled "Likelihood of Vessel Accidents".

4/23 am Plenary

The EI and MT WGs joined for plenary session at about midmorning. EI Chairperson Christopherson reported that her Group had found high sensitivity values in all segments (with minor separation of scores); each segment has some critical things in it. Since her Group had no Canadian representation, Segment #2 was assumed to be similar to Segment #1, likewise for #s 5 and 6. Since only the Makah were present to address cultural and archaeological values, these were assigned 5s for all segments.

The EI WG also noted that they weren't even asked to assess the economic and commercial aspects of spill sensitivity. They pointed out that the high sensitivities arrived at don't tell the whole story and that the importance of prevention cannot be overstressed. They also reported that the Hood Canal had been assessed for its sensitivity (also very high) even though it was not included as part of Segment 7.

Dr. Wenk pointed the importance of thinking on a system basis, but added that it is an organism, not a mechanism. The EXXON VALDEZ had revealed far flung human and organizational problems, and the long term lack of action in some areas may be itself an indication of a system problem.

MT Working Group 4/23 pm session

The last voting process was for the assessment of new measures and it went in five steps:

1. Completion of a list of target measures, as nominated by Group members, and categorization of the list.
2. Multi-voting (9 for each member) for most effective measures categories in each segment.
3. Picks by each member of the five most important specific measures (not segment specific).
4. Pick by each member of the single most important measures.
5. Query of each member "What would you do tomorrow to make the waterway safer?".

Step 1 was first a selection of three proposed measures each by the members; these were then categorized by nine prevention strategies, e.g., "crew enhancement" or "emergency procedure". Multi-voting in Step 2 (nine votes per member) then established the Group's preferred strategies for safety enhancement. Steps 3 and 4 refined this result by targeting preferences for specific measures and Step 5 was a sense of the meeting discussion on immediate actions that could help. The results of these appear in Attachments 1B.

4/23 pm Plenary

The entire Panel re-convened for a brief plenary at the end of the day. The MT WG reprised its findings on new measures (the segment by segment vote). EI reported that they had difficulty completing the assessment of new measures. They will have an additional meeting to complete.

#

Attachment 1A
MT Working Group Assessment of Accident Scenarios and Causal Factors

Ratings of relative likelihood of accident scenarios and causality are summarized in the spreadsheets at the end of the attachment.

SEGMENT 1

Captain Jim Morgan of ARCO described a passage from the northern approach to the J Buoy. The following are the elements of such a trip which a master must deal with. His comments were given in the context of a worst case scenario.

- Deep Draft Merchant Hazards

  WX Fog, Sea Clutter
  Canadian Tanker Exclusion Zone
  Fishing vessels traffic, particularly on L.P. Bank
  Fishing lights and loss of night vision and profile prospective
  Poor communications
  Fatigue of master

- TOFINO VTS gives recommended course of action; U.S. VTS more often relays traffic situation w/o recommending or mandating a course of action. From this perspective, passage is more difficult in internal waters.

The Group considered the likeliest accident scenarios and their causes for Segment 1 (cause not necessarily presented in order of significance).

Collision

- Visibility
- Traffic Density
  - Congestion at J Buoy
- Traffic Type (F/V)
- Bridge Resource Mgt.
- Communications
- Manning
- Fatigue
- Equipment Failure
- Weather
- Bridge Distractions

Drift Grounding

- Steering Failure, maintenance, operational failure
- Propulsion Failure
  - OP procedure--F/O change, testing
  - Maintenance/age
- Wind
- Sea State
- Current
- Fire

- Vessel Type and drift Characteristics
- Crew Competence, training and ship knowledge

Segment #2

Discussion of Segment #2 was along the same lines as Segment #1. Distinguishing characteristics were:

- Lack of VTS coverage south of Cape Alava.
- Proximity of Duntze rock to TSS.
- More barge traffic, in particular tank barges.
- Less danger from crossing traffic.

Segment #3

Captain Morgan's comments were brief regarding the outer Strait of Juan de Fuca. There is little crossing traffic and simple navigation (one small course change only). He opined that the traffic lanes are somewhat narrow considering the overall width of the waterway and the separation zone there, suggesting a possible widening of the lanes and narrowing of the separation zone. M It was pointed that VTS Seattle requiers check-in from the ships at the point of the single course change there. The discussion continued with the rest of the voyage to Cherry Point/Ferndale, starting at Port Angeles with the boarding of the pilot.

Segments 4, 5, and 6

Captain Morgan and Captain Endrody shared the lead in discussions from this point as the "virtual voyage" proceeded from the pilot pickup at Port Angeles to the northern terminals. Adverse factors cited are as worst case scenarios.

- Master getting fatigued
- Pilot and escort provide redundancy and robustness for safety
- Escort Plan
    - ARCO has own; Foss has a generic Puget Sound escort plan.
- Pilot abroad allows master to focus attention inward
- Concern about small boats
- Pilots more comfortable US/tradition
    - Good teamwork and communications
- Pilots have learned to work with poor English speakers w/sign language
- Endrody stated that currents are not generally a problem because they do not cross, but are with or against heading of ship.
- Voluntary speed down as going through to Cherry Point, not allowed to outrun escorts.
- Not much traffic from Bellingham
- Rosario Strait
    - Weather not normally a problem
    - Extreme weather can cause difficulties in docking; sometimes forced to anchor.
    - Weather restrictions at facilities, judgment of captains.
- Traffic in Rosario Strait
    - Tug and barge
    - Recreational boats a problem
    - Crossing ferry traffic, not a problem.
    - Close proximity of tethered escort

Same operational procedures for single and double hull ships

Rosario Strait has 1 way traffic for tankers >40,000dwt

Haro Strait

- Used by tankers if traffic conflict in Rosario causes great delay. Risk of meetings w/outbound Vancouver traffic noted.
- In Segment #5, traffic heading across Haro Strait is the primary concern
  Small freight (tug/barge), fish processors, recreational boats.
- Must have underway checks with Vancouver VTS
- Simpler transit, fewer course changes than Rosario
- Some tankers outbound have partial load and escort tugs
- No underway pilot Xfer as go through Canadian waters
- Some fog
- No meetings allowed at Turn Point (mandatory or not)
- 2 way traffic allowed in Haro Strait, a wider channel
- Significant course changes
- Escort required in US waters, voluntary in Canadian waters
- Weather can cause ferry route deviations

FERRY OPERATIONS

Captain Caspers led discussion on ferry traffic issues and traffic generally in Segment # 7 and 8.

- Less organization pressure to maintain schedule than in past.
- VTS management advisories critical to navigation safety.

SEGMENT #7

- Heavy tug and barge traffic
- 2 Ferries between Keystone and Port Townsend: "no problem".
- Ferry Edmonds- Kingston: "no problem".
- Pleasure boats congestion at Edmonds, peak density at Shilshole
- Pleasure boats not a concern Ship Canal and Everett
- Bremerton/Eagle Harbor ferries not a problem
- Small boats at Tree Tree Point
- Tacoma has many weekend sailboats
- Tanker crew fatigue a concern; they pick up 2nd pilot in harbor
- Edmonds- Kingston: difficult visibility departing dock; VTS helps. Used to have large fishing fleet.
- Elliot Bay high traffic
- TSS not in middle of waterway, different from Segments 4, 5, 6.
- Current less
- Softer bottoms
- More traffic generally and especially ferry

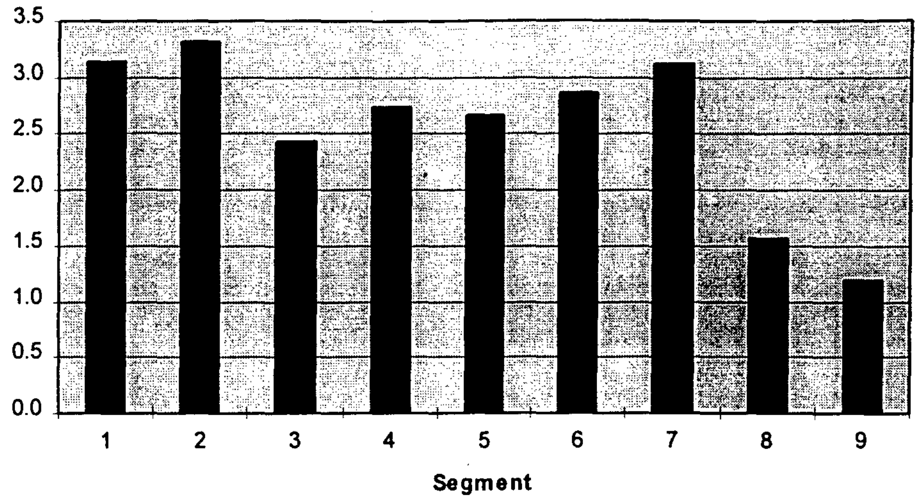
SEGMENT 8

- Mukilteo- Clinton Ferry not a problem; however, recreational boats are a problem
- Changing VTS not a problem
- Fishing vessels traffic
  Fishing has dropped off in recent years, decline of stocks
  Fishing congestion at Apple Cove was a nightmare now a Regulated Navigation area
- At Keystone terminal, 2 turning vessels may have a problem if meeting.
  High wind and treacherous tide
  Keystone Toughest ferry landing

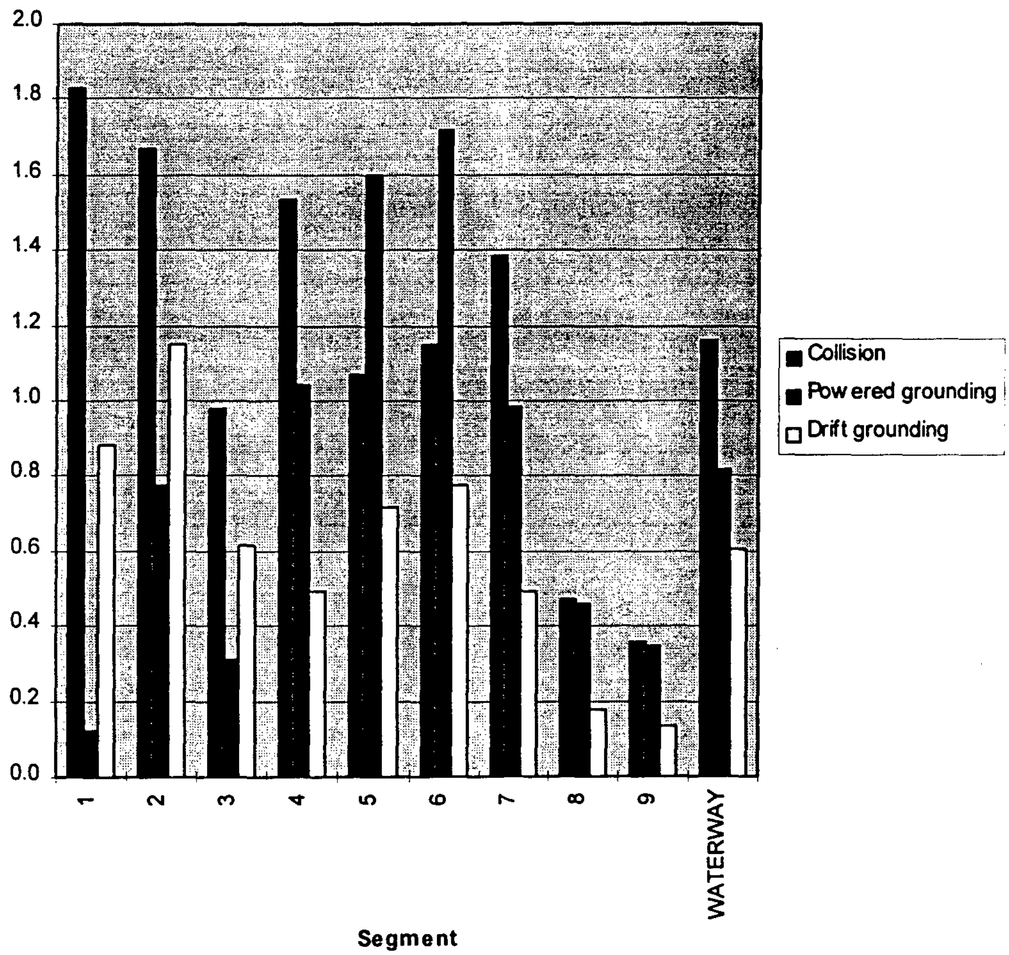
Remarks of CDR Paul Huscher, re: USN use of the waterway.

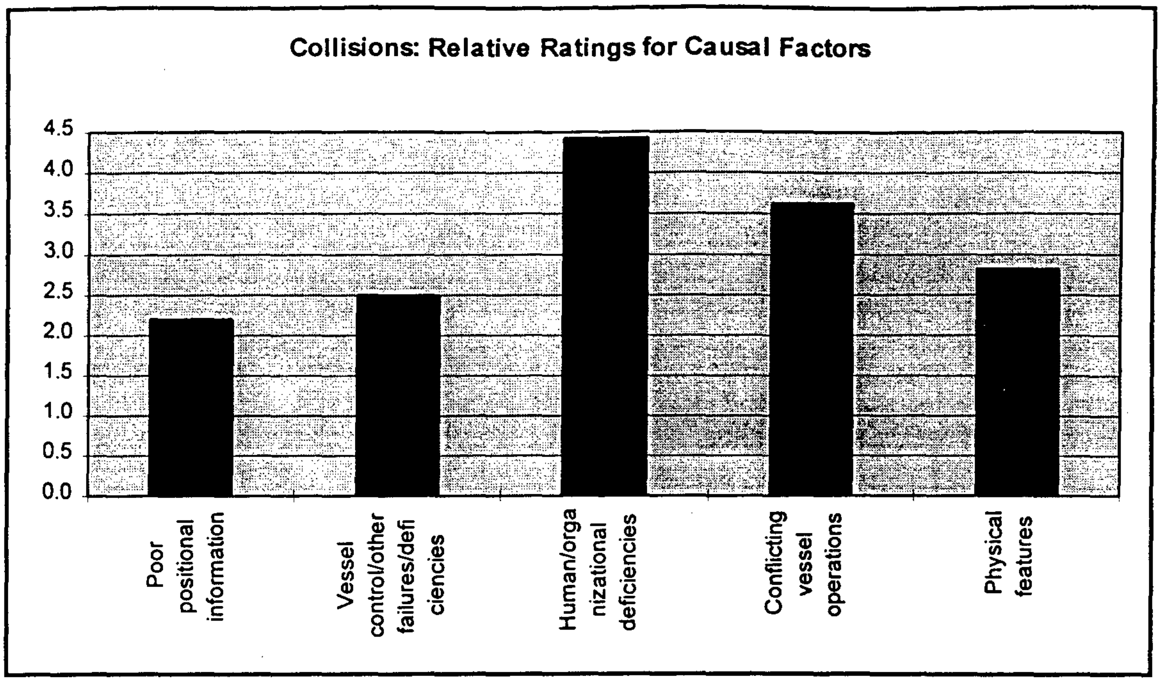
- Period of Navy growth in region is over; all ship transfers have taken place.
- Everett base
  - 4 Ships
  - 2 usually in maintenance availabilities
- Bremerton
  - 1 Carrier and 1 Oiler
- Most drills (include UNREP) are outside 50 nm
  - OPS in Straits or Southern Cal
  - If rough (winter) drill at mouth of Puget Sound (Segment 4)

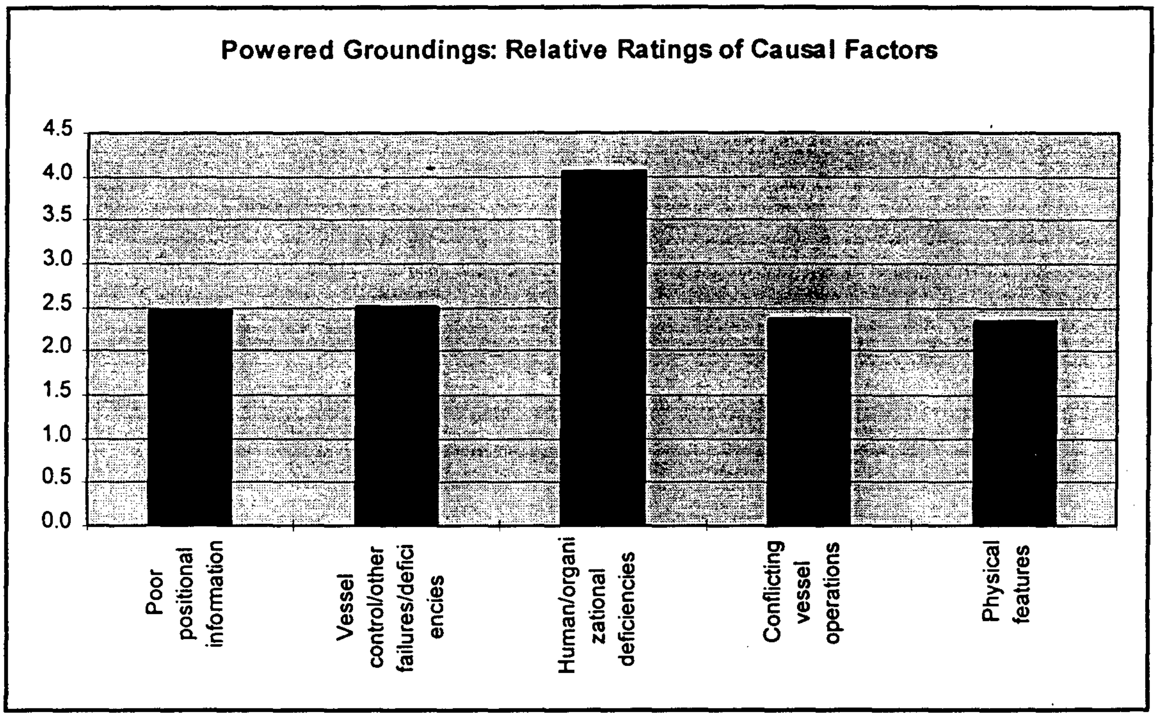
Likelihood of Vessel Accidents Resulting in Spills

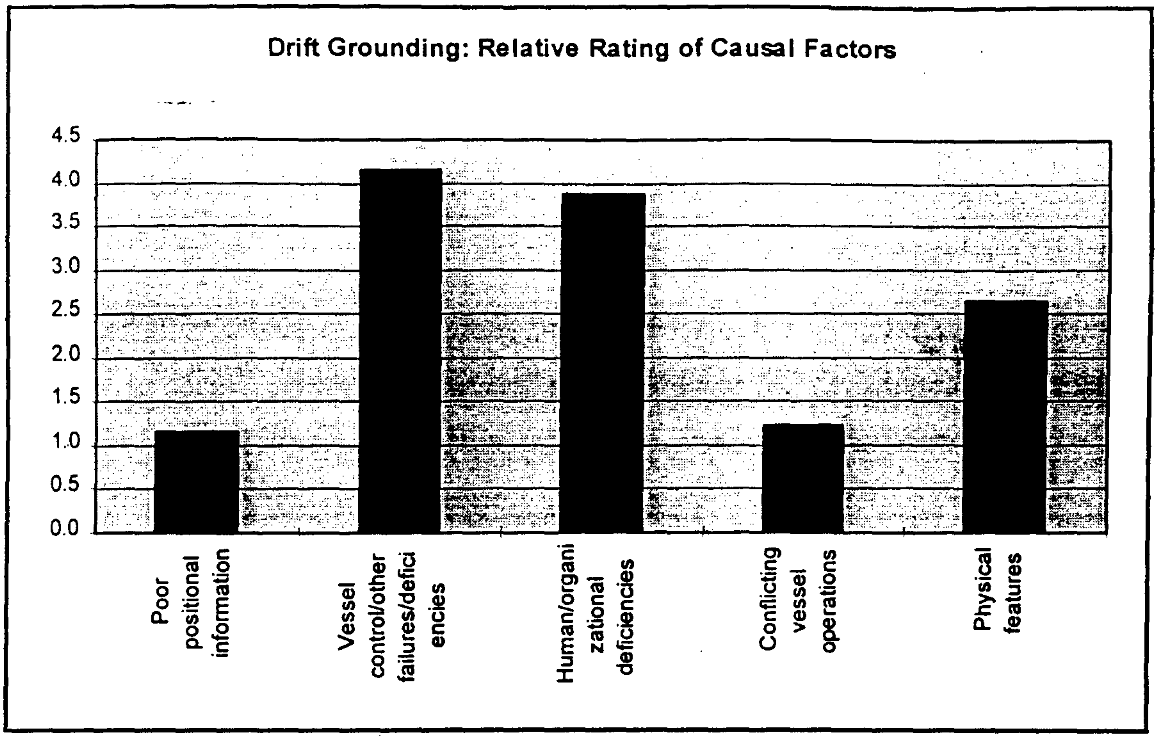


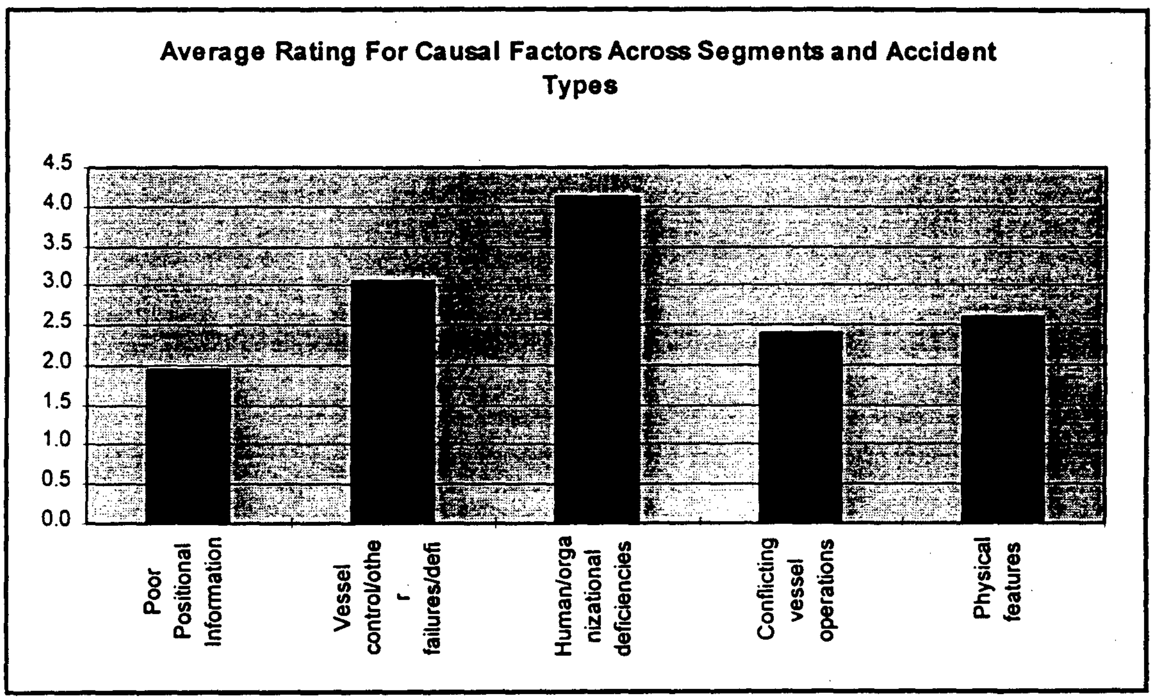
Relative Likelihood of Vessel Accidents




Collisions: Relative Ratings for Causal Factors
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Poor positional information
Vessel control/other failures/deficiencies
Human/organizational deficiencies
Conflicting vessel operations
Physical features

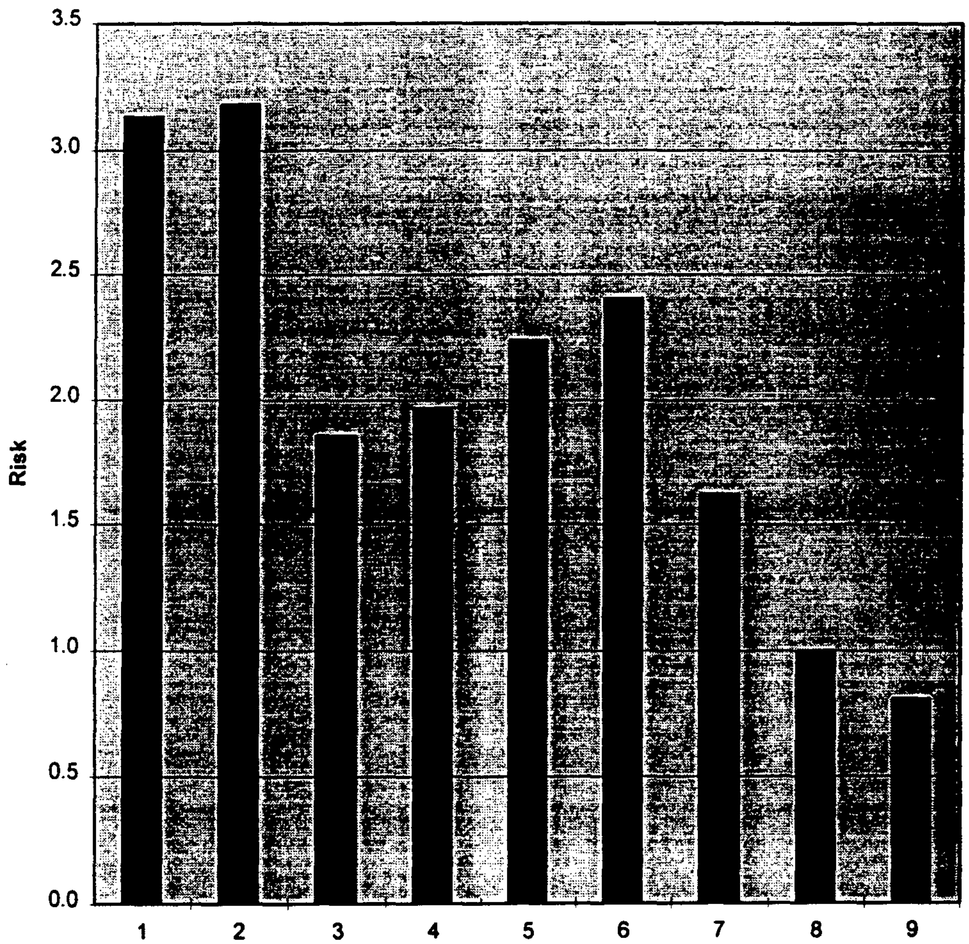

Powered Groundings: Relative Ratings of Causal Factors
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Poor positional information
Vessel control/other failures/deficiencies
Human/organizational deficiencies
Conflicting vessel operations
Physical features


Drift Grounding: Relative Rating of Causal Factors
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Poor positional information
Vessel control/other failures/deficiencies
Human/organizational deficiencies
Conflicting vessel operations
Physical features


Average Rating For Causal Factors Across Segments and Accident Types
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Poor Positional Information
Vessel control/other failures/defi
Human/organizational deficiencies
Conflicting vessel operations
Physical features

Segment	Rel. Spill. Likelihood	Net Cons. Rating	Interim Result	Spill Risk Rating
1	3.1	5.0	15.7	3.1
2	3.3	4.8	15.9	3.2
3	2.4	3.8	9.3	1.9
4	2.7	3.6	9.8	2.0
5	2.7	4.2	11.2	2.2
6	2.9	4.2	12.0	2.4
7	3.1	2.6	8.1	1.6
8	1.6	3.2	5.0	1.0
9	1.2	3.4	4.0	0.8

Spill Risk (= Probability * Consequence) Rating by Segment



Data Review

In response to questions concerning the inclusion of data for vessels other than tank vessels and freight ships (e.g., ferries, fishing vessels and freight barges), we re-queried the database to investigate the effect of this data on the outcomes. In order to make this comparison, the number of vessels had to be utilized, and not the number of records as used in the report. As discussed in Chapter 4, the number of records represents a low bound on the likelihood, while the number of vessels represents a high bound. Over the ten years covered by the study there were, as discussed, 136 accident records involving 182 vessels. Table D-5 compares the accident likelihood's by segment derived from these two data sets. Segments are listed in rank order from the main body of the report. As noted, the main body of the report used the number of accident records as representative. It should be noted that some of the likelihood representations provided here will not sum to one due to rounding.

Table D-5: Segment Likelihood's by Records and by Vessels

Segment	Likelihood by Records	Likelihood by Vessels
7	0.35	0.40
6	0.18	0.16
4	0.12	0.11
2	0.11	0.10
3	0.09	0.09
8	0.06	0.03
1	0.05	0.05
9	0.02	0.03
5	0.01	0.02

As seen, the rank and likelihood's of the segments are virtually unchanged when using the number of vessels. No segment changes likelihood magnitude by more than 5%, and the only rank order change was from segments 8 and 1 flipping.

The hazard significance of accident types was then compared between records and vessels, with the results shown in Table D-6 below. As can be seen, the primary difference between the two data sets were increased likelihood's for allisions and collisions when using the number of vessels as representative. With the likelihood by vessels, then, collision moved into the top three accident types, with no other changes in the ranking.

Table D-6: Accident Likelihood's by Records and by Vessels

Accident Type	Likelihood by Records	Likelihood by Vessels
Allision	0.29	0.36
Powered Ground	0.23	0.21
Fire/Explosion	0.15	0.12
Stability	0.15	0.10
Collisions	0.14	0.16
Drift Ground	0.03	0.02
Structural	0.01	0.03

Finally, the hazard significance of causal types was then compared between records and vessels, with the results shown in Table D-7 below. As can be seen, there were virtually no differences between the two data sets.

Table D-7: Causal Likelihood's by Records and by Vessels

Accident Type	Likelihood by Records	Likelihood by Vessels
Human & Organizational Error	0.39	0.41
Physical Environment	0.27	0.23
Conflicting Operations	0.19	0.15
Vessel Control	0.10	0.13
Positional Information	0.05	0.05

In order to pursue the effect of including various vessel types in the analysis, we then compared the results obtained by using all vessel types (as presented above), with two combinations. The first combination included tank vessels (barges and ships), freight ships and passenger vessels (ferries), and excluded, freight barges, towboats/tugboats, fishing vessel and "other" vessels (e.g., research vessels). The second combination removed passenger vessels from consideration as well, so that only tank vessels and freight ships were considered. Additionally, the effect of including incidents (e.g., propulsion discrepancies) was also investigated

For the first comparison, we investigated the effect of including various vessel types on the likelihood by segment. The results are presented in Table D-8. Here and in subsequent tables, category A includes all vessels, category B includes just tank vessels, freight ships and passenger vessels, and category C represents tank vessels and freight ships. Segments are listed in their rank order as obtained by using all vessel types.

Table D-8: Segment Likelihood's by Vessel Combinations

	Accidents + Incidents			Accidents		
Segment	A	B	C	A	B	C
7	0.40	0.39	0.39	0.40	0.39	0.39
6	0.16	0.20	0.20	0.16	0.20	0.20
4	0.11	0.11	0.12	0.11	0.12	0.12
2	0.10	0.09	0.09	0.10	0.09	0.09
3	0.09	0.09	0.09	0.09	0.09	0.09
8	0.05	0.05	0.06	0.05	0.05	0.06
1	0.03	0.02	0.03	0.03	0.02	0.03
9	0.03	0.03	0.03	0.03	0.03	0.03
5	0.02	0.01	0.00	0.02	0.01	0.00

As shown above, both the ranking and the likelihood rating of the segments are fairly insensitive to the data set utilized. In fact, the order of the top six segments are unchanged no matter which vessels are included and no matter whether incidents are used or not. Furthermore, the magnitude of the likelihood's are virtually identical, as seen.

For the next comparison, we investigated the effect of including various vessel types on the likelihood by accident type. The results are presented in Table D-9. Here again, category A includes all vessels, category B includes just tank vessels, freight ships and passenger vessels, and category C represents tank vessels and freight ships. Accident types are listed in their rank order as obtained by using all vessel types.

Table D-9: Accident Likelihood's by Vessel Combinations

	Accidents + Incidents			Accidents		
Type	A	B	C	A	B	C
Allision	0.19	0.09	0.17	0.36	0.29	0.26
Powered Ground	0.11	0.08	0.13	0.21	0.24	0.21
Collisions	0.08	0.06	0.12	0.16	0.19	0.18
Fire/Explosion	0.06	0.04	0.09	0.12	0.13	0.13
Stability	0.05	0.03	0.09	0.10	0.08	0.13
Structural	0.01	0.02	0.05	0.03	0.06	0.08
Drift Ground	0.01	0.00	0.00	0.02	0.00	0.00
Propulsion	0.21	0.27	0.10			
Steering	0.13	0.20	0.10			
Other	0.13	0.20	0.14			

As shown above, both the ranking and the likelihood rating of the accident types are fairly insensitive to the vessels included. In fact, the order is unchanged no matter which vessels are included and no matter whether incidents are used or not. Furthermore, the magnitude of the likelihood's are virtually identical, as seen. Similar results can be noted in the collection of accidents and incidents.

For the final comparison, we investigated the effect of including various vessel types on the likelihood by accident cause. The results are presented in Table D-10. Here again, category A includes all vessels, category B includes just tank vessels, freight ships and passenger vessels, and category C represents tank vessels and freight ships. Accident causes are listed in their rank order as obtained by using all vessel types. For this analysis, incident data were not analyzed by cause. Therefore, only the accident results are shown below. As can be seen, the results here are fairly insensitive to the vessels included.

Table D-10: Causal Likelihood's by Vessel Combinations

	Accidents		
Type	A	B	C
Human & Organizational Error	0.41	0.43	0.49
Physical Environment	0.23	0.21	0.18
Conflicting Operations	0.21	0.15	0.15
Vessel Control	0.10	0.13	0.12
Positional Information	0.05	0.08	0.06

To recap, while the likelihood of a significant oil spill may and likely will change by vessel type, the overall effect of including data from fishing and other vessels which do not carry large amounts of oil was insignificant. For the most part, the results for segment, accident type and accident causal hazard significances are unchanging with the vessels included. As such, we retained all vessels in the data set for this report.

TOTAL (+VCAS + MINMOD)

	1	2	3	4	5	6	7	8	9	Total
Collisions	1	0	0	2	0	4	23	3	0	33
Positional Information	0	0	0	0	0	0	3	0	0	3
Vessel Control	0	0	0	0	0	0	3	0	0	3
Human & Organizational Error	1	0	0	2	0	1	17	0	0	21
Conflicting Operations	1	0	0	2	0	1	15	3	0	22
Physical Environment	0	0	0	2	0	3	10	0	0	15
Powered Groundings	0	1	0	2	1	12	11	3	4	34
Positional Information	0	0	0	1	0	1	2	0	0	4
Vessel Control	0	0	0	0	0	0	0	0	0	0
Human & Organizational Error	0	0	0	1	1	10	8	0	4	24
Conflicting Operations	0	0	0	0	0	0	0	0	0	0
Physical Environment	0	1	0	1	1	4	4	3	1	15
Drift Groundings	0	0	0	0	1	0	1	2	0	4
Positional Information	0	0	0	0	0	0	0	1	0	1
Vessel Control	0	0	0	0	1	0	1	0	0	2
Human & Organizational Error	0	0	0	0	0	0	0	0	0	0
Conflicting Operations	0	0	0	0	0	0	0	1	0	1
Physical Environment	0	0	0	0	0	0	0	0	0	0
Allisions	0	0	0	0	0	4	50	4	4	62
Positional Information	0	0	0	0	0	0	0	0	0	0
Vessel Control	0	0	0	0	0	1	11	3	0	15
Human & Organizational Error	0	0	0	0	0	2	27	1	1	31
Conflicting Operations	0	0	0	0	0	0	21	0	0	21
Physical Environment	0	0	0	0	0	3	17	0	3	23
Fire/Explosion	0	1	0	3	0	6	8	1	2	21
Stability Failure	0	2	1	2	1	3	9	5	0	23
Structural Failure	0	0	0	2	0	0	3	0	0	5
TOTAL	1	4	1	11	3	29	105	18	10	182

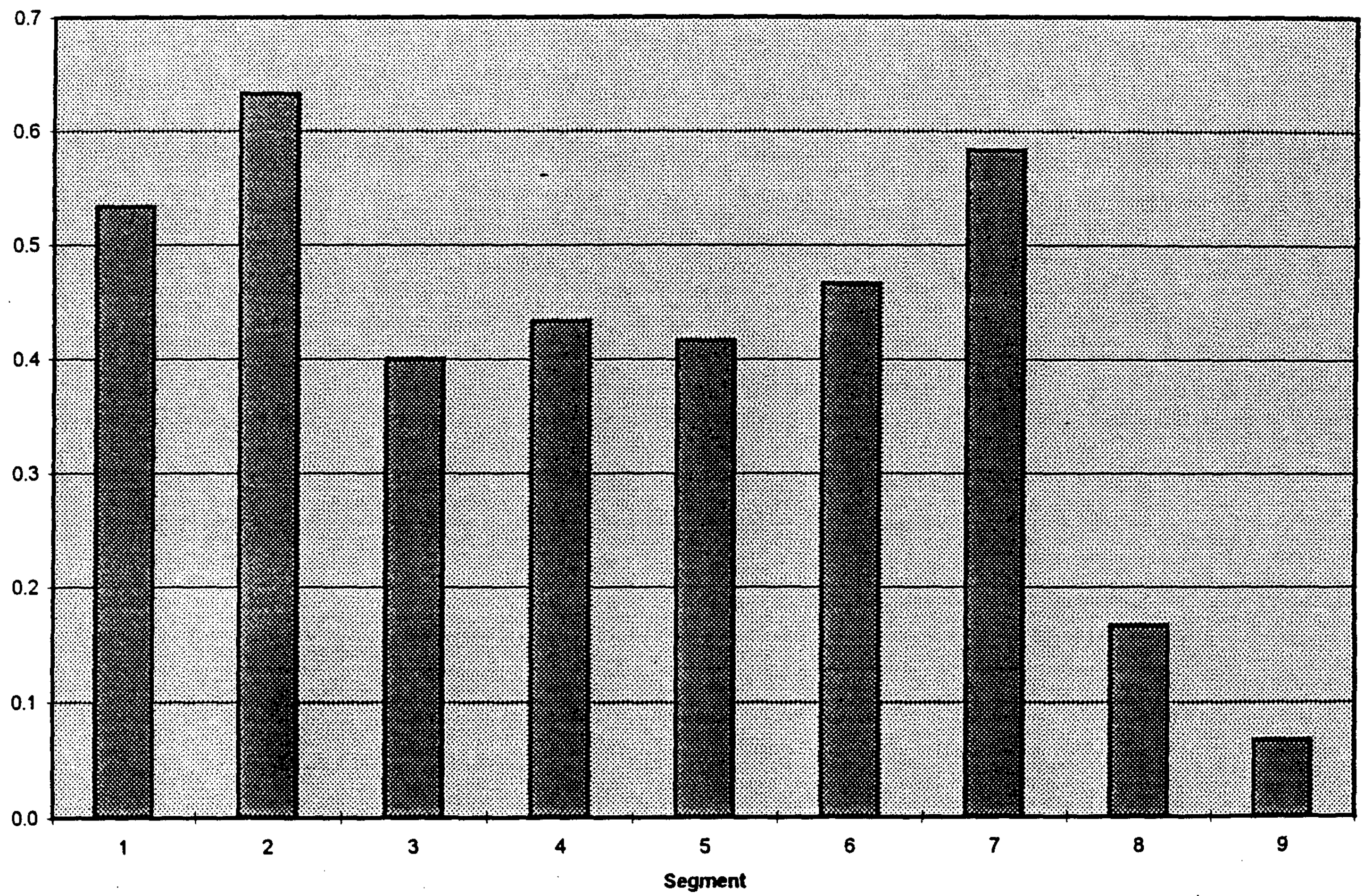
MINMOD

	1	2	3	4	5	6	7	8	9	Total
Collisions	1	0	0	0	0	1	9	2	0	13
Positional Information	0	0	0	0	0	0	2	0	0	2
Vessel Control	0	0	0	0	0	0	2	0	0	2
Human & Organizational Error	1	0	0	0	0	1	5	0	0	7
Conflicting Operations	1	0	0	0	0	1	9	2	0	13
Physical Environment	0	0	0	0	0	0	2	0	0	2
Powered Groundings	0	1	0	1	0	2	2	0	0	6
Positional Information	0	0	0	1	0	1	2	0	0	4
Vessel Control	0	0	0	0	0	0	0	0	0	0
Human & Organizational Error	0	0	0	0	0	2	0	0	0	2
Conflicting Operations	0	0	0	0	0	0	0	0	0	0
Physical Environment	0	1	0	0	0	0	1	0	0	2
Drift Groundings	0	0	0	0	0	0	0	1	0	1
Positional Information	0	0	0	0	0	0	0	1	0	1
Vessel Control	0	0	0	0	0	0	0	0	0	0
Human & Organizational Error	0	0	0	0	0	0	0	0	0	0
Conflicting Operations	0	0	0	0	0	0	0	0	0	0
Physical Environment	0	0	0	0	0	0	0	0	0	0
Allisions	0	0	0	0	0	1	33	0	3	37
Positional Information	0	0	0	0	0	0	0	0	0	0
Vessel Control	0	0	0	0	0	0	9	0	0	9
Human & Organizational Error	0	0	0	0	0	0	15	0	0	15
Conflicting Operations	0	0	0	0	0	0	21	0	0	21
Physical Environment	0	0	0	0	0	0	14	0	3	17
Fire/Explosion	0	1	0	0	0	0	3	0	0	4
Stability Failure	0	2	0	0	1	0	2	4	0	9
Structural Failure	0	0	0	0	0	0	0	0	0	0
TOTAL	1	4	0	1	1	4	49	7	3	70

VCAS	1	2	3	4	5	6	7	8	9	Total
Collisions	0	0	0	2	0	3	14	1	0	20
Positional Information	0	0	0	0	0	0	1	0	0	1
Vessel Control	0	0	0	0	0	0	1	0	0	1
Human & Organizational Error	0	0	0	2	0	0	12	0	0	14
Conflicting Operations	0	0	0	2	0	0	6	1	0	9
Physical Environment	0	0	0	2	0	3	8	0	0	13
Powered Groundings	0	0	0	1	1	10	9	3	4	28
Positional Information	0	0	0	0	0	0	0	0	0	0
Vessel Control	0	0	0	0	0	0	0	0	0	0
Human & Organizational Error	0	0	0	1	1	8	8	0	4	22
Conflicting Operations	0	0	0	0	0	0	0	0	0	0
Physical Environment	0	0	0	1	1	4	3	3	1	13
Drift Groundings	0	0	0	0	1	0	1	1	0	3
Positional Information	0	0	0	0	0	0	0	0	0	0
Vessel Control	0	0	0	0	1	0	1	0	0	2
Human & Organizational Error	0	0	0	0	0	0	0	0	0	0
Conflicting Operations	0	0	0	0	0	0	0	1	0	1
Physical Environment	0	0	0	0	0	0	0	0	0	0
Allisions	0	0	0	0	0	3	17	4	1	25
Positional Information	0	0	0	0	0	0	0	0	0	0
Vessel Control	0	0	0	0	0	1	2	3	0	6
Human & Organizational Error	0	0	0	0	0	2	12	1	1	16
Conflicting Operations	0	0	0	0	0	0	0	0	0	0
Physical Environment	0	0	0	0	0	3	3	0	0	6
Fire/Explosion	0	0	0	3	0	6	5	1	2	17
Stability Failure	0	0	1	2	0	3	7	1	0	14
Structural Failure	0	0	0	2	0	0	3	0	0	5
TOTAL	0	0	1	10	2	25	56	11	7	112

			Accident Ratings				
			Votes by rating				
	1	2	3	4	5	Rating	Ave
Segment							
1	0	3	8	3	1	0.5333	3.13
2	0	2	7	7	0	0.6333	3.53
3	2	7	5	2	0	0.4000	2.60
4	1	4	8	2	0	0.4333	2.73
5	2	4	6	3	0	0.4167	2.67
6	2	3	5	5	0	0.4667	2.87
7	0	2	10	4	0	0.5833	3.33
8	7	9			0	0.1667	1.67
9	13	3			0	0.0667	1.27

Expert Judgment: Likelihood of Vessel Accidents Resulting in Spills



Likelihood scores for Marine Transportation Working Group (NOTE: Scores are not conditional on accident)

SEGMENT 1

SCENARIO	HAZARD		Scenario/hazard rankings								
				Votes by rating							
			1	2	3	4	5	Rating	Ave.		
Collision					1	10	6	0.54	4.29		
	Poor posit. info.	IH1	1	8	6	2		0.15	2.53		
	Vessel control/other failures/deficiencies	IH2	1	9	7			0.14	2.35		
	Human/organizational deficiencies	IH3				4	13	0.28	4.76		
	Conflicting vessel operations	IH4			3	9	4	0.24	4.06		
	Physical features	IH5			12	5		0.19	3.29	chec	1.00
Powered grounding			17					0.13	1.00		
	Poor posit. info.	IH1	17					0.20	1.00		
	Vessel control/other failures/deficiencies	IH2	17					0.20	1.00		
	Human/organizational deficiencies	IH3	17					0.20	1.00		
	Conflicting vessel operations	IH4	17					0.20	1.00		
	Physical features	IH5	17					0.20	1.00		
Drift grounding			2	3	10	1		0.33	2.63		
	Poor posit. info.	IH1	17					0.07	1.00		
	Vessel control/other failures/deficiencies	IH2					17	0.37	5.00		
	Human/organizational deficiencies	IH3			3	9	5	0.31	4.12		
	Conflicting vessel operations	IH4	17					0.07	1.00		
	Physical features	IH5	5	6	2	4		0.17	2.29		
Allision								0.00	0.00		
	Poor posit. info.	IH1						0.20	0.00		
	Vessel control/other failures/deficiencies	IH2						0.20	0.00		
	Human/organizational deficiencies	IH3						0.20	0.00		
	Conflicting vessel operations	IH4						0.20	0.00		
	Physical features	IH5						0.20	0.00		
Fire/explosion								0.00	0.00		
	Poor posit. info.	IH1						0.20	0.00		
	Vessel control/other failures/deficiencies	IH2						0.20	0.00		
	Human/organizational deficiencies	IH3						0.20	0.00		
	Conflicting vessel operations	IH4						0.20	0.00		
	Physical features	IH5						0.20	0.00		
Stability failure								0.00	0.00		
	Poor posit. info.	IH1						0.20	0.00		
	Vessel control/other failures/deficiencies	IH2						0.20	0.00		
	Human/organizational deficiencies	IH3						0.20	0.00		
	Conflicting vessel operations	IH4						0.20	0.00		
	Physical features	IH5						0.20	0.00		
Structural failure								0.00	0.00		
	Poor posit. info.	IH1						0.20	0.00		
	Vessel control/other failures/deficiencies	IH2						0.20	0.00		
	Human/organizational deficiencies	IH3						0.20	0.00		
	Conflicting vessel operations	IH4						0.20	0.00		
	Physical features	IH5						0.20	0.00		

	A	B	C	D	E	F	G	H	I	J
1		SEGMENT 2								
2				Scenario/hazard rankings						
3	SCENARIO	HAZARD		Votes by rating						
4				1	2	3	4	5	Rating	Ave.
5	Collision				1	5	9	2	0.41	3.71
6		Poor posit. info.	IH1	1	8	6	2		0.15	2.53
7		Vessel control/other failures/deficiencies	IH2	1	9	7			0.14	2.35
8		Human/organizational deficiencies	IH3				4	13	0.28	4.76
9		Conflicting vessel operations	IH4			3	9	4	0.24	4.06
10		Physical features	IH5			12	5		0.19	3.29
11										
12	Powered grounding			4	9	3	1		0.23	2.06
13		Poor posit. info.	IH1		10	7			0.17	2.41
14		Vessel control/other failures/deficiencies	IH2	1	9	6		1	0.17	2.47
15		Human/organizational deficiencies	IH3				1	16	0.35	4.94
16		Conflicting vessel operations	IH4		3	13	1		0.20	2.88
17		Physical features	IH5	10	6	1			0.10	1.47
18										
19	Drift grounding				6	3	6	2	0.36	3.24
20		Poor posit. info.	IH1	17					0.07	1.00
21		Vessel control/other failures/deficiencies	IH2					17	0.37	5.00
22		Human/organizational deficiencies	IH3			3	9	5	0.31	4.12
23		Conflicting vessel operations	IH4	17					0.07	1.00
24		Physical features	IH5	5	6	2	4		0.17	2.29
25										
26	Allision								0.00	0.00
27		Poor posit. info.	IH1						0.20	0.00
28		Vessel control/other failures/deficiencies	IH2						0.20	0.00
29		Human/organizational deficiencies	IH3						0.20	0.00
30		Conflicting vessel operations	IH4						0.20	0.00
31		Physical features	IH5						0.20	0.00
32										
33	Fire/explosion								0.00	0.00
34		Poor posit. info.	IH1						0.20	0.00
35		Vessel control/other failures/deficiencies	IH2						0.20	0.00
36		Human/organizational deficiencies	IH3						0.20	0.00
37		Conflicting vessel operations	IH4						0.20	0.00
38		Physical features	IH5						0.20	0.00
39										
40	Stability failure								0.00	0.00
41		Poor posit. info.	IH1						0.20	0.00
42		Vessel control/other failures/deficiencies	IH2						0.20	0.00
43		Human/organizational deficiencies	IH3						0.20	0.00
44		Conflicting vessel operations	IH4						0.20	0.00
45		Physical features	IH5						0.20	0.00
46										
47	Structural failure								0.00	0.00
48		Poor posit. info.	IH1						0.20	0.00
49		Vessel control/other failures/deficiencies	IH2						0.20	0.00
50		Human/organizational deficiencies	IH3						0.20	0.00
51		Conflicting vessel operations	IH4						0.20	0.00
52		Physical features	IH5						0.20	0.00

SEGMENT 3

			Scenario/hazard rankings						
CENARI	HAZARD			Votes by rating					
			1	2	3	4	5	Rating	Ave.
Collision				1	7	9		0.49	3.47
	Poor posit. info.	IH1	4	11				0.12	1.73
	Vessel control/other failures/deficiencies	IH2		1	16			0.20	2.94
	Human/organizational deficiencies	IH3			2	4	11	0.31	4.53
	Conflicting vessel operations	IH4		8	9			0.18	2.53
	Physical features	IH5	2	5	6	4		0.19	2.71
Powered grounding			13	4	1			0.19	1.33
	Poor posit. info.	IH1	5	11			1	0.16	1.88
	Vessel control/other failures/deficiencies	IH2	1	11	4	1		0.19	2.29
	Human/organizational deficiencies	IH3				4	12	0.40	4.75
	Conflicting vessel operations	IH4	12	3				0.10	1.20
	Physical features	IH5	4	12	1			0.15	1.82
Drift grounding			2	6	7			0.33	2.33
	Poor posit. info.	IH1	17					0.07	1.00
	Vessel control/other failures/deficiencies	IH2			3	3	10	0.33	4.44
	Human/organizational deficiencies	IH3			1	11	4	0.31	4.19
	Conflicting vessel operations	IH4	17					0.07	1.00
	Physical features	IH5	1	6	5	4	1	0.21	2.88
Allision								0.00	0.00
	Poor posit. info.	IH1						0.20	0.00
	Vessel control/other failures/deficiencies	IH2						0.20	0.00
	Human/organizational deficiencies	IH3						0.20	0.00
	Conflicting vessel operations	IH4						0.20	0.00
	Physical features	IH5						0.20	0.00
Fire/explosion								0.00	0.00
	Poor posit. info.	IH1						0.20	0.00
	Vessel control/other failures/deficiencies	IH2						0.20	0.00
	Human/organizational deficiencies	IH3						0.20	0.00
	Conflicting vessel operations	IH4						0.20	0.00
	Physical features	IH5						0.20	0.00
Stability failure								0.00	0.00
	Poor posit. info.	IH1						0.20	0.00
	Vessel control/other failures/deficiencies	IH2						0.20	0.00
	Human/organizational deficiencies	IH3						0.20	0.00
	Conflicting vessel operations	IH4						0.20	0.00
	Physical features	IH5						0.20	0.00
Structural failure								0.00	0.00
	Poor posit. info.	IH1						0.20	0.00
	Vessel control/other failures/deficiencies	IH2						0.20	0.00
	Human/organizational deficiencies	IH3						0.20	0.00
	Conflicting vessel operations	IH4						0.20	0.00
	Physical features	IH5						0.20	0.00

	SEGMENT 4								
			Scenario/hazard rankings						
SCENARIO	HAZARD			Votes by rating					
			1	2	3	4	5	Rating	Ave.
Collision						**10**	**6**	**0.49**	**4.38**
	Poor posit. info.	IH1	1	7	8	1		0.16	2.53
	Vessel control/other failures/deficiencies	IH2		5	12			0.17	2.71
	Human/organizational deficiencies	IH3			3	8	6	0.26	4.18
	Conflicting vessel operations	IH4		1	6	7	3	0.23	3.71
	Physical features	IH5		4	10	3		0.18	2.94
Powered grounding				**5**	**9**	**3**		**0.32**	**2.88**
	Poor posit. info.	IH1		3	5	8		0.20	3.31
	Vessel control/other failures/deficiencies	IH2		8	5	2	1	0.17	2.75
	Human/organizational deficiencies	IH3			2	2	12	0.28	4.63
	Conflicting vessel operations	IH4		9	8			0.15	2.47
	Physical features	IH5		2	8	4	2	0.20	3.38
Drift grounding			**8**	**7**	**2**			**0.18**	**1.65**
	Poor posit. info.	IH1	11	5	1			0.10	1.41
	Vessel control/other failures/deficiencies	IH2		2	5	3	5	0.27	3.73
	Human/organizational deficiencies	IH3			5	8	4	0.29	3.94
	Conflicting vessel operations	IH4	7	8	2			0.13	1.71
	Physical features	IH5		3	14			0.21	2.82
Allision								**0.00**	**0.00**
	Poor posit. info.	IH1						0.20	0.00
	Vessel control/other failures/deficiencies	IH2						0.20	0.00
	Human/organizational deficiencies	IH3						0.20	0.00
	Conflicting vessel operations	IH4						0.20	0.00
	Physical features	IH5						0.20	0.00
Fire/explosion								**0.00**	**0.00**
	Poor posit. info.	IH1						0.20	0.00
	Vessel control/other failures/deficiencies	IH2						0.20	0.00
	Human/organizational deficiencies	IH3						0.20	0.00
	Conflicting vessel operations	IH4						0.20	0.00
	Physical features	IH5						0.20	0.00
Stability failure								**0.00**	**0.00**
	Poor posit. info.	IH1						0.20	0.00
	Vessel control/other failures/deficiencies	IH2						0.20	0.00
	Human/organizational deficiencies	IH3						0.20	0.00
	Conflicting vessel operations	IH4						0.20	0.00
	Physical features	IH5						0.20	0.00
Structural failure								**0.00**	**0.00**
	Poor posit. info.	IH1						0.20	0.00
	Vessel control/other failures/deficiencies	IH2						0.20	0.00
	Human/organizational deficiencies	IH3						0.20	0.00
	Conflicting vessel operations	IH4						0.20	0.00
	Physical features	IH5						0.20	0.00

	SEGMENT 5/6								
			Scenario/hazard rankings						
CENARI	HAZARD		Votes by rating						
			1	2	3	4	5	Rating	Ave.
Collision			1	1	10	5		0.33	3.12
	Poor posit. info.	IH1	11	3	3			0.10	1.53
	Vessel control/other failures/deficiencies	IH2		3	12	2		0.18	2.94
	Human/organizational deficiencies	IH3				9	8	0.28	4.47
	Conflicting vessel operations	IH4			8	8	1	0.22	3.59
	Physical features	IH5		1	7	8	1	0.22	3.53
Powered grounding					4	11	2	0.42	3.88
	Poor posit. info.	IH1			6	10	1	0.19	3.71
	Vessel control/other failures/deficiencies	IH2			10	6	1	0.18	3.47
	Human/organizational deficiencies	IH3				6	11	0.24	4.65
	Conflicting vessel operations	IH4			7	10		0.19	3.59
	Physical features	IH5			4	11	2	0.20	3.88
Drift grounding			5	4	5	3		0.25	2.35
	Poor posit. info.	IH1	13	4				0.09	1.24
	Vessel control/other failures/deficiencies	IH2			3	5	7	0.30	4.27
	Human/organizational deficiencies	IH3			3	12	2	0.28	3.94
	Conflicting vessel operations	IH4	13	4				0.09	1.24
	Physical features	IH5			6	11		0.25	3.65
Allision								0.00	0.00
	Poor posit. info.	IH1						0.20	0.00
	Vessel control/other failures/deficiencies	IH2						0.20	0.00
	Human/organizational deficiencies	IH3						0.20	0.00
	Conflicting vessel operations	IH4						0.20	0.00
	Physical features	IH5						0.20	0.00
Fire/explosion								0.00	0.00
	Poor posit. info.	IH1						0.20	0.00
	Vessel control/other failures/deficiencies	IH2						0.20	0.00
	Human/organizational deficiencies	IH3						0.20	0.00
	Conflicting vessel operations	IH4						0.20	0.00
	Physical features	IH5						0.20	0.00
Stability failure								0.00	0.00
	Poor posit. info.	IH1						0.20	0.00
	Vessel control/other failures/deficiencies	IH2						0.20	0.00
	Human/organizational deficiencies	IH3						0.20	0.00
	Conflicting vessel operations	IH4						0.20	0.00
	Physical features	IH5						0.20	0.00
Structural failure								0.00	0.00
	Poor posit. info.	IH1						0.20	0.00
	Vessel control/other failures/deficiencies	IH2						0.20	0.00
	Human/organizational deficiencies	IH3						0.20	0.00
	Conflicting vessel operations	IH4						0.20	0.00
	Physical features	IH5						0.20	0.00

	SEGMENT 7								
			Scenario/hazard rankings						
SCENARIO	HAZARD			Votes by rating					
			1	2	3	4	5	Rating	Ave.
Collision					3	10	3	0.48	4.00
	Poor posit. info.	IH1	5	8	3			0.14	1.88
	Vessel control/other failures/deficiencies	IH2	1	10	4			0.16	2.20
	Human/organizational deficiencies	IH3			4	7	4	0.29	4.00
	Conflicting vessel operations	IH4			5	10		0.26	3.67
	Physical features	IH5	2	9	4			0.15	2.13
Powered grounding				7	9			0.31	2.56
	Poor posit. info.	IH1		7	8			0.16	2.53
	Vessel control/other failures/deficiencies	IH2		6	5	4		0.19	2.87
	Human/organizational deficiencies	IH3			2	6	7	0.28	4.33
	Conflicting vessel operations	IH4			10	5		0.22	3.33
	Physical features	IH5		10	5			0.15	2.33
Drift grounding			5	10	1			0.21	1.75
	Poor posit. info.	IH1	11	4				0.11	1.27
	Vessel control/other failures/deficiencies	IH2			6	9		0.32	3.60
	Human/organizational deficiencies	IH3		4	4	5	2	0.30	3.33
	Conflicting vessel operations	IH4	14	1				0.09	1.07
	Physical features	IH5	6	3	6			0.18	2.00
Allision								0.00	0.00
	Poor posit. info.	IH1						0.20	0.00
	Vessel control/other failures/deficiencies	IH2						0.20	0.00
	Human/organizational deficiencies	IH3						0.20	0.00
	Conflicting vessel operations	IH4						0.20	0.00
	Physical features	IH5						0.20	0.00
Fire/explosion								0.00	0.00
	Poor posit. info.	IH1						0.20	0.00
	Vessel control/other failures/deficiencies	IH2						0.20	0.00
	Human/organizational deficiencies	IH3						0.20	0.00
	Conflicting vessel operations	IH4						0.20	0.00
	Physical features	IH5						0.20	0.00
Stability failure								0.00	0.00
	Poor posit. info.	IH1						0.20	0.00
	Vessel control/other failures/deficiencies	IH2						0.20	0.00
	Human/organizational deficiencies	IH3						0.20	0.00
	Conflicting vessel operations	IH4						0.20	0.00
	Physical features	IH5						0.20	0.00
Structural failure								0.00	0.00
	Poor posit. info.	IH1						0.20	0.00
	Vessel control/other failures/deficiencies	IH2						0.20	0.00
	Human/organizational deficiencies	IH3						0.20	0.00
	Conflicting vessel operations	IH4						0.20	0.00
	Physical features	IH5						0.20	0.00

	SEGMENT 8/9								
			Scenario/hazard rankings						
SCENARIO	HAZARD			Votes by rating					
			1	2	3	4	5	Rating	Ave.
Collision				**6**	**9**			**0.41**	**2.60**
	Poor posit. info.	IH1		8	5	2		0.18	2.60
	Vessel control/other failures/deficiencies	IH2	4	8	3			0.13	1.93
	Human/organizational deficiencies	IH3			1	9	5	0.29	4.27
	Conflicting vessel operations	IH4			3	12		0.26	3.80
	Physical features	IH5	3	10	2			0.13	1.93
Powered grounding				**7**	**6**	**1**		**0.40**	**2.57**
	Poor posit. info.	IH1		9	5	1		0.17	2.47
	Vessel control/other failures/deficiencies	IH2		7	4	4		0.20	2.80
	Human/organizational deficiencies	IH3			2	8	5	0.29	4.20
	Conflicting vessel operations	IH4		13	2			0.15	2.13
	Physical features	IH5		6	8	1		0.19	2.67
Drift grounding			**13**	**1**	**1**			**0.19**	**1.20**
	Poor posit. info.	IH1	13	2				0.10	1.13
	Vessel control/other failures/deficiencies	IH2	1	2	8	4		0.25	3.00
	Human/organizational deficiencies	IH3			8	6	1	0.30	3.53
	Conflicting vessel operations	IH4	10	1	3	1		0.14	1.67
	Physical features	IH5		7	8			0.21	2.53
Allision								**0.00**	**0.00**
	Poor posit. info.	IH1						0.20	0.00
	Vessel control/other failures/deficiencies	IH2						0.20	0.00
	Human/organizational deficiencies	IH3						0.20	0.00
	Conflicting vessel operations	IH4						0.20	0.00
	Physical features	IH5						0.20	0.00
Fire/explosion								0.00	0.00
	Poor posit. info.	IH1						0.20	0.00
	Vessel control/other failures/deficiencies	IH2						0.20	0.00
	Human/organizational deficiencies	IH3						0.20	0.00
	Conflicting vessel operations	IH4						0.20	0.00
	Physical features	IH5						0.20	0.00
Stability failure								0.00	0.00
	Poor posit. info.	IH1						0.20	0.00
	Vessel control/other failures/deficiencies	IH2						0.20	0.00
	Human/organizational deficiencies	IH3						0.20	0.00
	Conflicting vessel operations	IH4						0.20	0.00
	Physical features	IH5						0.20	0.00
Structural failure								0.00	0.00
	Poor posit. info.	IH1						0.20	0.00
	Vessel control/other failures/deficiencies	IH2						0.20	0.00
	Human/organizational deficiencies	IH3						0.20	0.00
	Conflicting vessel operations	IH4						0.20	0.00
	Physical features	IH5						0.20	0.00

	Weight
USA Data	0
Local Data	0.5
Expert	0.5

	1	2	3	4	5	6	7	8	9	Average
Collision	0.77	0.21	0.24	0.30	0.17	0.23	0.33	0.27	0.20	0.30
Local	1.00	0.00	0.00	0.11	0.00	0.12	0.17	0.13	0.00	0.17
Expert	0.54	0.41	0.49	0.49	0.33	0.33	0.48	0.41	0.41	0.43
Powered Grounding	0.06	0.24	0.09	0.27	0.37	0.41	0.22	0.36	0.37	0.27
Local	0.00	0.25	0.00	0.22	0.33	0.40	0.14	0.31	0.33	0.22
Expert	0.13	0.23	0.19	0.32	0.42	0.42	0.31	0.40	0.40	0.31
Drift Grounding	0.17	0.18	0.16	0.09	0.29	0.13	0.11	0.16	0.17	0.16
Local	0.00	0.00	0.00	0.00	0.33	0.00	0.01	0.13	0.00	0.05
Expert	0.33	0.36	0.33	0.18	0.25	0.25	0.21	0.19	0.33	0.27
Allision	0.00	0.00	0.00	0.00	0.00	0.06	0.21	0.13	0.17	0.06
Local	0.00	0.00	0.00	0.00	0.00	0.12	0.42	0.25	0.33	0.13
Expert	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fire/Explosion	0.00	0.13	0.00	0.17	0.00	0.12	0.06	0.03	0.17	0.07
Local	0.00	0.25	0.00	0.33	0.00	0.24	0.11	0.06	0.33	0.15
Expert	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Stability	0.00	0.25	0.50	0.11	0.17	0.06	0.06	0.06	0.00	0.13
Local	0.00	0.50	1.00	0.22	0.33	0.12	0.13	0.13	0.00	0.27
Expert	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Structural	0.00	0.00	0.00	0.06	0.00	0.00	0.01	0.00	0.00	0.01
Local	0.00	0.00	0.00	0.11	0.00	0.00	0.01	0.00	0.00	0.01
Expert	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

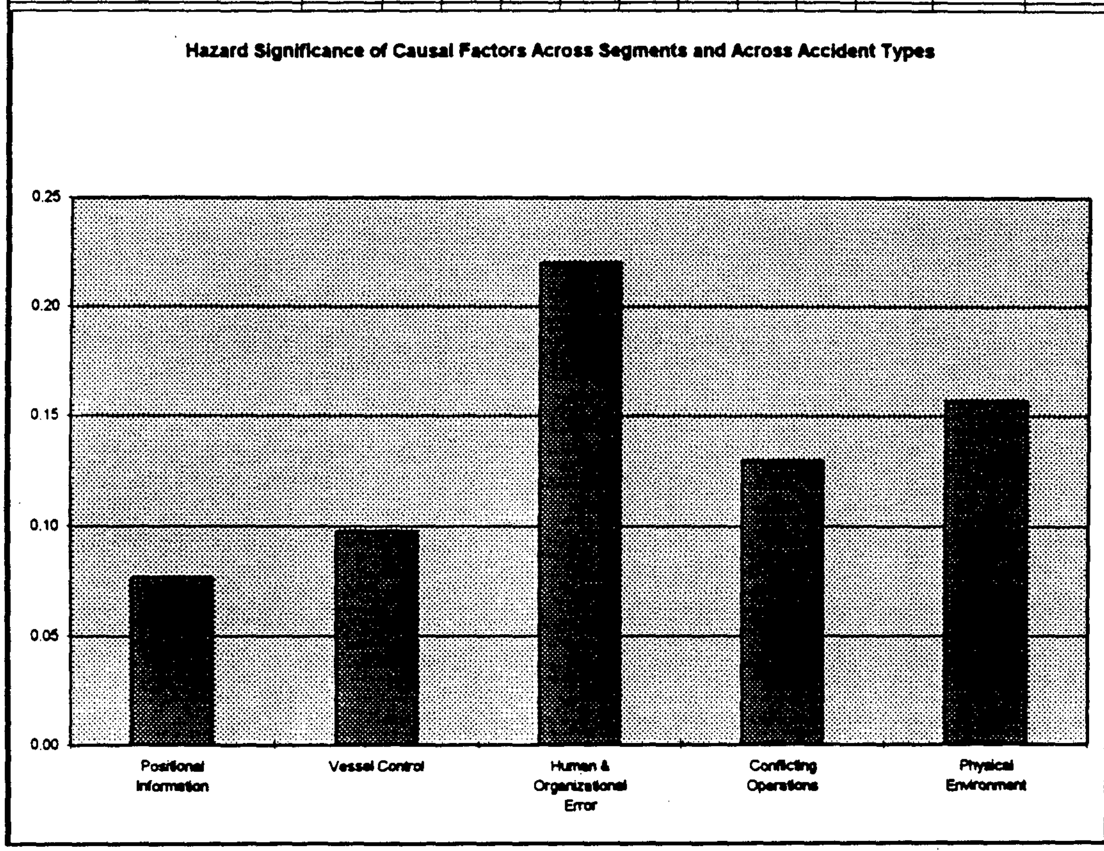
	1	2	3	4	5	6	7	8	9	Average
Collision	0.77	0.21	0.24	0.30	0.17	0.23	0.33	0.27	0.20	0.30
Powered Grounding	0.06	0.24	0.09	0.27	0.37	0.41	0.22	0.36	0.37	0.27
Drift Grounding	0.17	0.18	0.16	0.09	0.29	0.13	0.11	0.16	0.17	0.16
Allision	0.00	0.00	0.00	0.00	0.00	0.06	0.21	0.13	0.17	0.06
Fire/Explosion	0.00	0.13	0.00	0.17	0.00	0.12	0.06	0.03	0.17	0.07
Stability	0.00	0.25	0.50	0.11	0.17	0.06	0.06	0.06	0.00	0.13
Structural	0.00	0.00	0.00	0.06	0.00	0.00	0.01	0.00	0.00	0.01

I	1	2	3	4	5	6	7	8	9	P[j]
P[i]	0.09	0.13	0.10	0.12	0.06	0.15	0.25	0.06	0.04	
C[i]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Collision	0.07	0.03	0.02	0.04	0.01	0.03	0.08	0.02	0.01	0.31
Powered Grounding	0.01	0.03	0.01	0.03	0.02	0.06	0.06	0.02	0.01	0.26
Drift Grounding	0.01	0.02	0.02	0.01	0.02	0.02	0.03	0.01	0.01	0.15
Allision	0.00	0.00	0.00	0.00	0.00	0.01	0.05	0.01	0.01	0.08
Fire/Explosion	0.00	0.02	0.00	0.02	0.00	0.02	0.01	0.00	0.01	0.08
Stability	0.00	0.03	0.05	0.01	0.01	0.01	0.02	0.00	0.00	0.13
Structural	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01
P[j|i]*P[i]*P[j]										
	Overall	Expert	Local							
Collision	0.3061	0.4373	0.1517	P[j]						
Powered Grounding	0.2552	0.2976	0.2061							
Drift Grounding	0.1465	0.2728	0.0160							
Allision	0.0754	0.0000	0.1927							
Fire and Explosion	0.0761	0.0000	0.1623							
Stability	0.1350	0.0000	0.2525							
Structural	0.0084	0.0000	0.0187							

	Weight								
USA Data	0								
Local Data	0.5								
Expert	0.5								
	1	2	3	4	5	6	7	8	9
P[i]	0.09	0.13	0.10	0.12	0.06	0.15	0.25	0.06	0.04
Collision	0.77	0.21	0.24	0.30	0.17	0.23	0.33	0.27	0.20
Positional Information	0.07	0.07	0.06	0.08	0.05	0.05	0.11	0.09	0.09
Local	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00
Expert	0.15	0.15	0.12	0.16	0.10	0.10	0.14	0.18	0.18
Vessel Control	0.07	0.07	0.10	0.08	0.09	0.09	0.12	0.07	0.07
Local	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00
Expert	0.14	0.14	0.20	0.17	0.18	0.18	0.16	0.13	0.13
Human & Organizational Error	0.39	0.14	0.16	0.30	0.14	0.26	0.32	0.15	0.15
Local	0.50	0.00	0.00	0.33	0.00	0.25	0.36	0.00	0.00
Expert	0.28	0.28	0.31	0.26	0.28	0.28	0.29	0.29	0.29
Conflicting Operations	0.37	0.12	0.09	0.28	0.11	0.24	0.29	0.63	0.13
Local	0.50	0.00	0.00	0.33	0.00	0.25	0.32	1.00	0.00
Expert	0.24	0.24	0.18	0.23	0.22	0.22	0.26	0.26	0.26
Physical Environment	0.10	0.10	0.09	0.26	0.11	0.36	0.16	0.07	0.07
Local	0.00	0.00	0.00	0.33	0.00	0.50	0.16	0.00	0.00
Expert	0.19	0.19	0.19	0.18	0.22	0.22	0.15	0.13	0.13
Powered Grounding	0.06	0.24	0.09	0.27	0.37	0.41	0.22	0.36	0.37
Positional Information	0.10	0.09	0.08	0.27	0.10	0.13	0.08	0.19	0.09
Local	0.00	0.00	0.00	0.33	0.00	0.08	0.00	0.20	0.00
Expert	0.20	0.17	0.16	0.20	0.19	0.19	0.16	0.17	0.17
Vessel Control	0.10	0.09	0.10	0.08	0.09	0.09	0.09	0.10	0.10
Local	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Expert	0.20	0.17	0.19	0.17	0.18	0.18	0.19	0.20	0.20
Human & Organizational Error	0.10	0.17	0.20	0.31	0.37	0.51	0.41	0.25	0.48
Local	0.00	0.00	0.00	0.33	0.50	0.77	0.54	0.20	0.67
Expert	0.20	0.35	0.40	0.28	0.24	0.24	0.28	0.29	0.29
Conflicting Operations	0.10	0.10	0.05	0.07	0.09	0.09	0.11	0.07	0.07
Local	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Expert	0.20	0.20	0.10	0.15	0.19	0.19	0.22	0.15	0.15
Physical Environment	0.10	0.55	0.08	0.27	0.35	0.18	0.31	0.39	0.26
Local	0.00	1.00	0.00	0.33	0.50	0.15	0.46	0.60	0.33
Expert	0.20	0.10	0.15	0.20	0.20	0.20	0.15	0.19	0.19
Drift Grounding	0.17	0.18	0.16	0.09	0.29	0.13	0.11	0.16	0.17
Positional Information	0.04	0.04	0.04	0.05	0.04	0.04	0.06	0.55	0.05
Local	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
Expert	0.07	0.07	0.07	0.10	0.09	0.09	0.11	0.10	0.10
Vessel Control	0.19	0.19	0.16	0.14	0.65	0.15	0.16	0.13	0.13
Local	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
Expert	0.37	0.37	0.33	0.27	0.30	0.30	0.32	0.25	0.25
Human & Organizational Error	0.15	0.15	0.16	0.14	0.14	0.14	0.15	0.15	0.15
Local	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Expert	0.31	0.31	0.31	0.29	0.28	0.28	0.30	0.30	0.30
Conflicting Operations	0.04	0.04	0.04	0.06	0.04	0.04	0.05	0.07	0.07
Local	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Expert	0.07	0.07	0.07	0.13	0.09	0.09	0.09	0.14	0.14
Physical Environment	0.09	0.09	0.11	0.10	0.13	0.13	0.09	0.11	0.11
Local	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Expert	0.17	0.17	0.21	0.21	0.25	0.25	0.18	0.21	0.21
Allision	0.00	0.00	0.00	0.00	0.00	0.06	0.21	0.13	0.17
Positional Information	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Local	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Expert	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Vessel Control	0.10	0.10	0.10	0.10	0.10	0.23	0.16	0.48	0.10
Local	0.00	0.00	0.00	0.00	0.00	0.25	0.12	0.75	0.00
Expert	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Human & Organizational Error	0.10	0.10	0.10	0.10	0.10	0.23	0.28	0.23	0.35
Local	0.00	0.00	0.00	0.00	0.00	0.25	0.36	0.25	0.50
Expert	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Conflicting Operations	0.10	0.10	0.10	0.10	0.10	0.10	0.23	0.10	0.10
Local	0.00	0.00	0.00	0.00	0.00	0.00	0.26	0.00	0.00
Expert	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Physical Environment	0.10	0.10	0.10	0.10	0.10	0.35	0.23	0.10	0.35
Local	0.00	0.00	0.00	0.00	0.00	0.50	0.26	0.00	0.50
Expert	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20

	1	2	3	4	5	6	7	8	9	Sum	USA	P[k]
Collision	0.07	0.03	0.02	0.04	0.01	0.03	0.08	0.02	0.01			
Positional Information	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.02	2.5	0.02
Vessel Control	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.03	2.5	0.03
Human & Organizational Error	0.03	0.00	0.00	0.01	0.00	0.01	0.03	0.00	0.00	0.09	5	0.09
Conflicting Operations	0.03	0.00	0.00	0.01	0.00	0.01	0.02	0.01	0.00	0.09	2.5	0.09
Physical Environment	0.01	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.00	0.05	2.5	0.05
Powered Grounding	0.01	0.03	0.01	0.03	0.02	0.06	0.06	0.02	0.01			
Positional Information	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.03	2.5	0.03
Vessel Control	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.02	2.5	0.02
Human & Organizational Error	0.00	0.01	0.00	0.01	0.01	0.03	0.02	0.01	0.01	0.09	5	0.09
Conflicting Operations	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.02	2.5	0.02
Physical Environment	0.00	0.02	0.00	0.01	0.01	0.01	0.02	0.01	0.00	0.08	2.5	0.08
Drift Grounding	0.01	0.02	0.02	0.01	0.02	0.02	0.03	0.01	0.01			
Positional Information	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	2.5	0.01
Vessel Control	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.03	2.5	0.03
Human & Organizational Error	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	5	0.02
Conflicting Operations	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	2.5	0.01
Physical Environment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	2.5	0.02
Allision	0.00	0.00	0.00	0.00	0.00	0.01	0.05	0.01	0.01			
Positional Information	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	2.5	0.01
Vessel Control	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	2.5	0.01
Human & Organizational Error	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.02	5	0.02
Conflicting Operations	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	2.5	0.01
Physical Environment	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.02	2.5	0.02

	P[k]
Positional Information	0.08
Vessel Control	0.10
Human & Organizational Error	0.22
Conflicting Operations	0.13
Physical Environment	0.16



APPENDIX E
CHAPTER 5

Contents

1. Environmental Impact Working Group proceedings, April 21-23, 1997
2. Environmental Impact Working Group proceedings, May 22, 1997
3. Comments from B.C. Ministry of environment, Lands and parks on sensitivity and response in Canadian segments
4. Pre-staged oil spill response equipment maps
5. Description of salvage equipment in the study area
6. Sample NRDAM output
7. Sample Washington DOE Marine spill compensation output

ENVIRONMENTAL IMPACT WORKING GROUP PROCEEDINGS

EXECUTIVE SUMMARY OF WORKSHOP FINDINGS
April 21 - 23, 1997 at the Bellevue Inn Best Western, Bellevue, WA

Participants

The Environmental Impact Working Group (EI) consisted of seven expert panelists, six advisors, and one observer. An eighth expert panelist, Stafford Reid, representing B.C. Ministry of the Environment, was unable to attend, with the result that the panel included no expertise on Canadian natural resources. A seventh advisor, Fred Felleman, chose to participate in the Marine Transportation Working Group, instead of the EI, as permitted by the Chairs. Four representatives of the Coast Guard, Volpe Center and NOAA were also in attendance to facilitate and record the proceedings. The attendees are listed below.

NAME	AFFILIATION
Experts	
Sharon Christopherson, Ph.D., Chairperson	NOAA
Roald Bendixon	U.S. Coast Guard, 13th District (M)
Anthony B. Ford	Shipmaster, spill planner, responder
J.H. Leitz	Leitz Marine Recovery Systems
John Haughton	Pentec Environmental
Roland Miller	Clean Sound Cooperative
Jon Neel	Washington State Department of Ecology
Advisors	
Chad Bowechop	Makah Nation
Dale Ferriere	TEEKAY Shipping (Canada) Ltd.
Todd Jacobs	Olympic Coast National Marine Sanctuary
Andrew Palmer	Ocean Policy Associates
Dean Smith	Fishery Biologist, U.S. Navy
Dr. Jacques White	People for Puget Sound
Observers	
Tom Murphy	Leitz Marine Recovery Systems
Facilitators	
CDR Mark VanHaverbeke	U.S. Coast Guard, Headquarters
Judy Schwenk	Volpe Transportation Systems Center
Heather Parker	NOAA
Neil Thayer	U.S. Coast Guard, 13th District

Background

The purpose of the three-day EI meeting was to provide the Volpe Center with expert input to the Additional Hazards Study on a number of topics:

environmental sensitivity of the Puget Sound area to spills by underway vessels of crude oil and refined petroleum products,
available response capabilities in the Puget Sound area,
typical conditions for response efforts in the Puget Sound area,
the effectiveness of existing and proposed safety measures in addressing spill consequences

The Volpe Center prepared a package of worksheets to guide the panel in its thinking about the issues and to produce results in a form that could be incorporated by Volpe into its study. The EI was asked to focus on worksheets

3B Segment Environmental Sensitivities
3C Spill Response
3D Recovery Conditions
5A Applicability of Current Measures
5B Applicability of Proposed Measures

The EI was successful in completing worksheets 3B, 3C and 3D, but was unable to address 5A and 5B in the time allotted, and agreed to meet again within two weeks to complete these last two worksheets. Although the time and place of such a meeting is yet to be determined, it will be in the Seattle area, and will include as many of the participants listed above as possible, except for Coast Guard Headquarters and Volpe Center representatives.

Prior to the commencement of work on the first worksheet, the EI members agreed to suppress their own self-interests to the extent necessary to produce objective and unbiased information for Volpe. A consensus-building approach was adopted, rather than a voting process, to fill in the data items in the worksheets. "Expert" panel members, "Advisor" panel members and "Observers" were all given the opportunity to participate in the discussions preceding each scoring process, and in almost all cases, consensus was reached.

Initial Observations on the Process

The EI panel made initial observations describing the framework within which they were operating, dealing with the information gathering process, the study scope, the limitations of the panel expertise, as well as the breadth of its expertise.

The rankings are relative only within Puget Sound, and do not provide a comparison with other U.S. ports.
Because only one Tribal entity, the Makah Nation, was represented on the panel, and there was no representative from Canada, the panel findings address comprehensively neither treaty rights nor Canadian interests throughout the Sound.
Conversely, the panel had broad representation from a cross-section of agencies and interests, not just environmental scientists. The recommendations resulting from this panel should be interpreted in light of the varied information resources members brought to the table.
During deliberations panel members were unclear as to the exact manner in which individual rankings drove the Volpe model and its final results.
The EI felt the worksheet numbers did not represent the rich discussion involved in generating them. They advise users of these numbers to consider the associated comments and assumptions, and the context in which they were developed.

Environmental Sensitivity of the Puget Sound Area

The EI rated the sensitivity of the various natural resources in the nine segments of the Puget Sound Area on a scale of 1 (low sensitivity) to 5 (high sensitivity). To focus their thinking, the panel considered the effects of a medium-sized spill of medium thickness crude oil on natural resources. "Sensitivity" was defined as the ability of a resource to recover and be as productive as it was before the spill. The panel proceeded through the rating exercise by rating one resource across the nine segments before moving on to the next resource. Ratings were relative to other segments in the Puget Sound area, and not to other regions of the U.S.

The table below shows the sensitivity ratings. Following the table are the rating criteria for each resource. Canadian segments 1 and 5 were given the same ratings for the geographically closest American segments 2 and 6, respectively. The predetermined boundaries set for some of these segments resulted in the potential for underestimating the sensitivity of these areas based upon the range of resources and habitats present in different sections of the segment (e.g., sections of segment 7).

Segment Number	Marine Mammals	Recreation and Parks	Birds	Cultural and Archaeological	Aqua-culture	Shoreline Habitats	Fin Fish
1	5	5	5	5	4	2	4
2	5	5	5	5	4	2	4
3	3	3	5	5	4	2.5	5
4	4	2	5	5	3	3	5
5	4	5	4.5	5	4	4	5
6	4	5	4.5	5	4	4	5
7	2	4	2	5	3	4	4.5
8	3	3	3	5	4.5	5	5
9	3	2	3	5	5	5	4

Criteria for Rating Marine Mammals (whales, pinnipeds and otters)
A "5" rating denotes the presence of otters, and very large numbers of mammals.
A "4" rating denotes large numbers of individual mammals, and pupping activity.
A "3" rating denotes significant numbers of individual mammals, and haulout areas.
A "2" rating denotes smaller numbers of individuals.

Criteria for Rating Recreational Areas and Parks
A "5" rating denotes a large number of parks and/or extent of parkland, and a high density of recreational activities that would be impacted by a spill. The persistence of the oil causing extended or frequent interruptions to these activities was also considered.
A "4" rating indicated a decreased density of recreational activities, fewer users of the parks and other areas, and lower persistence of spilled substances in the area interfering with recreational activities.
A "3" rating denotes lower density of recreational activities and a lower number and extent of parks and parkland.
A "2" rating denotes lower values of the above factors.

Criteria for Rating Bird Vulnerability
In addition to the oiling of birds that come into direct contact with oiled water, the EI considered locations of especially large concentrations of birds, oiling of young at nests by the transfer of oil from adults, and impacts to shoreline nesting areas. Initial ratings were adjusted according to the presence of endangered and threatened species.

A "5" rating denoted large numbers of stressed populations, large numbers of breeding individuals, and/or a large portion of an entire population in the area.
A " 4" rating indicated the population density was lower with significant use of the area by birds, but less breeding.
A "3" rating indicated large numbers of shorebirds, a large amount of feeding, the presence of waterfowl feeding areas, and delta habitat impacts from an oil spill.
A "2" rating denoted the same criteria as "3", but with fewer individuals.

Criteria for Rating the Vulnerability of Cultural and Archaeological Resources
The panel felt that they lacked enough expertise to rate this resource; they could not separate the effects of a spill on ceremonial vs. subsistence vs. archaeological sites. Although panel discussion included effects of both direct impacts and secondary impacts of response activities to these sites, they decided to rank all segments a 5.

Criteria for Rating Aquaculture/Shellfish
Panel considered the concentration of the resource, its likelihood of being impacted by an oil spill according to its habitat type (beach, substrate), and the flushing activity/persistence of oil at the sites.

Criteria for Rating Habitat Vulnerability

The panel considered

- overall sensitivity of the shoreline substrate to oil and relative persistence of oil
- resource specific habitat needs
- biological diversity of an area, density and productivity
- sediment particle size and characteristics
- recovery capability

Eel grass and kelp beds were not considered part of this resource. Hatchery impacts were considered under either the finfish or shellfish categories.

Criteria for Rating Finfish Vulnerability

Realizing that there are extremely important fish resources in every segment of the Puget Sound area, EI considered differences among segments in nursery and reproductive vulnerability, foraging impacts, population concentrations and densities, populations already at risk, and the persistence of the impact. Their task was complicated by the difficulty of assessing vulnerability of larvae to oil spills because of their varying depth in the water column, by the abundant variation in the feeding breeding and nursery habits of different species, and by the differences in commercial vs. cultural valuations and recreational vs. ecological valuations for various species.

Overall Segment Ratings and Comparison with DOE Model Sensitivity Ranks

Segment ratings for each resource were combined to obtain overall segment ratings, assigning equal weight to each resource. Relative ratings were then adjusted to spread the range of original ratings. As an additional data point, the panel invited Dick Logan of Washington Department of Ecology (DOE) to provide segment ratings using their Natural Resources Damage Assessment Model. The two sets of ratings were in agreement in eight out of nine segments, with a difference noted in segment 8. Although the panel considered the large concentrations of eel grass and kelp in segment 8 to be fairly resistant to spilled oil, recovering more quickly than other types of habitats, they rated the segment more sensitive than the DOE model because of the sensitivity of the other resources living there. The ratings and comparison are shown below.

Segment Number	Panel Average Ratings	Panel Relative Ratings	DOE Relative Ratings
1	4.3	5	5
2	4.3	5	5
3	3.9	4	4
4	3.9	4	4
5	4.4	5	5
6	4.4	5	5
7	3.4	3	3
8	4.0	4	2
9	3.9	4	4

Response Capabilities in the Puget Sound Area

The EI rates the relative response capabilities in the nine segments of the Puget Sound area. Background information was provided by Roland Miller of Clean Sound Cooperative on pre-staged oil spill response equipment, and by Micky Leitz of Leitz Salvage on local salvage resources. Their presentations are summarized in an attachment.

The panel ratings for the categories of response measures are shown below. The panel proceeded through the exercise by rating one response measure across the nine segments before moving on to the next measure. Again, due to lack of Canadian representation, the panel rated the Canadian segments the same as their nearest geographical U.S. segments, modified as panel members' best knowledge and experience suggested.

Segment Number	Containment/ Recovery Equipment		Defensive Measures		Clean-up	Salvage		Overall rating	Relative rating
	Assets	Time	Assets	Time		Assets	Time		
1	2	2	1	1	1	2	2	1.5	1
2	2	2	2	1	2	2	2	1.9	2
3	3	3	3	3	3	3	2	2.9	3
4	5	5	4	3	3.5	4	3	4.0	4
5	4	4	4	3	2	3	3	3.1	3
6	4	4	4	2	2	4	3	3.1	3
7	5	5	5	3	4	5	5	4.5	5
8	5	5	4	3	2	5	5	3.9	4
9	4	4	3	3	2	4	3	3.1	3

Criteria for Containment and Recovery Assets and Response Time Ratings

For the purposes of rating segments, the panel used a 24-hour window as a benchmark to evaluate relative capability to respond to spills in all segments.

Criteria for Defensive Measures Assets and Response Time Ratings

A "5" rating denoted the existence of the appropriate assets and the means to get equipment on-scene to protect the resources identified as important. Equipment included both mechanical and alternative measures.

A "4" rating denoted that assets were available in the segment, but not necessarily the appropriate ones to protect the resources present.

A "3" rating was similar to "4", but less so. In particular, shallow water equipment was lacking.

Criteria for Cleanup Ratings

The panel did not rank response time for cleanup because timing is not the issue; the limiting factors are a matter of technology and logistics. Their definition of cleanup did not cover the cleaning of birds and mammals. They downrated the segment if it contained a large amount of shallow waters and mudflats not able to be cleaned by mechanical means that inflict as much damage or more than the spilled substance itself.

Criteria for Rating Salvage Capabilities

The EI evaluated the segments based on the ability to bring the appropriate equipment and technology to stem the outflow of a spill resulting from a stranding or collision within the first 24-hour period. The panel felt that the Pacific Northwest has reliable salvage equipment; the ratings focus more on the effects that weather and the physical environment have on the salvage response. The panel felt that professional salvage is the most effective of the response measures at minimizing the consequences of a casualty to the environment.

Weighting of Each Factor in the Overall Rating

Choosing an appropriate response technique must include a complete evaluation of the environmental effects of each response strategy under consideration. The EI believed that certain spill response measures were more effective than others. However, after reviewing the result of equal weighting for the factors, they believed the overall ratings were appropriate.

Response Conditions in the Puget Sound Area

Results of the panel's discussion of response conditions in the Puget Sound area are shown in the table below. The panel felt it had enough general knowledge and experience of the environmental conditions in the area to give relative ratings to the nine segments without following Worksheet 3B methodology.

Segment	Rating
1	1
2	1
3	2
4	2
5	3
6	2.5
7	3
8	4
9	4

Net Consequence Rating

Combining the results from the three rating exercises above and assuming the spill scenario results would yield similar results to the panel's rating of environmental sensitivity, the table below was produced showing the net consequence rating of the nine segments. The panel believed the net consequences accurately represented their understanding of the overall environmental sensitivity and conditions in the Puget Sound area.

The table shows the outer coastal areas to be most vulnerable to spill consequences because of their relative abundance and diversity of sensitive resources, generally unfavorable response conditions, and relatively limited ability to mount an effective spill response. The outer coastal areas were followed in order of decreasing net consequence ratings by Upper Puget Sound (San Juan Islands, Haro Strait), the Strait of Juan de Fuca, the extreme southern part of Puget Sound, the area east of Whidbey Island, and finally the main channel of Southern Puget Sound. The EI emphasizes that these ratings are relative only to the different areas within and around Puget Sound, recognizing that the entire area is rich with natural resources, and extremely sensitive to any introduction of hazardous materials into the environment.

Segment Number	Environmental Sensitivity	Spill Response Capabilities	Response Conditions	Net Consequence Rating
1	5	1	1	5
2	5	2	1	4.8
3	4	3	2	3.8
4	4	4	2	3.6
5	5	3	3	4.2
6	5	3	2.5	4.2
7	3	5	3	2.6
8	4	4	4	3.2
9	4	3	4	3.4

General Recommendations

Mechanical recovery is not alone sufficient to do the job of response. We need to explore the further use of alternative technologies to get oil off the water and/or the shoreline.

This study should include public vessel transportation (Navy, Coast Guard, etc.) patterns in the likelihood of a marine transportation accident in the Puget Sound area.

The Hood Canal should have been included in this study as another segment due to its vulnerability to an oil spill from nearby segments, particularly from a spill in Admiralty Inlet.

The Volpe Center should make provisions to allow continual review of this process so that this Risk Assessment is not a singular static document.

The high volume port locations in the Puget Sound area are defined to start 50nm within the Strait of Juan de Fuca, as opposed to the entrance of the Strait. This is not consistent with inland boundaries for other national high volume port areas, and relocating the boundary to Buoy "J" needs to be reassessed.

GRP strategies in the Puget Sound area call for extensive booming of shallow shoreline habitats. Limited intertidal boom assets in this area and the greater time requirement for their deployment both need to be revisited in the response planning process by the local Area Committee.

SUBMISSION BY R. LOGAN, WASHINGTON DEPARTMENT OF ECOLOGY TO ENVIRONMENTAL IMPACT WORKING GROUP

Description of Compensation Table Model Development

In 1989, the Washington State Legislature passed the Resource Damage Assessment Act (ESHB 1853) which directed the state's Department of Ecology to develop a simplified approach for determining public resource damages created by oil spills in state waters (subsequently referred to as the "Comp Table"). Additionally, the legislation prescribed specific guidance concerning design elements to be included for the Comp Table, creation of a Scientific Advisory Board and development of a Resource Damage Assessment (RDA) committee. Based on that guidance Ecology initiated the following actions:

a. Developed a skeleton Comp Table model designed to incorporate the legislative design elements of environmental sensitivity, oil type and actions of the responsible party and
b. Appointed a Scientific Advisory Board composed of several subcommittees, each designed to address a specific element of the model

The marine waters of the state were subdivided into 131 subregions to address area specific resource issues. This subregional marine breakdown followed the work of Wahl et al (1981) and Wahl (1990, personal communications). Wahl's research quantified marine bird populations for the Environmental Protection Agency Marine Ecosystems Analysis for Puget Sound and was designed to evaluate the offshore oil and gas leasing program. These data represented the broadest comprehensive ranking system available for birds and the effects of oil on bird populations. The other 6 resource categories (marine mammals, marine fish, shellfish, salmon, habitat and recreation) were than ranked using these subregions.

The development of the marine model incorporated a subregional resource ranking scheme from 1-low to 5-high for all 7 resource components. Each subregional resource vulnerability ranking is specific to season of the year, type and abundance of resource present. Additionally, a 1-5 ranking based on the severity of effects of each oil on resources was also developed (Leschine et al, 1992). Resource and seasonal specificity were taken into account by evaluating the oil spill vulnerability of the seven resource categories. Each of the resource vulnerability scores was developed in consultation with the individual scientific subcommittee assigned to that resource or oil category. These subcommittees were composed of resource experts from state and federal agencies, academic institutions, consulting firms, Indian Tribes and environmental organizations.

For a spill into a marine subregion, the following variables must be determined:

a. Subregion affected
b. season
c. habitat types and percent of total

d. resources affected
e. type of oil
f. volume of spilled oil to reach the water

Individual subregional resource scores are summed; then adjusted by the type of oil since each oil affects resources in different ways (multiply resource sum by individual oil scores). This total is then calibrated to fit within the legislatively mandated $1-50/gallon range. Finally, the Comp Table formula produces a damage figure in dollars/gallon which is multiplied by the number of gallons spilled to produce the damage assessment total. At this point the oil recovery actions taken by the responsible party are quantified and the total assessment is discounted appropriately.

Subcommittee members determined that since the compensation schedule was constructed from substantive field and laboratory data, the model was appropriate to provide information required to assess damages. Public involvement was a priority throughout the rule development process. A focus sheet on the proposed rule was distributed via an 800-entry mail list. Following completion of a preliminary version of the rule in April 1991, Ecology held four public workshops in western Washington. In December 1991, a second round of workshops were held in 5 cities statewide. The public comment period ended January 20, 1992. Ecology responded to all comments in a Responsiveness Summary. The rule became effective May 24, 1992.

Regional Scoring for DOT Study

The DOT study created 9 regions for purposes of a comparative risk analysis. As part of the risk analysis environmental risk was ranked using the compensation table model. The broader DOT regions encompassed a number of individual CT subregions and were not divided by season. Consequently, a broad assumption was made concerning the resource rankings. When aggregating all subregional scores within a larger region the highest score for each resource category was selected regardless of season. It should be noted that this generalization resulted in high scores for virtually all regions although the high score may have only represented a single subregion and/or a single seasonal high.

ENVIRONMENTAL IMPACT WORKING GROUP

EXECUTIVE SUMMARY OF WORKSHOP FINDINGS - Part 2

May 22, 1997 in Seattle, WA

A continuation of the Environmental Impact Working Group Panel discussions was held to discuss the effectiveness of proposed safety measures for consequences mitigation. All original Panel members and advisors were present with the exception of Dean Smith. A summary of Dean's concerns and ratings were provided to all panel members at the beginning of our meeting. In addition, three observers attended the discussions: Jeff Fishel from the WA Office of Marine Safety, Kurt Beckett from Congressman Norman Dick's office, and Ardis Dumett from Senator Patty Murray's office.

The Panel first reviewed the list of proposed safety measures and consequence factors from the 4B Worksheet provided by the VOLPE Center. A considerable amount of discussion was still required in an attempt to clarify what the group would consider in rating each of the proposed safety measures. At VOLPE's request, Panel members identified several additional proposed safety measures and added them to the list for evaluation. The Panel then rated the proposed safety measures for their effectiveness in mitigating the consequences of a spill once it occurred.

I. Discussion Notes: Consequence Factors (Worksheet 4B, 5/1/97):

The amount spilled and amount recovered was generally assumed to be the amount of oil spilled or recovered from the water.

Defensive protection was assumed to include shoreline protection strategies such as exclusion or deflective booming; and open water protection strategies such as containment of the oil at the source, towing leaking vessel away from sensitive environment or redirecting floating oil away from a more vulnerable habitat/resource toward a less vulnerable.

There was considerable discussion on whether to include Proximity to Natural Resources and what it actually meant relative to consequence mitigation. Suggestions that this represented time to response or likelihood of sensitive resources being impacted because of location were both discussed. The Panel settled on impact to natural resources as the rating factor.

The most difficult issue in evaluating the various consequence factors were the large number of possible spill scenarios which can change a rating from 1 to 5 for a given proposed safety measure. The Panel agreed to consider a 10,000 barrel spill of crude oil as a general bench mark, but differences in cause of accident, location, environmental conditions, types of habitats threatened can significantly affect the ratings.

II. Discussion Notes: Proposed Safety Measures (Worksheet 4B, 5/1/97):

Proposed Safety Measure A. The Panel recommends putting back in the proposed safety measure to revise boundary and regulations of the ABTA because it can be effective in reducing consequences of a spill by increasing time available to respond. Changes to the regulations to be considered would be making it mandatory (vs. voluntary), expanding the types of vessels it covers, and increasing the buffer zone at the entrance to the Straits of Juan de Fuca. Refers to Segment 1.

Proposed Safety Measure B. The Panel recommends adding the relocation of the boundary of the Puget Sound high volume port from Port Angeles out to the entrance of the Strait of Juan de Fuca (Buoy J). Current definition is not consistent with the definition of high volume ports for other areas in the United States and ignores the fact that traffic volume and congestion at the Buoy J is just as high as it is at Port Angeles. Redefinition of the boundary would result in increased spill response capability in the outer straits. It was felt by the Panel that this could be accomplished by reallocating equipment already present in Puget Sound without significantly jeopardizing response capability elsewhere in the Sound. Refers to Segments 1, 2 and 3.

Proposed Safety Measure C. Better coastal response capabilities -include dedicated vessel for deploying propositioned skimmers, booms and other equipment in Neah Bay, Gray's Harbor, etc. Refers to Segment 1, including the junction of Segment 1 with Segments 2 and 3.

Proposed Safety Measure D. Station a dedicated spill response vessel(s) capable of deploying booms, skimmers, etc., at other (outside of segment 1) critical environmentally sensitive location(s) - panel highlighted the value for this measure in Segment 9, especially with the increased freight and bunkering activity proposed for Port of Olympia.

Proposed Safety Measure E. Panel defined this safety measure to be rapidly deployable salvage capability that can be on scene in sensitive areas within 4 to 6 hours to handle emergency fire fighting, lighering, patching (stability), and towing rather than locally staged salvage capability. The Panel saw this as a trained team with portable equipment that could be rapidly deployed to the scene and staged on platforms of opportunity or on the vessel in trouble until large scale salvage resources could be mobilized to the scene. All Segments.

Ranking for this category was broken down into coastal segments 1 - 3 and inland segments 4 - 9. The two ratings separated by a "/" indicate a difference of opinion between the environmental expertise and operational expertise panel members. The environmental experts and advisors disagreed with the operational experts and advisors on how successful salvage would be in mitigating the amount spilled and impact to natural resources. Both groups agreed on the importance of salvage in protecting sensitive environments, especially in the outer coast where convention mechanical recovery methods are less effective.

Upon review of these discussion notes, Tony Ford's position is that this measure should be deleted. There appears to be some confusion among members of the Panel on whether a vessel was included in this proposed safety measure and whether the proposal as stated is really practical. The Panel Chair was not able to resolve this over the phone.

Proposed Safety Measure F. The Panel felt the requirement for response plans for all vessel types was too vague. Vessel response plans are currently required on vessels over 300 GT. Using the term gross tons refers to cargo vessels of some type. The Panel felt that these plans could be improved by including a salvage contract which includes regional contractors on standby. Comment received from M. Leitz: "The Panel felt that these plans could be improved by insuring that real salvage systems are in place by contract for contingency plan holders. First, evaluate risk/benefit of each salvage response measure individually. Fire, explosion, collision, grounding and sinking, etc.... require unique equipment and personnel requirements. Resolve those incidents which would likely cause the largest impact. Finally insure/audit the existence of those contracts of salvage." All Segments.

Proposed Safety Measure G. Outflow mitigation systems on tank/freight vessels over 300 gross tons such as quick closure valves for tank vents to reduce loss of fuel following sinkings and groundings. Use of the term gross tons refers to cargo vessels of some type. Pointed out by several Panel members that this type of system could result in potential for increased accidents from bunkering and would require regulation change. All Segments.

Proposed Safety Measure H. Vessel fittings to speed lightering operations and the transfer of contents from one tank to another on vessels over 300 gross tons. Use of the term gross tons refers to cargo vessels of some type. All Segments.

Proposed Safety Measure I. Increased consideration and capability for use of in situ burning in Segments 1, 2 and 3 within first 12 to 24 hours. Assumes in situ burning will be done in compliance with existing policy; that adequate fire boom and support equipment is available for deployment in first 12 hours of spill; and that decision has been made that there is a net environmental benefit to burning the oil.

Proposed Safety Measure J. Increased consideration and capability for use of dispersants in Segments 1, 2 and 3 within first 12 to 24 hours. Assumes dispersant application will be done in compliance with existing policy; that adequate dispersant and support equipment is available for deployment in first 12 hours of spill; and that decision has been made that there is a net environmental benefit to dispersing the oil. Existing policy requires that monitoring be done as part of dispersant application. To date, there is no approved monitoring protocol. This would have to be developed and the logistics for implementing before this measure could be effective.

III. Discussion Notes: Issues not rated.

- International Training standards for additional types of incidents - need to know specific training standards being proposed before measure can be rated.

    1. besides spilling oil, other incidents can result in environmental impacts if they cannot be mitigated (like fires, flooding, sinking)
    2. if vessels could mitigate these other casualties before they get out of hand, then it would probably prevent a catastrophic release of oil
    3. not clear what training standards are being addressed
    4. panel members pointed out the ITOS standardized training program is still to be developed
    5. most tugs are not currently ready (re: training and outfitting) to respond to other incidents such as flooding, sinking, fire
    6. panel feels strongly that training for fire-fighting, and response to other ship casualty incidents is essential for ITOS vessels
- Extension of tug escorts to Buoy J for laden tankers and high risk cargo vessels with expanded response capability (should be a new line item) to include towing, fire fighting, lightering, and emergency patching resources
- Area Committee review of GRP response technologies - encourage Area Committee to ground truth protection strategies and continue to try and develop strategies for sensitive shallow bay habitats
- Panel recommends the Coast Guard evaluate pre-booming for fuel transfers of vessels > 300 gross tons and for oil transferred as cargo in areas where tide and currents allow for effective booming. The members recognized that this activity could be counterproductive with highly flammable products (gasoline) or in areas with strong tidal/river currents. In other more protected areas, such action could reduce the consequences of a spill by containing it at the source where it could more effectively be recovered.

IV. Final Comments

The Panel as a whole still supports their position from the Hazard Assessment Phase of this activity that enhanced salvage will provide the best chance of mitigating the consequences of a spill.

Salvage was defined by the Panel to include a broad range of activities including fire fighting, patching, ballast adjustments, lightering and towing. Ten proposed safety measures were identified and rated. The rating was done with respect to the effectiveness in mitigating the consequences of a spill relative to the effectiveness of what is currently in existence or being practiced and did not take into effect the cost of implementing the measure. Four of these proposed safety measures were considered by the panel to apply to waterway segments throughout Puget Sound (Measures E, F, G, H). Safety Measure D was identified as most effective in Segment 9. Safety Measures A, B, and C specifically referred to coastal segments and outer strait. The effectiveness of Safety Measures I and J was rated for Segments 1, 2, and 3 because by policy, this is where these alternative technologies are most likely to get approval for use.

In discussing the effectiveness of salvage in mitigating the consequences of a spill, the members of the Panel discussed a number of proposed systems or approaches to improve salvage and response capability, especially for the coastal areas. These include (not represented in any ranked order):

- International Tug of Opportunity System (ITOS)
- spill response vessel staged in Neah Bay in conjunction with ITOS
- escorts to J Buoy with expanded response capability (e.g., firefighting, preliminary salvage) for laden tankers and high risk cargo vessels in conjunction with ITOS
- dedicated salvage response tug in Neah Bay with towing capacity
- possibility of staging Navy salvage assets in Port Angeles or straits (offset recent increased Navy traffic in north Puget Sound)
- redefine boundary for Puget Sound High Volume Port

The Panel was not able to rate the effectiveness of these measures relative to each other. The effectiveness in mitigating consequences varies significantly with different spill scenarios relative to size, location, cause, and weather. A cost/benefit analysis taking these factors into consideration should be done as part of the rating process.

4B WORKSHEET SUMMARY: Effectiveness of Proposed Safety Measures for Consequence Mitigation (Environmental Impact Working Group) 5/22/97.

Proposed Safety Measures	Amount Spilled	Impact Nat Res	Amount Recov'd	Defensive Protection	Restoration
A. Revise boundary and regulations of the ABTA to increase buffer zone at entrance to Straits (increases response time window). Segment 1 only.	N/A	4	N/A	3.5	N/A
B. Relocate boundary of high volume port from Port Angeles out to Buoy J.	N/A	3	3	2.5	N/A
C. Better coastal oil spill response capabilities (dedicated vsl for deploying pre-positioned equip in Neah Bay, Gray's Harbor, etc.). Segments 1 & 2.	N/A	3	3	2.5	N/A
D. Station a spill response vessel at other critical environmentally sensitive locations. Segment 9, especially Olympia Area.	N/A	3	3	3	N/A
E. Rapid deployable salvage capability in sensitive areas (top line indicates ratings for coastal Segments 1,2,3; second line indicates ratings for inland areas 4-9). The double numbers indicate lack of consensus by panel; first rating reflects marine industry point of view and second number reflects environmental community point of view.	2/4 1/3	2/4 2/4	N/A N/A	5 5	N/A N/A

4B WORKSHEET SUMMARY continued 5/22/97

Proposed Safety Measures	Amount Spilled	Impact Nat Res	Amount Recov'd	Defensive Protection	Restoration
F. Response plans for all vessel over 300 GT to include pre identified salvage contract on stand by for initial response (top line indicates ratings for coastal segments 1,2,3; second line indicates ratings for inland segments 4-9). The double numbers indicate lack of consensus by panel; first rating reflects marine industry point of view and second number reflects environmental community point of view.	2/4 1/3	2/4 2/4	N/A N/A	5 5	N/A N/A
G. Outflow mitigation systems on tank/freight vessels greater than 300 GT (e.g., quick closure valves on tank vents).	3	3	N/A	3	N/A
H. Vessel fittings to speed transfer of contents to other spaces & lightering equipment.	3	3	N/A	3	N/A
I. Increased consideration and capability for use of in situ burning in Segments 1, 2 and 3 within first 12 to 24 hours.	N/A	4	N/A	4	N/A
J. Increased consideration and capability for use of dispersants in Segments 1, 2 and 3 within first 12 to 24 hours.	N/A	3.5	N/A	3.5	N/A

ENVIRONMENTAL SENSITIVITY AND SPILL RESPONSE

CANADIAN SEGMENTS

Provided on April 16th were the worksheets 3B and 3C. The following is an elaboration on the completion of these worksheets.

Worksheet: 3B Segment Resource Sensitivities

The Province of British Columbia has, and continues, to undertake coastal inventory data collection for the purpose of coastal protection and management. This coastal resource inventory is the foundation behind the BC Marine Oil Spill Information System (referred to as OSRIS). OSRIS uses the coastal resource data to determine what nearshore and on-shore resources are sensitive to oil contamination and to determine the most environmentally-sound cleanup methods. Key parameters in modeling oil sensitivity includes: shore geomorphology, exposure (fetch), biological resources, human use, and relative ecological/social importance of coastal resources. The model accommodates seasonal variability.

The coastal areas of British Columbia where shore oil sensitivity mapping has been done includes: the Southwest coast of Vancouver Island (Juan de Fuca Strait), and the Southern and Northern Strait of Georgia (e.g. Gulf Islands & Fraser Estuary). As such, the environmental sensitivity to a major oil spill within the Canadian segments (1, 3 & 5) of the Risk Study have been pre-determined. The following coastal resource sensitivity rankings reflects the data and sensitivity modeling of the BC OSRIS.

The following ranking does not infer any measure of "acceptability" of an oil spill within a particular segment. The ranking relates to "relative" level the initial impact, resilance and recovery of off-shore, near-shore and on-shore coastal resources and human uses.

Segment 1 - Entrance to the Juan de Fuca (Canadian side only)

The entrance to the Juan de Fuca and the outer coast of the southwest portion of Vancouver Island is a high exposure (energy) marine environment. As such, the beach sediments (sand, pebble, cobble, and boulder) are typically devoid of marine growth and organisms. Fixed, bed-rock platforms and cliffs, however, have lush growth of fixed marine life. As well, sheltered coves on the outer coast have high biological productivity. With the exception of the sheltered coves, which there are only a few, this coastal areas benefits from natural cleaning by ocean surf. Nearshore and offshore marine species include pelagic birds and transient whales (Orca and Grey Whale). The former is know to be highly vulnerable to oil.

Along segment 1, there are small, but highly oil-sensitive reaches of shoreline. High fisheries values are located at the entrance and within the Nitnat Lake (a tidal lake).

Through out the length of segment 1, there is a significant native subsistence and cultural values. The presence of the popular and nationally significant West Coast Trail along the entire length of segment 1 provides moderate to high recreational value.

As result of the high exposure and shore geomorphology of segment 1, has the lowest ranking for sensitivity to an oil spill. The largest impact would be closure of the West Coast Trail (at one year), and impacts on Native subsistence fisheries.

Fin Fisheries - 2 (reflects fisheries values of the Nitnat Lake)
Aquaculture/Shell Fish - 2 (reflects native subsistence fishing)
Marine Mammals - 2 (reflects vulnerability of small populations of seals)
Recreational/Park Values - 3 (reflects the value of the West Coast Trail)
Cultural & Archeological Resources - 4 (reflects historic use of coastal area/resources by 1st Nations)
Birds - 2 (reflects the presence of pelagic birds, and some small populations of nearshore species)
Shoreline Habitats and Hatcheries - 1 (reflects that natural cleaning benefit of open coast shores).

Overall Score: **16**

Segment 3 - Strait of Juan de Fuca (Canadian Side)

The outer portion of Juan de Fuca Strait (segment 3) on the Canadian side is a high energy marine environment similar to the outer coast. The highest sensitivity is the shores near and around Race Rocks, Sooke basins, Jordan River, and Juan de Fuca Port. The shorelines between these areas are mixed, mobile sediments (sand, gravel, pebble, cobble) and rock cliff that is subject ocean surf.

There is high recreational fishing use in the areas, particularly near Victoria. There is extensive native subsistence fisheries throughout the area. Recreational values are moderate to high owing to the Provincial Botanical Park, the newly established Juan de Fuca Coastal Trail, and several Regional District Parks (e.g. Wittys Lagoon). Bird species are mainly nearshore species... dabbling, diving, ducks and alcids. Race Rocks is an ecological reserve owing to its significant seal populations, intertidal and subtidal biology, and bird populations. An oil spill in this area primary impact is closure/interruption of recreational use of shores and impacts to marine mammal.

Fin Fisheries - 3 (reflects recreational fisheries values)
Aquaculture/Shell Fish - 3 (reflects native subsistence fishing)
Marine Mammals - 3 (reflects vulnerability of Race Rock seal populations)
Recreational/Park Values - 2 (reflects the value of the Botanical Beach Park, Juan de Fuca Trail, and Regional District Parks)
Cultural & Archeological Resources - 3 (reflects historic use of coastal area/resources by 1st Nations)
Birds - 2 (reflects the presence of populations of nearshore species)
Shoreline Habitats and Hatcheries - 2 (reflects that natural cleaning benefit of open coast shores).

Overall Score: **18**

Segment 5 - Victoria, Gulf Islands, Boundary Bay, Roberts and Sturgeon Banks

With the exception of the Victoria area, segment 5 is a low energy environment. There are essentially two environments, the Gulf Island complex (e.g. Pender, Prevost, Saltspring, Galiano, etc) and the Fraser River estuary (Boundary Bay, Roberts and Sturgeon Banks). The former has complex shoreline types, many of which are susceptible to oil penetration and retention. The recreational values - primarily boating and beach use - is very high in the Gulf Islands. The Fraser River estuary is comprised of extensive areas of vegetated flats (sand and mud). Fisheries values are extremely high owing to salmon rearing habitats. The Fraser River estuary is an international renown area for migratory waterfowl and raptors. There is high 1st Nations subsistence use of the shellfish/fisheries in the Fraser River estuary.

Fin Fisheries - 5 (reflects salmon rearing habitat of the Fraser River estuary)
Aquaculture/Shell Fish - 4 (reflects native subsistence fishing in the Fraser River estuary)
Marine Mammals - 2 (reflects harbour seal populations, primarily in the Gulf Islands)
Recreational/Park Values - 3 (reflects the boating and beach use value of the Gulf Islands and Marine Parks)
Cultural & Archeological Resources - 3 (reflects historic use of coastal area/resources by 1st Nations, particularly in the Fraser River estuary)
Birds - 5 (reflects the high populations of resident and migratory bird species in the Fraser River estuary)
Shoreline Habitats and Hatcheries - 5 (reflects low energy environments and complex shoreline types throughout the segment.

Overall Score: **27**

Worksheet 3C Spill Response

The BC Marine Oil Spill Response Atlas provides detailed information on shoreline access, booming opportunities, and cleanup options for all three segments with Canadian waters. Canada has essential two sources of marine oil spill response capability: Burrard Clean Operations Ltd and the Canadian Coast Guard. Burrard Clean Operations is only certified Response Organization in western Canada. They are capable of managing a 10,000 tonne spill. Both Burrard Clean Operations and the Canadian Coast Guard has depots of response equipment (boats, booms, skimmers, etc) located in Victoria/Esquimalt Harbour and the Port of Vancouver. The Province of British Columbia has a very small supply of shoreline cleanup equipment.

Segment 1 - Entrance to the Juan de Fuca (Canadian side only)

For shoreline cleanup, the primary access to shores on the outer coast of Southwestern British Columbia is largely limited to the West Coast Trail. Boat landing is prohibited by wide bedrock platforms and cliffs. Natural shoreline cleaning potential is high. A common approach for coarse sediment beach would be "beach relocation" to augment ocean surf cleaning.

Nearshore response in the outer coast is very limited owing to surf and high currents.

Offshore response has a high potential for dispersant use and in-situ burning, assuming that the equipment, supplies and decision protocols are established (which they are not).

Salvage potential is low owing to the frequency of high seas and fog. This area is the most distant from rescue/salvage tugs, as well as oil spill response depots.

Spill Response Rating is **10** (this reflects greatest positive factor favouring effective response is that most of this segment - subject to a comprehensive Shore Cleanup Assessment Team (SCAT) process - will benefit from natural cleaning and remediation)

Segment 3 - Strait of Juan de Fuca (Canadian Side)

Similar to the outer coast, Juan de Fuca Strait is a high energy environment. Beach access is fairly good owing to frequency of Provincial and Regional District Parks. Boat landings could be prohibited by high ocean swells and surf.

Nearshore protection is limited by ocean swells and surf. Highly sensitive shorelines such as Sooke Harbour and Becher Bay have opportunities for nearshore protection booming.

Offshore response is suitable for dispersant use and in-situ burning, and some offshore oil recovery.

Salvage response is limited owing to distance from rescue/salvage tugs.

The closest location of response equipment is Victoria.

Spill Response Rating is **16** (reflects improved beach access and proximity to response equipment).

Segment 5 - Victoria, Gulf Islands, Boundary Bay, Roberts and Sturgeon Banks

Segment 5 has the highest level of response capability owing to the proximity to response equipment depots, shoreline workers, beach access. The response effectiveness is, however, hampered owing to the lack of opportunity to utilize natural shoreline cleaning (a low energy environment)

Nearshore protection is very limited in the Gulf Island owing to high currents, and in the Fraser River estuary owing to vegetated sand and mud flats.

Offshore response is limited to oil recovery in low current areas. Opportunity for use of dispersants and insitu burning is very limited owing to proximity to the Fraser river estuary (salmon rearing area) and human populations, respectively.

Salvage opportunity is high owing to the proximity to major ports. The narrow passages and high currents (e.g. Haro Strait) requires a very fast response time before groundings.

Spill Response Rating is **29** (reflects improved beach access and proximity to response equipment).

IMPORTANT NOTE:

It is important to note that the greater access and response time within Segment 5 is not necessarily indicative of an improved level of oil impact mitigation. The major disadvantage in segment 5 is the inability to utilize natural cleaning of ocean waves, and the inability to deploy boom in sand/mud estuary environments. Essentially, almost all shore units will require some level of human intervention, and hence cumulative impact, to remove stranded oil.

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April 17, 1997

BRITISH COLUMBIA'S MARINE OIL SPILL RESPONSE INFORMATION SYSTEM (OSRIS)

Background & Overview

As crude oil drifted in Alaska's Prince William Sound during the Exxon Valdez tanker incident in 1989, the Coast Guard, Environment Departments, communities, and industry scrambled to decide which coastal areas needed protection first. The complexity of quickly figuring out what constitutes a "sensitive" shoreline became obvious. Physical properties had to be weighted against ecological and social values; consensus was reached under duress, and costly mistakes happened in terms of environmental impacts and misspent funds.

Once the oil reached Alaskan shores, a long, expensive cleanup program followed. During the peak of this cleanup, there were over 10,000 workers and over $6 million (US) dollars spent daily. The issue changed to deciding which shores to clean up first and by what method. After many millions of dollars were spent and hundreds of kilometres of beach cleaned, some important lessons were learned. Many shorelines areas were cleaned unnecessarily - such many kilometres of exposed, outer-coast, rocky shores where letting the natural wave-action do the cleaning would have been a more environmentally-sound approach. Many shoreline-cleanup techniques, such as steam cleaning, caused more environmental harm than the oil itself.

In hindsight, understanding where and how to clean an oily shore is complex. There is a fine balance between harsh human interventions (rakes, shovel, hoses) and more gentle natural processes (tidal and wave action). Decisions have to be made on a shore-unit-by-shore-unit basis. Each smooth sandy beach, exposed rock headland, sheltered estuary, or protected cobblestone shore requires different cleanup methods. The wrong choice is not only environmentally damaging, but extremely expensive.

The Province of British Columbia's Solution

David Anderson's *Report to the Premier on Oil Transportation and Oil Spills* (1989), prepared after the *Nestucca* barge spill (1988) and the *Exxon Valdez* tanker spill (1989), gave special attention to coastal sensitivity analysis and mapping. The report stated:

> "If this is done effectively before a spill takes place, residents, industry, and government agencies will have a common understanding of objectives, and much of the initial confusion present in both the *Nestucca* spill and the *Exxon Valdez* spill will be avoided." (Section 4.02).

Identification of coastal inventory and oil sensitivity became a strategic objective of the British Columbia Ministry of Environment, Lands and Parks. This direction recognizes that British Columbia is the owner and steward of over 27,000 kilometers of foreshore, the waters and sea-bed between all headlands (the jaws of land), and major inland waters such as the Strait of Georgia.

The 1991, *BC Marine Oil Spill Prevention and Preparedness Strategy*, stated the following strategic principle:

> "The Province will take an active leadership and participatory role in coastal resource identification and, in the event of an oil spill, the protection and cleanup of the intertidal shoreline and seabed that are under the jurisdiction of the Province. The Province's response efforts will focus on identification and mapping of Provincial Crown resources, which include, but are not limited to, intertidal marine habitats, wildlife habitats and populations, archaeological, cultural, aquatic, parks, and ecological reserves."

British Columbia's *Marine Oil Spill Contingency Plan* reiterated this principle of provincial response efforts' focusing on identification and mapping of coastal resources. A major role of the provincial emergency response team is to set priorities for resource protection and to establish measures for oil spill cleanup. The main tool to fulfil this function is the *Marine Oil Spill Response Information System* (OSRIS).

Marine Oil Spill Response Information System

BC Environment began in 1992 to develop a computer-based Marine Oil Spill Response Information System (called "OSRIS"). The system includes multiple data-types such as satellite images, digital maps (topographical/bathometry), and geographically referenced information. The information within OSRIS relates to more than 50 coastal resources, including the physical character of the shorelines and the biological species that interact with the shoreline, such as fish, birds, and marine mammals. The database also includes human activities that occur in the coastal zone, such as sport and commercial fisheries, aquaculture, native harvesting, tourism, recreation, and commercial enterprises. Special status areas, such as archaeological and heritage sites (password protected), and ecological reserves and parks, are also included. Coastal inventory and human uses are linked independently to a uniquely defined shoreline unit. Each shoreline unit is based on its geomorphology: sandy beach, rock platform, cobble, rock cliff, etc.

The strength of OSRIS lies with its detailed coastal inventory. Based on this inventory, a sophisticated computer modeling program figures out the sensitivity of each shoreline unit. The modeling program considers such aspects as: oil residency, coastal resources present, species rating, seasonality, human-use rankings, and more. Identification of the most important and vulnerable coastal areas enables priorities for shoreline protection from oil pollution to be decided. Based on this sensitivity determination, OSRIS also identifies countermeasures strategies, such as protection booming. During a spill event, OSRIS has a spill trajectory model that can simulate the spread of oil on water depending on wind direction, time and current/tidal regimes. Where shoreline oiling occurs, OSRIS determines the most environmentally sound cleanup strategies. Post-spill functions of OSRIS include long-term monitoring, resource impact assessment, and damage evaluations.

Benefits of OSRIS include improved pre-spill determination of sensitive shorelines that would require protection or cleanup, improved capabilities to decide equipment deployment and cleanup logistics, improved resource damage assessments, and ability to conduct litigation for damage compensation.

Evolution of OSRIS

Before 1994, OSRIS was largely a prototype developed in-house by the Environmental Emergency Program of BC Environment with the assistance of contracted Geographic Information System (GIS) consultants, oil geomorphologists, biologists, and archaeologists. A comprehensive coastal-inventory database, satellite imagery, and video of the Southern Strait of Georgia (Gulf Islands, Vancouver Island from Nanaimo to Race Rocks, Roberts & Sturgeons Banks, and Boundary Bay) became the initial foundation of OSRIS. Burrard Clean Operations Ltd, an oil response cooperative of west coast oil companies, provided funds for coastal inventorying. The design and system development rested with BC Environment's Enforcement and Environmental Emergencies Branch.

Based on a partnership arrangement, OSRIS relocated to the Land Use Coordination Office (LUCO). Coastal inventorying and system enhancement continues using the combined expertise and resources of LUCO and BC Environment. This partnership is strategically beneficial in that LUCO provides important coastal data, system management, and continuing enhancements. This enables BC Environment to focus on the "operational" functions of OSRIS.

Coverage

Northern and Southern Strait of Georgia have been completed

Products

Coastal Shoreline Inventory and Oil Sensitivity Atlas for the Southern Strait of Georgia.

For more information contact:

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or
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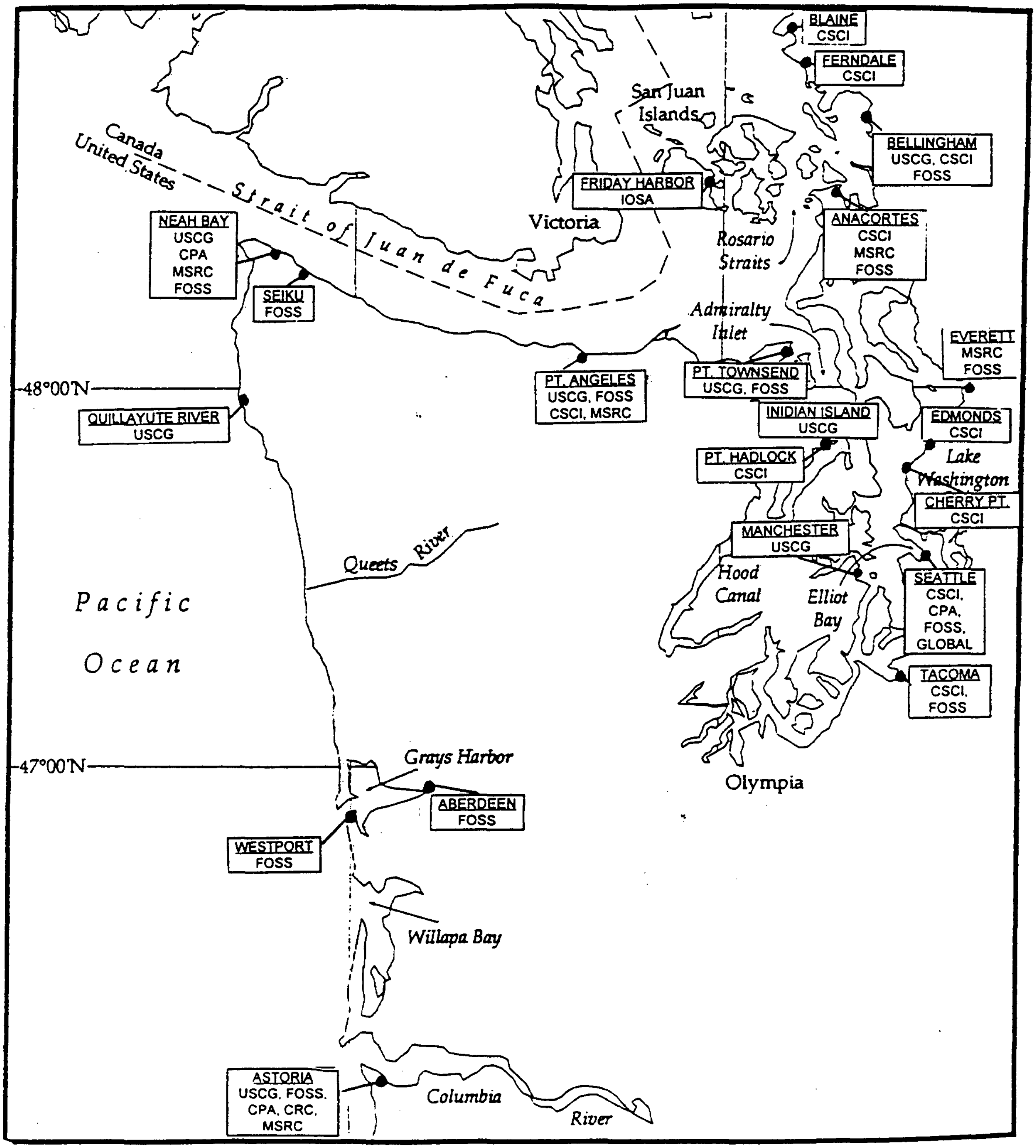
Land Use Coordination Office (250) 356-7721

PRE-STAGED OIL SPILL RESPONSE EQUIPMENT

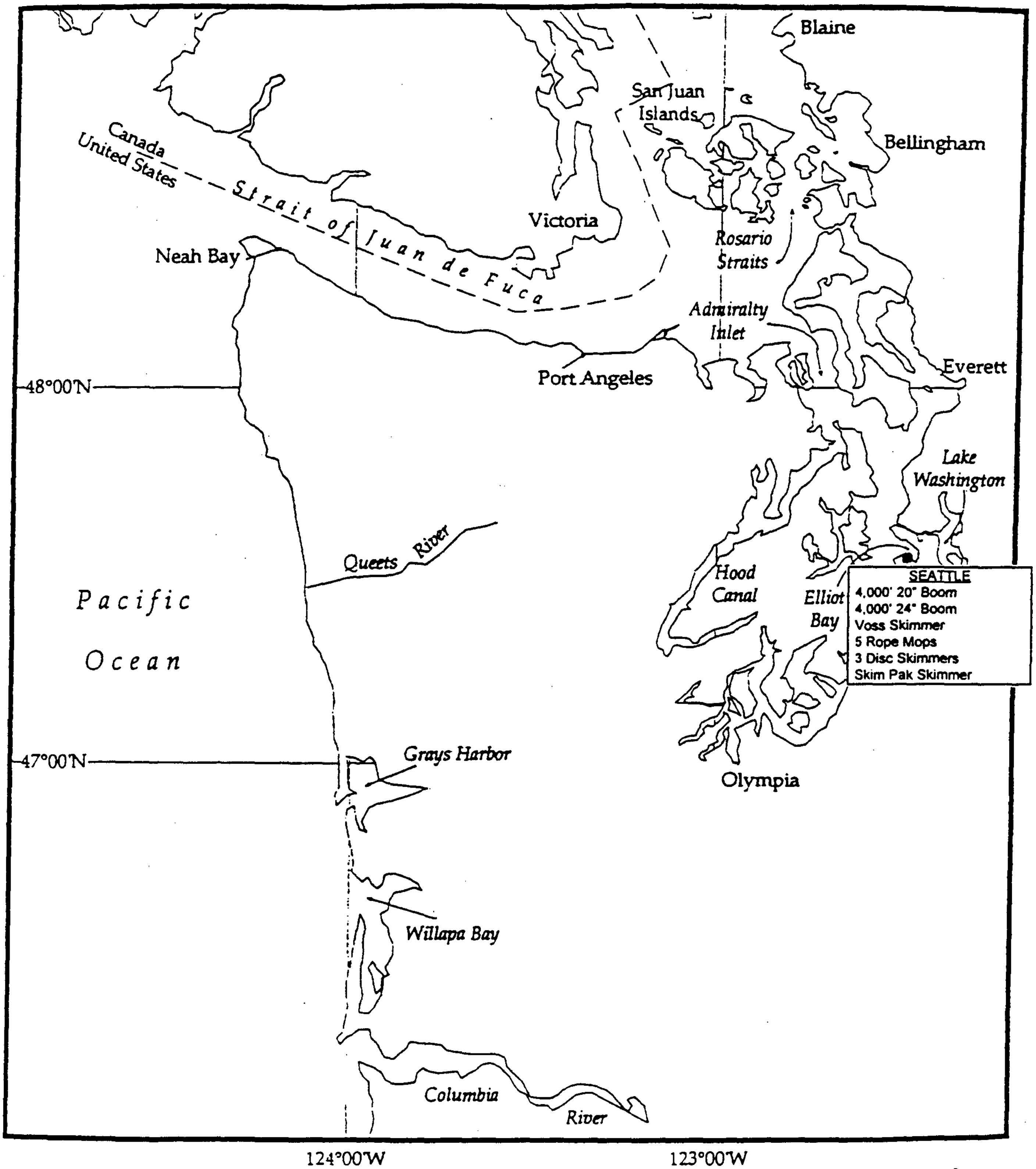
USE ONLY AS A GENRAL REFERENCE

USCG - CG District 13, MSO Puget Sound
MSRC - Marine Spill Response Corporation
CSCI - Clean Sound Cooperative, Inc.
IOSA - Island Oil Spill Association
FOSS - Foss Environmental
CPA - Clean Pacific Alliance
CRC - Clean Rivers Cooperative
GLOBAL - Global Diving & Salvage



GLOBAL ENVIRONMENTAL
PRE-STAGED SPILL RESPONSE EQUIPMENT

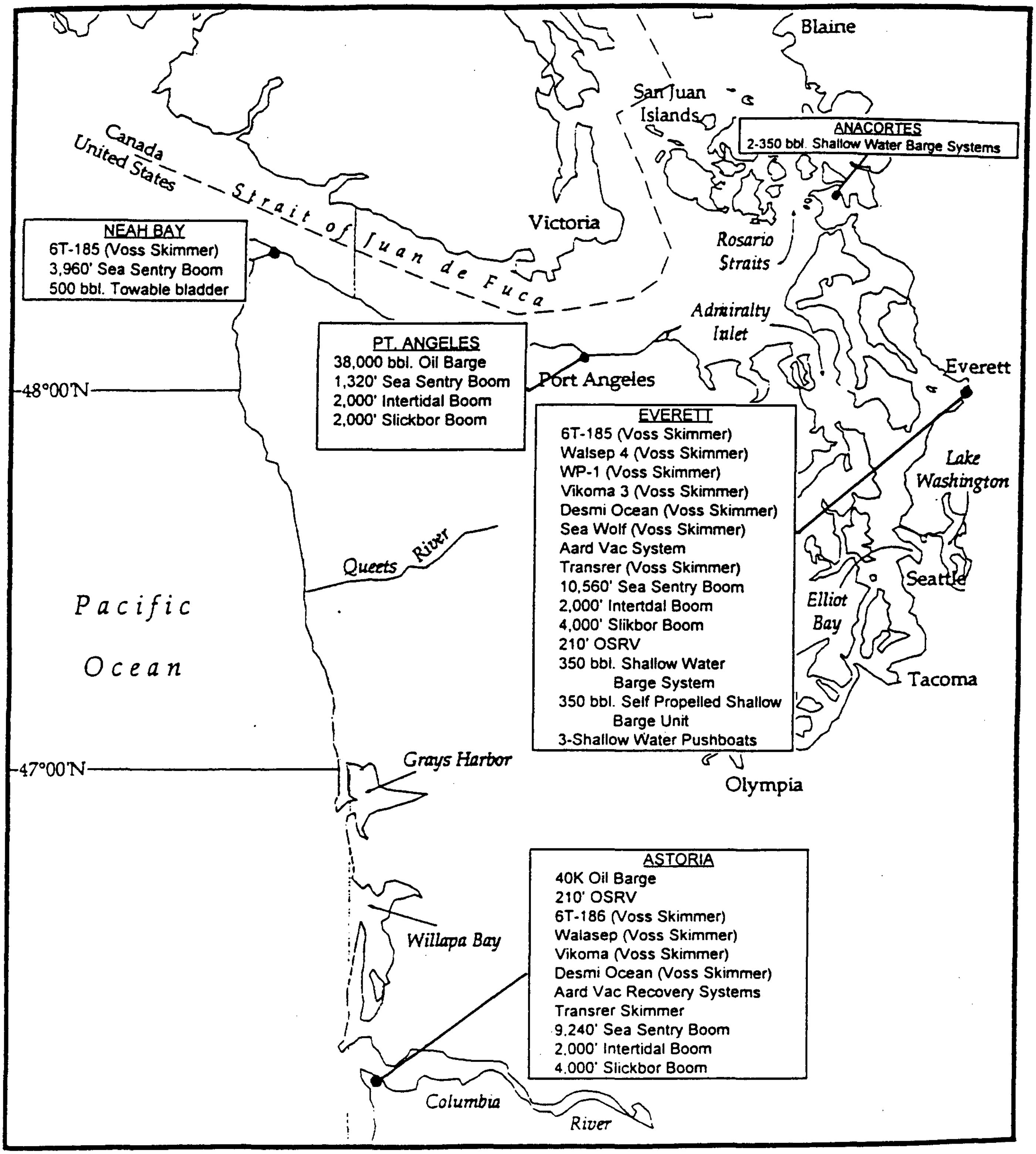
USE ONLY AS A GENRAL REFERENCE



MARINE SPILL RESPONSE CORP
PRE-STAGED SPILL RESPONSE EQUIPMENT

USE ONLY AS A GENERAL REFERENCE

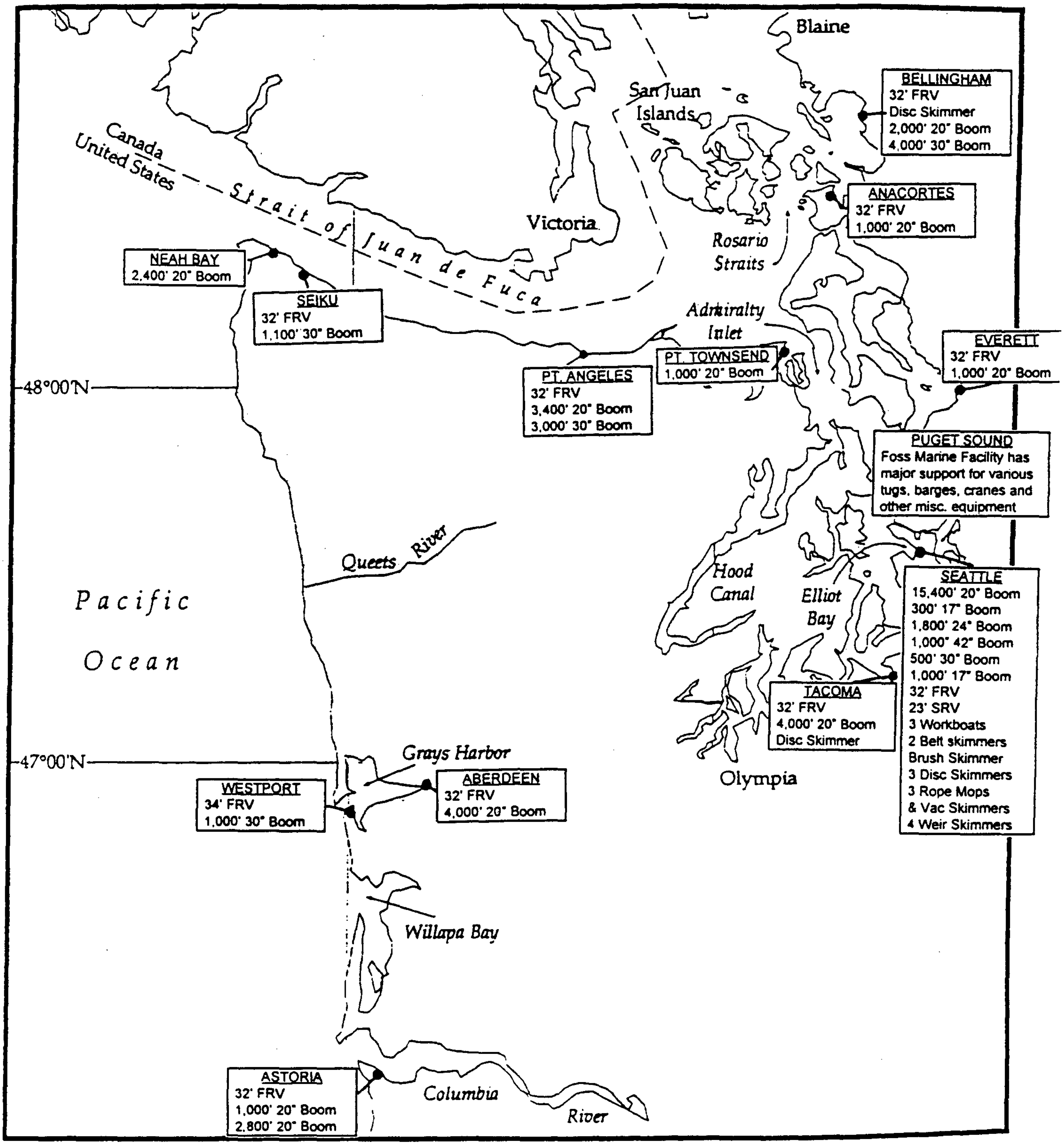
Abbreviations:
ORV- oil recovery vessel
SRV - spill response vessel
I/T-intertidal Texaboom
SKIM - skimmers
K - x 1000



FOSS ENVIRONMENTAL
PRE-STAGED SPILL RESPONSE EQUIPMENT

USE ONLY AS A GENRAL REFERENCE

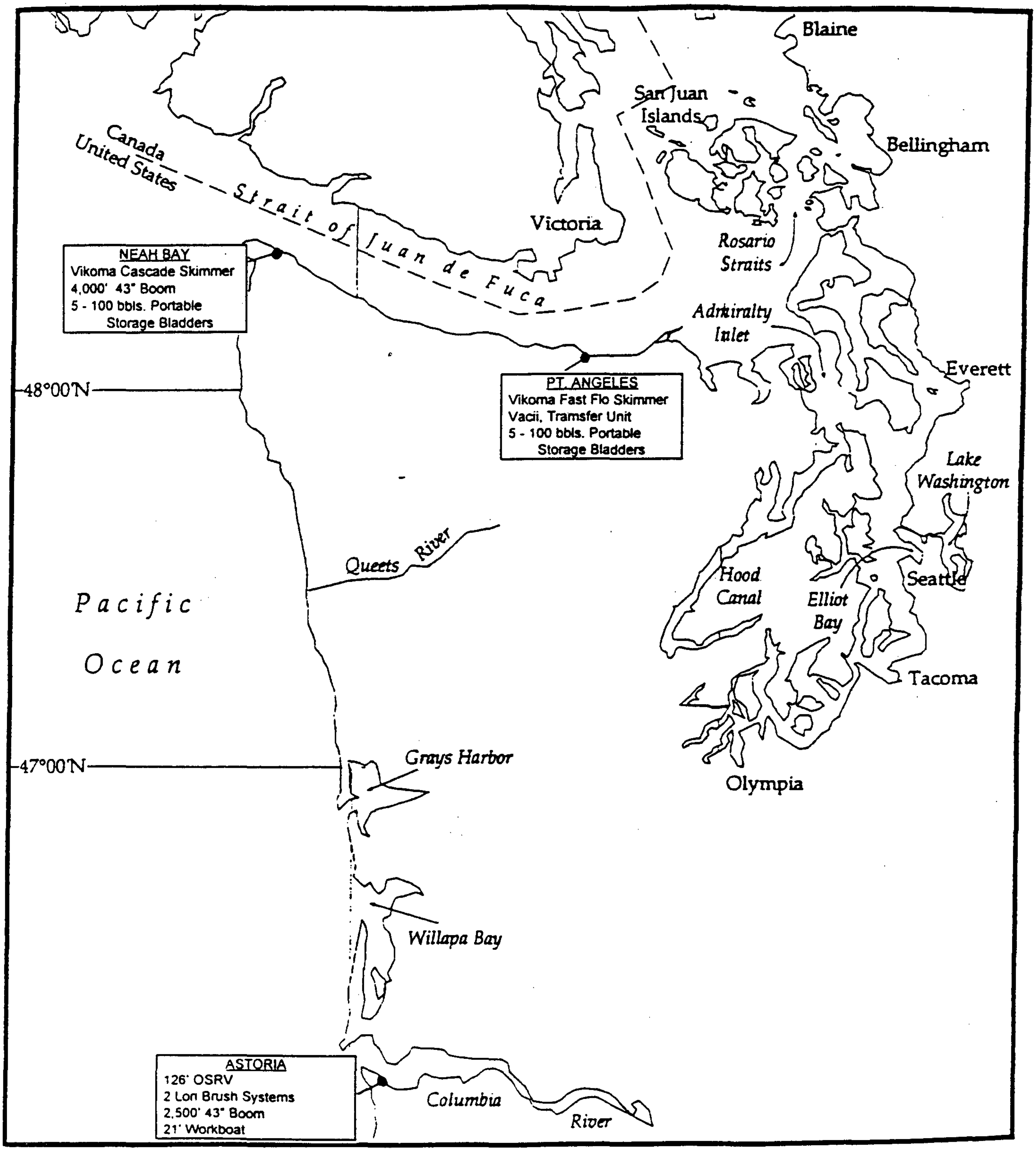
Abbreviations:
ORV - oil recovery vessel
FRV - fast response vessel
SRV - spill response vessel



CLEAN PACIFIC ALLIANCE
PRE-STAGED SPILL RESPONSE EQUIPMENT

USE ONLY AS A GENRAL REFERENCE

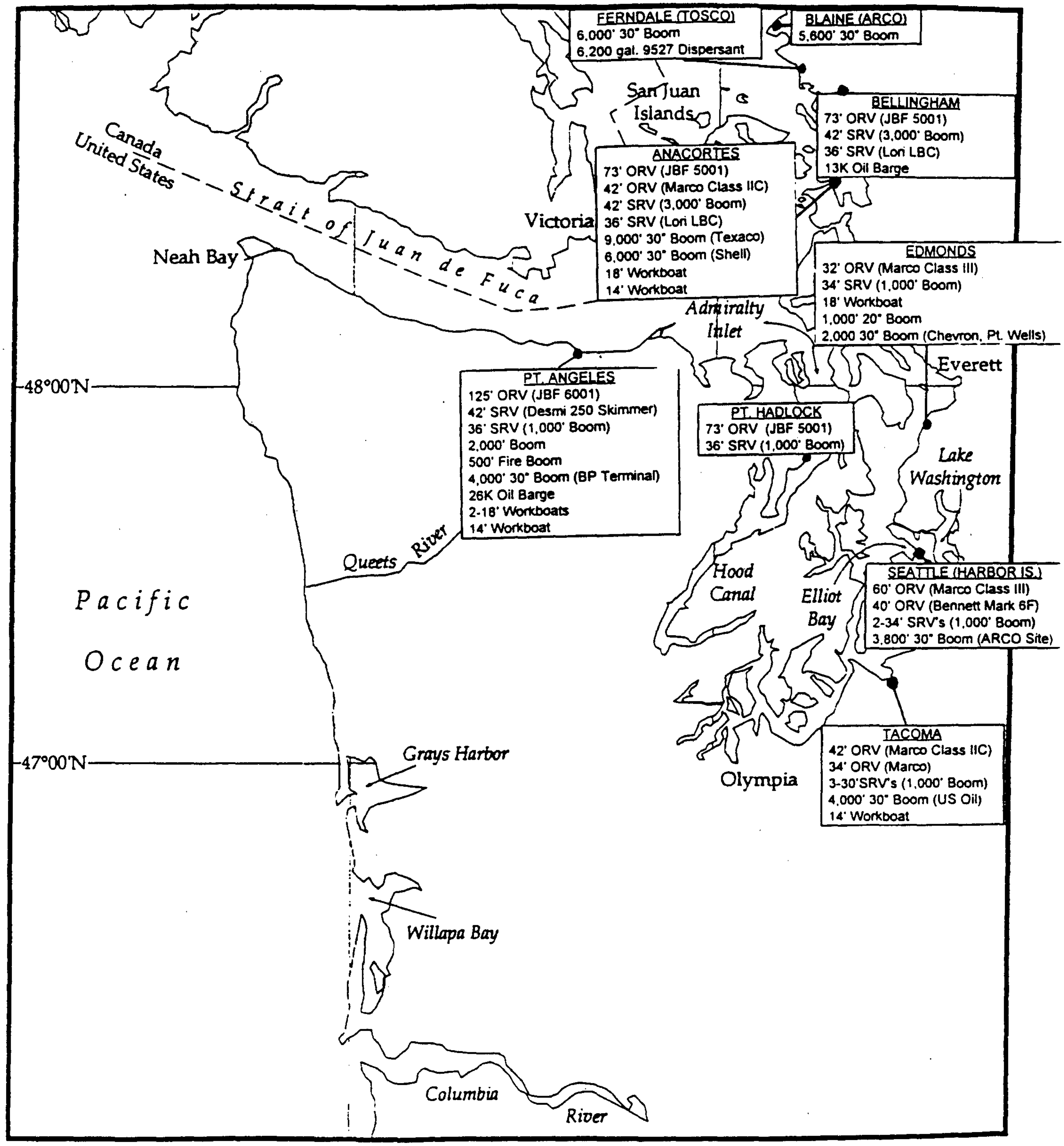
Abbreviations:
ORV - oil recovery vessel
SRV - spill response vessel
K - x 1000



CLEAN SOUND COOPERATIVE, INC.
PRE-STAGED SPILL RESPONSE EQUIPMENT

USE ONLY AS A GENRAL REFERENCE

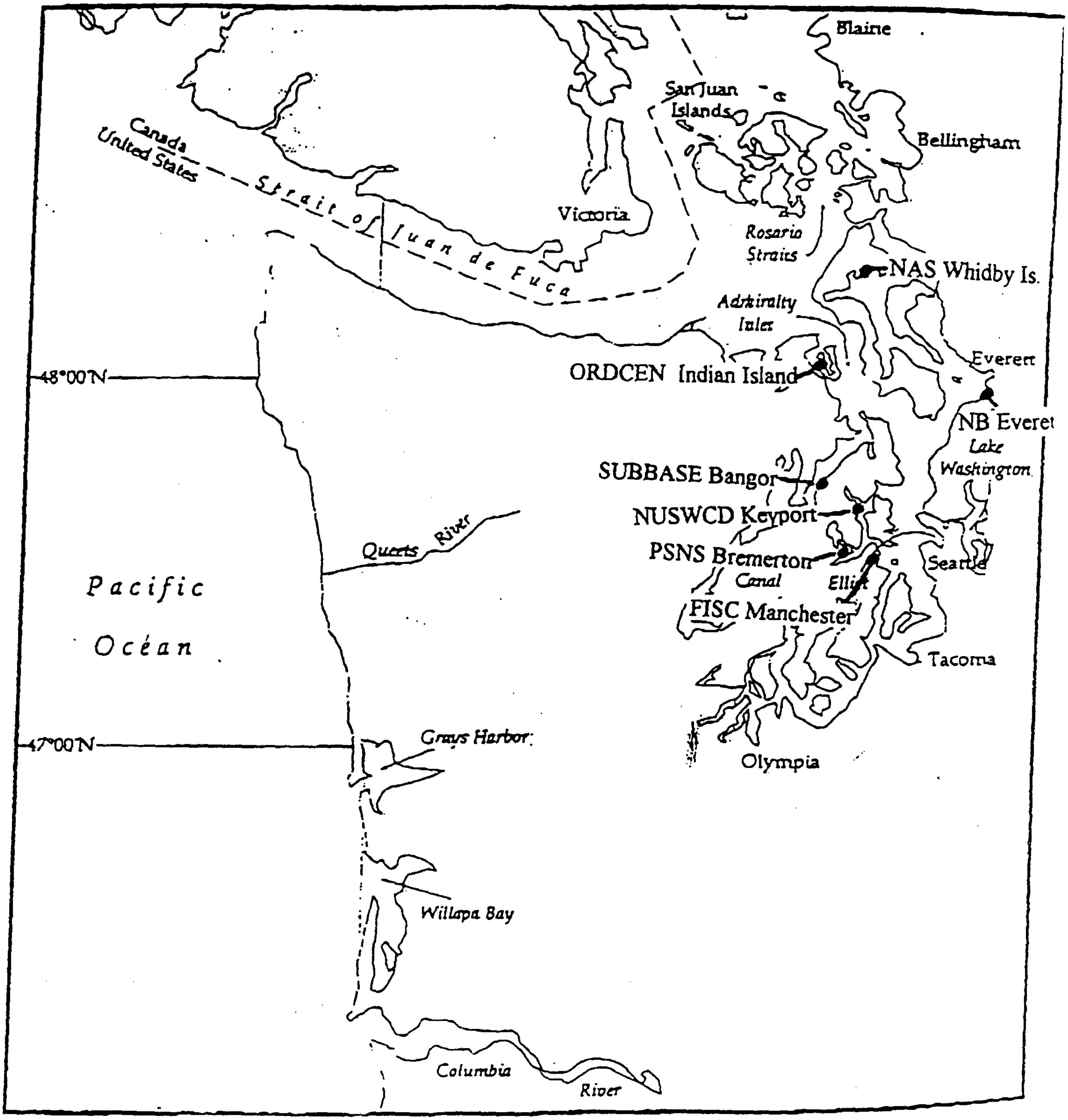
Abbreviations:
ORV - oil recovery vessel
SRV - spill response vessel
K - x 1000



U.S. Navy
PRE-STAGED SPILL RESPONSE EQUIPMENT

USE ONLY AS A GENRAL REFERENCE

Abbreviations:
ORV - oil recovery vessel
SRV - spill response vessc
K - x 1000



FISC Manchester
Boom Protected Water 7,500'
Boom Open Water 11,000'
Skimmer Small 4
Skimmer Rapid Deploy 1
Skimmer Large 1
Workboats 4

NB Everett
Boom Protected Water 2,000'
Boom Open Water 2,000'
Skimmer Small 6
Skimmer Rapid Deploy 1
Workboats 5

NAS Whidby Island
Boom Protected Water 3,000'
Boom Open Water 2,000'
Skimmer Small 1
Skimmer Rapid Deploy 1
Workboats 4

ORDCEN Indian Island
Boom Protected Water 2,500'
Skimmer Large 1
Workboats 2

SUBBASE Bangor
Boom Protected Water 5,000'
Boom Open Water 1,000'
Skimmer Small 1
Skimmer Large 1
Workboats 8

PSNS Bremerton
Boom Protected Water 6,000'
Skimmer Large 2
Workboats 3

NUSWCD Keyport
Boom Protected Water 2,500'
Workboats 1

CANADIAN RESPONSE EQUIPMENT

Ucluelet
Oil Boom 1000' 18"
Oil Boom 2900' 24"

Esquimalt
Oil Boom 4000' 24
Oli Boom 3900' 30"
Oil Boom 300' 42"
Oil Boom 2600' 50"
Skimmer Offshore 75 (Voss)
Skimmer 60' ORV Marco Class III
SRV 42'
Barge

Roberts Bank (Delta Port)
Oil Boom 1000' 24"
Oil Boom 3000' 42"
Oil Boom 1000' 50"
Barge

N. Vancouver
Oil Boom 2300' 18"
Oil Boom 5000' 20"
Oil Boom 16,100' 24"
Oil Boom 500' shoreseal 30"
Oil Boom 400' 36"
Skimmer ORV 40' JBF
Skimmer ORV 40' JBF
SRV 36' 2 each
SRV 38'
Workboat 18' 3 each
Barge

Nanaimo
Oil Boom 2500' 18"
Oil Boom 5100 24"
Oil Boom 600' 36"
Oil Boom 1000' 42"
Skimmer T-18 (Voss)
SRV 36'

THE MARINE SALVAGE CONSORTIUM, INC

Donjon Marine Co., Inc.
Dunlap Towing Company
Global Diving and Salvage, Inc
J.H. Leitz & Associates, Inc.

dba
Fred Devine Diving and Salvage Co.
6211 N Ensign
Portland, Oregon 97217
USA

Tel (503) 283 5285
Fax (503) 286 2871

May 28, 1997

Dr. Sharon Christopherson
NOAA Hazardous Material Response and
Assessment Division (N/ORCA 3)
7600 Sand Point Way NE
Seattle, WA 98115

Re: Puget Sound – Additional Hazard Assessments Meeting 4/22/97

Dear Dr. Christopherson:

Attached are the revisions to the April 22, 1997 Puget Sound - Additional Hazard Assessment meeting for worksheet 3C/B Salvage Resources. The meeting notes were augmented with firefighting and lightering resources.

To address D.O.T. Volpe Center's question, "Who is Devine" and "…why isn't Leitz Salvage included", I need to provide some background.

In 1993 **The Marine Salvage Consortium, Inc.** purchased Fred Devine Diving and Salvage, Inc. which continues business as a D.B.A. with J.H. Leitz as President and Salvage Master.

J.H. Leitz is the owner of Leitz Marine Recovery Systems which also owns various specialized salvage equipment used by The Marine Salvage Consortium, Inc. dba Fred Devine Diving and Salvage Company.

The Marine Salvage Consortium, Inc. consist of four owners. J.H. Leitz and Associates, Inc., Global Diving and Salvage Inc., Dunlap Towing Co., and Donjon Marine, Co. Inc. Through the expertise and resources brought to bear by the four participants, the Marine Salvage Consortium, Inc.; dba Fred Devine Diving and Salvage Company continues to offer the nation the highest level of emergency salvage response available today.

If you have further questions please contact Tom Murphy or myself at (503) 283-5285.

Thank you.

Sincerely yours,

J.H. Leitz

J.H. Leitz
President

Attachment – Table 3C notes, item B.

Cc: Judy Schwenk, D.O.T. Volpe Center w/attachement

II. Worksheet 3C: Spill Response

A. Summary of Pre-Staged Oil Spill Response Equipment (Roland Miller)

[Roland Miller will submit updated information and map]

B. Salvage firefighting and lightering Resources (Mickey Leitz, ~~LEITZ)~~

1. Astoria, Or. – 200' Salvage vessel ~~vssl.~~ ~~with~~ – 400 ton of tractive pulling capacity, (5) 250 Kw generators, twin screw 3600 HP, (2) 18 ton hydraulic cranes, (1) 25 ton electric operated boom, (30) transportable pumps w/ 3500 tons per hour pumping capacity, 10 portable high volume (900 cfm) low pressure air compressors, repair & patching materials and equipment. Extensive diver support capabilities. This vessel is particularly suited, and proven in ocean stranding situations.

2. Seattle – Crowley vssl.

3. Manson Construction – assorted heavy lift equipment to 500 tons.

4. General Construction – assorted heavy lift equipment to 200 tons.

5. Marine firefighting ~~control~~ – An agreement is in place with Williams Fire and Hazard Control and Fred Devine Diving and Salvage to procure ~~marine firefighting personnel and~~ equipment and marine firefighting personnel from outside Washington State on short notice.

6. Tugs, oil barges – FOSS, Crowley , and others concentrated in Seattle.

7. Portland – Large inventory of air transportable salvage resources are available.

8. Response times are longer on Northern Outer Coast from from either Seattle or Astoria.

9. Overall salvage capability in Pacific Northwest is very good at the present time, but salvage capability globally is diminishing – this industry is limited/dwindling due to lack of business or some other form of financial support.

10. Time is the most critical element to good mitigation measures. To improve the response time, vessels owners/charters under OPA-90 could be required to contract for a 4-6 hour salvage team. This team could be a primary resource to minimize oil outflow.

11. Open-ocean salvage is particularly challenging – larger tugs tend to draw more water and are not able to operate in shallow water which dominates along the Pacific NW coast.

12. Requirements for the establishment of contacts with salvor and ~~vssl~~ vessel operator prior to the start of salvage can impede a timely start.

13. A salvage and lightering (OPA-90) teaming agreement is in place between Foss Maritime and Fred Devine Diving and Salvage Co.

14. ITOS provides extremely limited salvage capablity which can not be improved on in any meaningful way due to space constrants and the small crew available. This deficiency can be significantly improved by redeploying the MV Salvage Cheif at either Neah Bay or Port Angeles, Washington. The suggested vessel has a proven track record for successful salvage on the Pacific Coast in the ocean environment existing in segments 1, 2 and to a lesser extent 3.

If the MV Salvage Cheif were stationed at either port listed above, portable high volume firefighting and oil recovery systems can be outfitted aboard to further enhance local emergency response capablities.

Owner	Salvage System	System Components	Location	Restrictions
FRED DIVINE DIVING & SALVAGE COMPANY 6211 N. ENSIGN PORTLAND, OR 97217 24 HRS: (503) 283-5285 CONTACT: KERRY WALSH	M/V "Salvage Chief"	LOA - 202 feet Beam - 34 feet Depth - 17.5 feet Draft - 9 feet	Astoria, Oregon	Commercial Contractor
	Surface Supply Dive Stations:	8 - Dive Stations 2 - Recompression Chambers	Portland, Oregon	Commercial Contractor
	Underwater Tools:	a. Pneumatic b. Hydraulic c. Welding/Cutting d. Video	Portland, Oregon	Commercial Contractor
	Dewatering Pumps:	53 - Engine Driven 9 - Hydraulic Driven 14 - Pneumatic Driven 8 - Electric Driven	Portland, Oregon	Commercial Contractor
	Misc. Pumps:	6 - Fire 1 - Jet 5 - Viscous Fluid 1 - Dredge	Portland, Oregon	Commercial Contractor
	Dewatering Blowers:	6 - Blowers	Portland, Oregon	Commercial Contractor
	Generators:	6 - 1.5KW to 150KW	Portland, Oregon	Commercial Contractor
	Air Compressors:	4 - 85cfm to 1100cfm	Portland, Oregon	Commercial Contractor
	Winches:	8 - Engine Driven 2 ton to 20 ton 36 - Pneumatic 2 ton to 25 ton	Portland, Oregon	Commercial Contractor
	Pneumatic Lift Systems	66 - Lift Barges 6 - Control Manifolds	Portland, Oregon	Commercial Contractor
	Hydraulic Power Units:	7 - Power Units	Portland, Oregon	Commercial Contractor
	Surface Supply Dive Systems:	16 - Dive Stations 1 - Mixed Gas System	Seattle, Washington	Commercial Contractor
	Lightering System:	2 - Hydraulic Systems 7 - Pumps from 450gpm to 3000gpm a. Tripods & Hose	Seattle, Washington	Commercial Contractor
	Underwater Tools:	a. Pneumatic b. Hydraulic c. Welding/Cutting d. Video	Seattle, Washington	Commercial Contractor
	Pumps:	13 - Engine Driven 1 - Electric Driven	Seattle, Washington	Commercial Contractor

Owner	Salvage System	System Components	Location	Restrictions
USCG NATIONAL STRIKE FORCE	Air Deployable Anti Pollution	ADAPTS - Large pump load.	Novato, CA	USCG
PACIFIC STRIKE TEAM	Transfer System (2 units)	Includes Prime Mover, Pumps,		
HANGER 2, HAMILTON FIELD		Tripod.		
NOVATO, CA 94949-5082				
24HRS: (415) 883-3311	Viscous Oil Pumping System	VOPS - Viscous oil Pumping	Novato, CA	
CONTACT: DUTY OFFICER	(1 unit)			
USCG 13TH DISTRICT (mep)	Pumping Equipment:	(2) CCN-150	Astoria, OR	USCG
JACKSON FEDERAL BUILDING		(2) Prime Movers	Astoria, OR	
2ND AVENUE		(2) CCN-150	Manchester, WA	
SEATTLE, WA 98174-1067		(2) Prime Movers	Manchester, WA	
DAY: (206) 220-7001				
CONTACT: DUTY OFFICER (mep)				
FOSS ENVIRONMENTAL	Marco VS50	1 each; 200 gpm (130 gpm high viscosity liquids)	Seattle, WA	Commercial Contractor
640 WEST EWING STREET				
SEATTLE, WA 98119-1587	Hydraulic Submersible Pump 6"	5 each	Seattle, WA	Commercial Contractor
24 HRS: (206) 767-0441	Diesel Pace Pump 6 inch	1 each	Portland, WA	Commercial Contractor
24 HR SPILL #: (800) 337-7455	Various 2,3&4" Pumps	14 pumps	Seattle, WA	Commercial Contractor
CONTACT: JOHN CRAWFORD	Various 2,3&4" Pumps	13 pumps	Portland, OR	Commercial Contractor
	Scavenger Oil Recovery System	2 each	Portland, WA	Commercial Contractor
CROWLEY MARINE	American Salvor			

Owner	Salvage System	System Components	Location	Restrictions
FRED DIVINE DIVING & SALVAGE COMPANY 6211 N. ENSIGN PORTLAND, OR 97217 DAY: (503) 283-5285 CONTACT: KERRY WALSH	Hydraulic Systems:	4 - Power Packs 1 - Hull Scrubbing Sys 1 - Core Tool	Seattle, Washington	Commercial Contractor
	Generators:	5 - 1KW to 5KW	Seattle, Washington	Commercial Contractor
	Pneumatic Lift Systems:	12 - 1/2 to 2 tons Bags 2 - Control Manifolds	Seattle, Washington	Commercial Contractor
GLOBAL DIVING & SALVAGE, INC 2763-13TH AVENUE SOUTHWEST HARBOR ISLAND SEATTLE, WA 98134 24 HRS: (206) 623-0621 CONTACT: THOM DAVIS	Surface Supply Dive Systems:	8 - Dive Stations 1 - Mixed Gas System		Commercial Contractor
	Air Compressors:	6 - 8cfm to 88 cfm		Commercial Contractor
	Hydraulic Systems:	4 - Power Packs 1 - Hull Scrubbing Sys 1 - Core Tool		Commercial Contractor
	Underwater Tools:	a. Pneumatic b. Hydraulic c. Welding/Cutting d. Video		Commercial Contractor
	Pumps:	13 - 62gpm to 610gpm		Commercial Contractor
	Pneumatic Lift Systems:	12 - 1/2 to 2 tons Bags		Commercial Contractor
	Lightering System:	4 - Power Packs 7 - Pumps from 450gpm to 3000gpm a. tripods & hose		Commercial Contractor
MARINE SPILL RESPONSE CORPORATION 1105 13TH ST EVERETT, WA 98201 24 HRS: (206) 252-1300 CONTACT: BILL PARK	Pumps:	(1) CCN -150 (1) CCN -150 (1) CCN -150	Everett, WA Astoria, WA Port Angeles, WA	
		(2) Desmi - D.O.P. (4) Desmi - D.O.P. (3) Desmi - D.O.P.	Everett, WA Astoria, WA Port Angeles, WA	
AIRO SERVICES 4110 EAST 11TH ST TACOMA, WA 98421-4286 24 HRS: (206) 383-4916 CONTACT: THERESE OLSON	Ventilating Blowers:	(1) Coppus CP-20 Turbine Blower (11,000 cfm)	Tacoma, WA	Commercial Contractor
CLEAN SOUND COOPERATIVE, INC 110 WEST DAYTON, SUITE 202 EDMONDS, WA 98020 24 HRS: (206) 744-0948 CONTACT: ROBERT WEICHERT	MPC Pumping System	(2) Prime Movers (2) CCN 150 Pumps (1) Tripod	Barge Kittiwake Port Angeles, WA	
	Anti-Pollution Transfer System (APTS) Model 20	(1) Prime Mover (1) Submersible 6" Pump	Barge Pelican Bellingham, WA	
NAVY SUPSALV NORTH BASE SEATTLE 7500 SAND POINT WAY NE SEATTLE, WA 98115-5012 24 HRS: (206) 526-3226 CONTACT: LT KEN KOELLERMEIER	Casualty oil recovery system	(1) Boiler-Clayton (4) Hot Taps, 6 in dia Hole in Tank	Stockton, CA Stockton, CA	

NRDA: SUMMARY OF TOTAL INJURY AND DAMAGES (1997 US $)
Scenario: SC6MC1

Spill date: May 5, 1997
Location: 48.518N, 122.615W
Prudhoe Bay Crude - Low Volatiles
12800.870 MT, OIL #: 0 13 1

Category Of Loss	Without Restoration	Including Restoration
Wildlife killed (# animals)	47481.1	46531.3
Fishery stock killed (kg)	567181.4	567181.4
Fishery young-of-yr killed (# at 1yr)	11061.6	11061.6
Lost catch (kg)	133676.7	133676.7
Lost #-years fish, shellfish	4681880.0	4681880.0
Lost hunting (# animals)	7262.5	6940.1
Lost #-years wildlife	255349.8	252226.3
Damages: catch (US $)	265909.	265909.
Damages: hunting (US $)	78342.	68848.
Damages: wildlife non-consumptive	1258358.	1234590.
Damages: Total compensable value for fish and wildlife losses	1602610.	1569347.
Beach damages: all shorelines	0.	0.
Damages: Total compensable value for all natural resource losses (US $)	1602610.	1569347.
Restoration costs for all habitats		0.
Restocking costs for all species		437884.
Restoration cost-assimilative capacity	3373.	3373.
for a remaining mass (MT) of:	256.69090	256.69090
Total compensable value and all estimated restoration costs (US $)	1605983.	2010604.

Habitat restoration plus restocking costs ($ 437883.60)
are more than 10. times the resulting reduction in
compensable value ($ 33263.00)
Habitat restoration and restocking are assumed not performed.

TOTAL DAMAGES ASSESSED (1997 US $) 1605983

Habitat # Type	Sediment or Habitat Area (m2) Toxic Long Term	Sedmnt.Replaced or Capped	Replanted Only
Total	.00000E+00	.00000E+00	.00000E+00

TOTAL KILLS BY SPECIES AND BY CATEGORY, ASSUMING RESTORATION PERFORMED:

Wildlife species	Number killed
Dabbling ducks,coots	83.4118
Geese	585.6473
Swans	.0001
Diving ducks	9773.6350
Loons	1207.8170
Grebes	1278.2930
Small alcids	1962.4230
Cormorants, anhinga	925.0857
Guillemots	647.2392
Gulls	643.2380
Murres	218.7194
Terns	.2023
Herons and egrets	464.7279
Sandpipers, plovers	28515.0700
Oystercatcher, stilt	15.2008
Bald eagles	11.5141
Kingfishers	198.3111
Toothed whales	.0002
Sea lions	.1540
Phocid seals	.5984

Wildlife category	Number killed
Waterfowl	12928.8000
Seabirds	4396.9070
Wading birds	464.7279
Shorebirds	28530.2700
Raptors, kingfishers	209.8252
Cetaceans	.0002
Pinnipeds (seals)	.7525

Fishery species	kg adults killed	# YOY killed
Herring, sea	.0000	419.4749
Smelt	.0000	2.9334

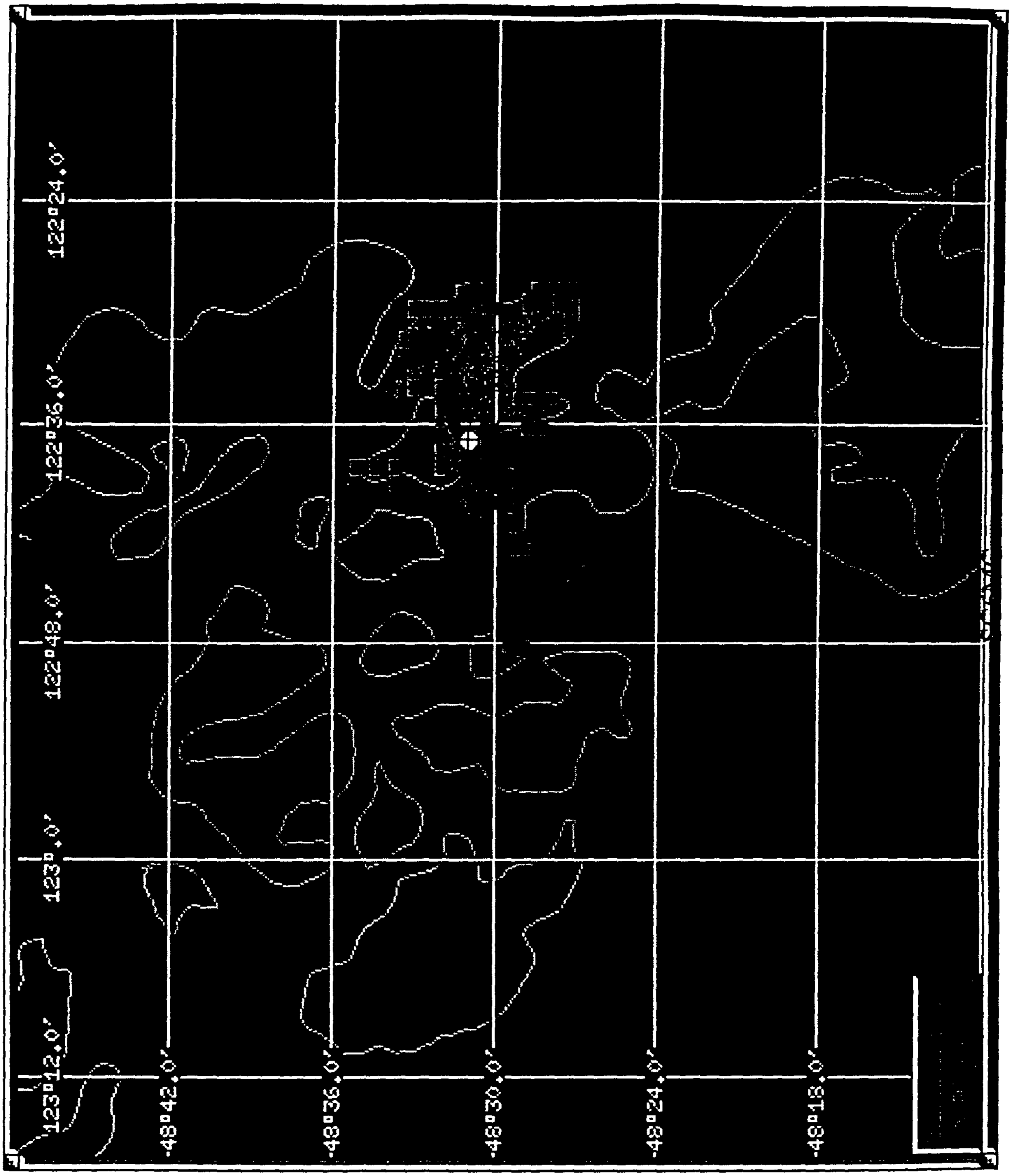
Chinook or Barracuda	.0016	.0000
Chum salmon/Billfish	.0034	.0000
Coho salmon	.0027	.0000
Pink salmon or Bonit	.0050	.0000
Sockeye salmon	.0093	.0000
Cod	6.7722	176.5896
Dogfish	87.6023	9634.1410
Greenlings	7.2324	.9907
Halibut	.6645	1.0556
Pollock	8.6717	208.8382
Rockfish	9.5094	[illegible].0000
Flounders	1.2228	.2757
Other groundfish	1.1326	40.6166
Shrimp, Northern	.0023	164.8921
Clams, geoduck	566856.4000	411.7593
Sea urchins	202.2019	.0000

Fishery category	kg adults killed	# YOY killed
Small pelagic fish	.0000	422.4082
Large pelagic fish	.0220	.0000
Semi-demersal ground	120.4525	10021.6100
Demersal groundfish	2.3554	40.8924
Crustaceans	.0023	164.8921
Mollusks	566856.4000	411.7593
Other benthic invert	202.2019	.0000

Area swept by surface slicks: .132752E+10 m2 .129983E+09 m2-days

Shorelines oiled above lethal threshold,
by shoreline type (assuming no restoration performed):

Shore type	Length (m)	m-days	Area (m2)	m2-days
Sand Beach	.205566E+06	.513767E+08	.452246E+07	.113028E+10


122°24.0'
122°36.0'
122°48.0'
123°.0'
123°12.0'
-48°42.0'
-48°36.0'
-48°30.0'
-48°24.0'
-48°18.0'

NRDA: SUMMARY OF TOTAL INJURY AND DAMAGES (1997 US $)
Scenario: SC6JC1

Spill date: Jan. 5, 1997
Location: 48.518N, 122.615W
Prudhoe Bay Crude - Low Volatiles
12800.870 MT, OIL #: 0 13 1

Category Of Loss	Without Restoration	Including Restoration
Wildlife killed (# animals)	180235.2	180112.2
Fishery stock killed (kg)	583031.1	583031.1
Fishery young-of-yr killed (# at 1yr)	11551.5	11551.5
Lost catch (kg)	137386.1	137386.1
Lost #-years fish, shellfish	4811504.0	4811504.0
Lost hunting (# animals)	57107.8	57107.8
Lost #-years wildlife	1137484.0	1137079.0
Damages: catch (US $)	274824.	274824.
Damages: hunting (US $)	492581.	492580.
Damages: wildlife non-consumptive	1106573.	1101300.
Damages: Total compensable value for fish and wildlife losses	1873978.	1868705.
Beach damages: all shorelines	0.	0.
Damages: Total compensable value for all natural resource losses (US $)	1873978.	1868705.
Restoration costs for all habitats		0.
Restocking costs for all species		58896.
Restoration cost-assimilative capacity	2067.	2067.
for a remaining mass (MT) of:	157.30300	157.30300
Total compensable value and all estimated restoration costs (US $)	1876046.	1929668.

Habitat restoration plus restocking costs ($ 58896.01)
are more than 10. times the resulting reduction in
compensable value ($ 5273.63)
Habitat restoration and restocking are assumed not performed.

TOTAL DAMAGES ASSESSED (1997 US $) 1876046

Habitat # Type	Sediment or Habitat Area (m2) Toxic Long Term	Sedmnt.Replaced or Capped	Replanted Only
Total	.00000E+00	.00000E+00	.00000E+00

TOTAL KILLS BY SPECIES AND BY CATEGORY, ASSUMING RESTORATION PERFORMED:

Wildlife species	Number killed
Dabbling ducks,coots	.0484
Geese	.0554
Swans	.0003
Diving ducks	86291.6300
Loons	10706.9700
Grebes	34245.8800
Small alcids	1652.9170
Cormorants, anhinga	6850.7640
Guillemots	1346.1760
Gulls	4222.5420
Murres	13097.5600
Terns	.0392
Herons and egrets	115.2200
Sandpipers, plovers	21508.2600
Oystercatcher, stilt	2.6965
Bald eagles	3.6927
Kingfishers	63.4821
Toothed whales	.0106
Sea lions	.8610
Phocid seals	3.3447

Wildlife category	Number killed
Waterfowl	131244.6000
Seabirds	27170.0000
Wading birds	115.2200
Shorebirds	21510.9600
Raptors, kingfishers	67.1748
Cetaceans	.0106
Pinnipeds (seals)	4.2056

Fishery species	kg adults killed	# YOY killed
Herring, sea	.0000	722.1086
[illegible]	[illegible]	[illegible]

Chinook or Barracuda	.0015	.0000
Chum salmon/Billfish	.0034	.0000
Coho salmon	.0027	.0000
Pink salmon or Bonit	.0049	.0000
Sockeye salmon	.0093	.0000
Cod	6.6914	181.5259
Dogfish	86.5571	9903.4450
Greenlings	7.1461	1.0091
Halibut	.5197	1.0851
Pollock	8.5683	214.6759
Rockfish	9.3960	.0000
Flounders	1.2084	.2834
Other groundfish	1.1191	41.7520
Shrimp, Northern	.0022	188.7223
Clams, geoduck	582702.0000	291.9198
Sea urchins	207.8540	.0000

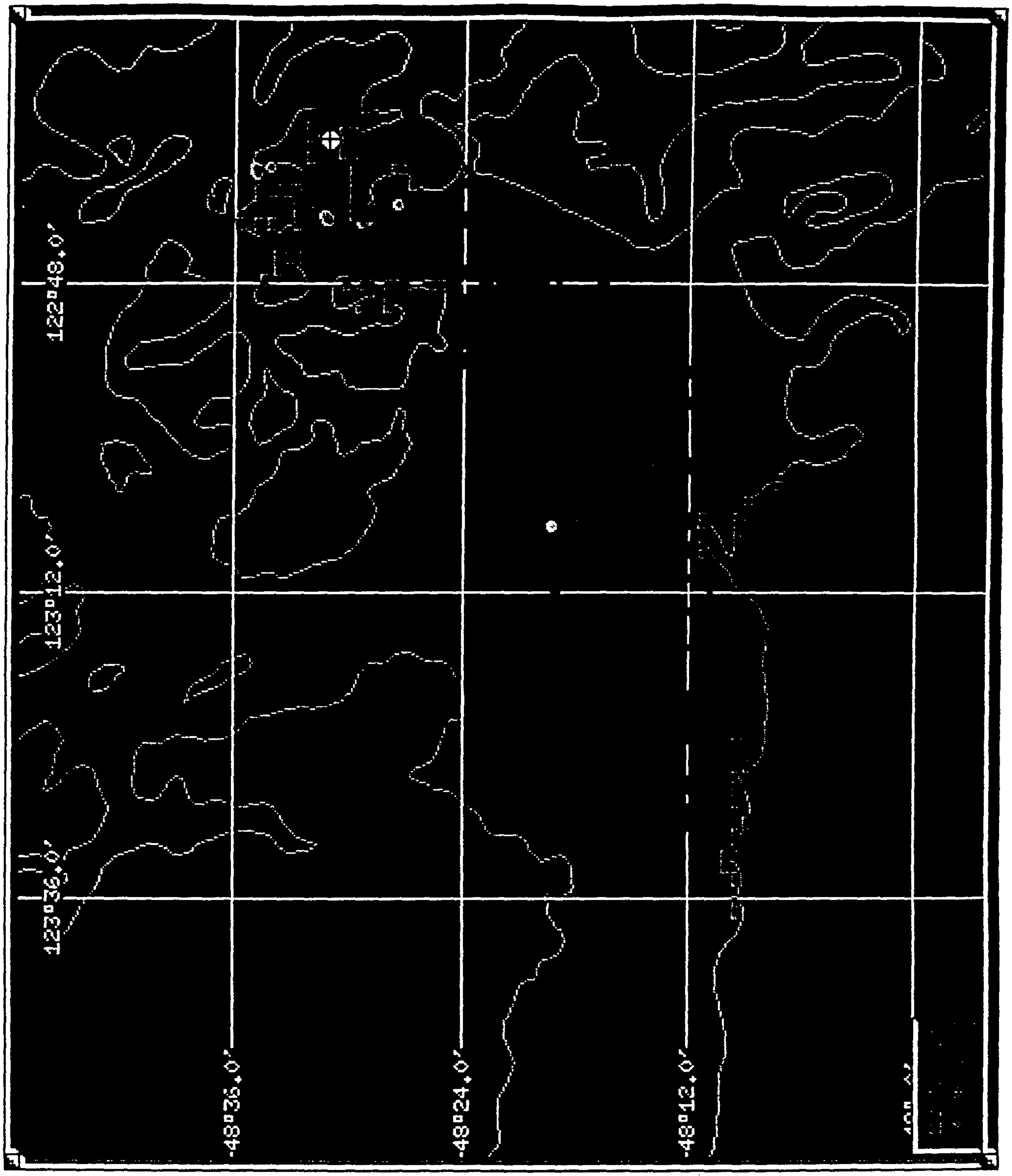
Fishery category	kg adults killed	# YOY killed
Small pelagic fish	.0000	727.0933
Large pelagic fish	.0218	.0000
Semi-demersal ground	118.8785	10301.7400
Demersal groundfish	2.3275	42.0354
Crustaceans	.0022	188.7223
Mollusks	582702.0000	291.9198
Other benthic invert	207.8540	.0000

Area swept by surface slicks: .239735E+10 m2 .328900E+09 m2-days

Shorelines oiled above lethal threshold,
by shoreline type (assuming no restoration performed):

Shore type	Length (m)	m-days	Area (m2)	m2-days
Sand Beach	.284787E+06	.756175E+08	.626532E+07	.166358E+10

SC6JC



	Marine/Estuarine Compensation Schedule - excluding Columbia River Estuary						
			VOLPE SC4MB				
Spill month	*Table Zone*	*Waterbody affected*	*Location*	*Amount Spilled (g)*	*Product Type*		
May	303	Strait of Juan de Fuca	Port Angeles	94280	Bunker		
	HABITAT VULNERABILITY (HVS)						
	Marine Intertidal (MI) Habitats			Percent	Oil(ac)	Oil(mech)	Oil(pers)
MI-1	Exposed & semi-exposed rocky shores			10	3.7	4.3	3.1
MI-2	Sand-scoured rocky shores			0	3.3	3.8	2.7
MI-3	Protected rocky shores			0	3	3.5	3
MI-4	Semi-exp. cobble & mixed coarse beaches			5	3.2	3.2	3.2
MI-5	Semi-exposed gravel beaches			0	3.2	1.4	2
MI-6	Exposed sandy beaches			5	2.9	1.3	1.8
MI-7	Semi-protected mixed-fine beaches			0	3.2	2.6	3.7
MI-8	Protected mud flats			5	3.8	2.7	4.3
	Marine Subtidal (MS) Habitats						
MS-1	Shallow subtidal rock & boulder			0	3.7	3.7	3.1
MS-2	Deep subtidal rock and boulder			0	2.7	2.7	3.3
MS-3	Deep subtidal cobble & mixed coarse			0	1.5	2.2	2.2
MS-4	Shallow subtidal mixed-coarse to mixed fine			20	3.6	3.6	3.6
MS-5	Shallow subtidal gravel or mixed fine			0	2.8	1.6	2.3
MS-6	Deep subtidal sand			15	1.6	2	1.6
MS-7	Deep subtidal mixed-fine			0	1.5	2.6	3.1
MS-9	Open water - kelp			10	7.5	4.8	3.3
MS-9	Open water			30	5	3.2	2.2

	Estuarine Intertidal (EI) Habitats	Percent	Oil(ac)	Oil(mech)	Oil(pers)
EI-1	Open rocky shores	0	3	3.5	3
EI-1	Open rocky shores (k/eg)	0	4.5	5.25	4.5
EI-2	Open mixed-coarse beaches & low marsh	0	3.7	3.2	3.2
EI-2	Open mixed-coarse beaches & low marsh (k/eg)	0	5.55	4.8	4.8
EI-3	Open gravel beaches	0	3.4	1.5	2.2
EI-4	Open sandy beaches	0	3.3	2.8	2.3
EI-4	Open sandy beaches (k/eg)	0	4.95	4.2	3.45
EI-5	Sandy low marshes		3.5	3	3
EI-6	Mixed-fine beaches and low marshes		4.3	4.3	4.3
EI-7	Saline lagoons		3.7	3.7	4.1
EI-8	Low-salinity lagoons		3	3.5	3.9
EI-9	Mud flats		3.7	2.6	4.1
EI-9	Mud flats (kelp/eelgrass)		5.55	3.9	6.15
EI-10	High salt marshes		3	3.5	3.9
EI-11	Transition zone wetlands		3	3.5	3.9
	Estuarine Subtidal (ES) Habitats				
ES-1	Shallow subtidal rock and boulders		3.2	3.2	2.6
ES-2	Deep subtidal rock and boulders		2.3	2.3	2.8
ES-3	Shallow subtidal cobble and mixed-coarse	0	2.6	3.2	3.2
ES-4	Deep subtidal cobble and mixed-coarse	0	1.5	2.2	2.2
ES-5	Shallow subtidal sandy or mixed-fine	0	3.2	3.2	3.2
ES-6	Deep subtidal sandy or mixed-fine		2	2.4	2.8
ES-7	Shallow subtidal muddy bays		3	2.4	3.9
ES-7	Shallow subtidal muddy bays (kelp/eelgrass)		4.5	3.6	5.85
ES-8	Deep subtidal muddy bays		1.8	1.8	2.9
ES-9	Open water	0	5	3.2	2.2

* The individual habitat vulnerability score is multiplied by 1.5 due to the presence of seagrass or kelp

HVS(ac) =	4.075						
HVS (mech)	3.25						
HVS (pers) =	2.725						
BVS =	3	* The bird vulnerability score is multiplied by 1.5 when state or federal T& E species present					
MVS =	4						
MFVS =	5						
SFVS =	5						
RVS =	5						
SAVS:							
	Habitat type		%	Chinook - Subyr	Ch-sub (adjust)	Chinook - Y	Ch-yr (adjust)
	Intertidal - Rocky		10	1	0.1	1	0.1
	Intertidal - Cobble		5	2	0.1	3	0.15
	Intertidal - Gravel		0	3	0	3	0
	Intertidal - Sand (vegetated)			4	0	3	0
	Intertidal - Sand (unvegetated)		5	3	0.15	3	0.15
	Intertidal - Mud (vegetated)			4	0	3	0
	Intertidal - Mud (unvegetated)		5	3	0.15	3	0.15
	Subtidal		35	2	0.7	2	0.7
	Pelagic		40	4	1.6	4	1.6
	Total Score				2.8		2.85
	Habitat type		%	Pink	Pink (adjust)	Coho	Coho (adjust)
	Intertidal - Rocky		10	1	0.1	1	0.1
	Intertidal - Cobble		0	2	0	2	0
	Intertidal - Gravel		0	3	0	2	0
	Intertidal - Sand (vegetated)			5	0	4	0
	Intertidal - Sand (unvegetated)		5	3	0.15	3	0.15
	Intertidal - Mud (vegetated)			5	0	4	0
	Intertidal - Mud (unvegetated)		5	3	0.15	3	0.15
	Subtidal			2	0	1	0
	Pelagic		100	4	4	3	3
	Total Score				4.4		5

	Habitat type		%	Chum	Chum (adjust)	Sockeye	Sockeye (adj)
	Intertidal - Rocky		10	1	0.1	2	0.2
	Intertidal - Cobble		0	2	0	2	0
	Intertidal - Gravel		0	3	0	2	0
	Intertidal - Sand (vegetated)			5	0	2	0
	Intertidal - Sand (unvegetated)		5	3	0.15	2	0.1
	Intertidal - Mud (vegetated)			5	0	2	0
	Intertidal - Mud (unvegetated)		5	3	0.15	3	0.15
	Subtidal			2	0	1	0
	Pelagic		100	4	4	4	4
	Total Score				4.4		4.45
Pink salmon are absent:		SAVS =	4.195				
* The SAVS is multiplied by 1.5 due to the presence of state or federal T& E species							
Final SAVS =	6.29						
SVS(at) =	32.3675		OIL (at) =	2.3			
SVS (mi) =	31.5425		OIL (mi) =	5			
SVS (per) =	31.0175		OIL (per) =	5			
$/gallon =	0.1 x	[(OIL (at) x SVS (at)] +		[(OIL (mi) x SVS (mi)] +		[(OIL (per) x SVS (per)]	
=		74.44525		157.7125		155.0875	
=	$38.72						
	TOTAL $ =	**$3,650,522**					

	Marine/Estuarine Compensation Schedule - excluding Columbia River Estuary						
			VOLPE SC6JC				
Spill month	*Table Zone*	*Waterbody affected*	*Location*	*Amount Spilled (g)*	*Product Type*		
January	501	San Juan Islands	Bellingham Channel	3800000	Crude		
	HABITAT VULNERABILITY (HVS)						
	Marine Intertidal (MI) Habitats			Percent	Oil(ac)	Oil(mech)	Oil(pers)
MI-1	Exposed & semi-exposed rocky shores			0	3.7	4.3	3.1
MI-2	Sand-scoured rocky shores			0	3.3	3.8	2.7
MI-3	Protected rocky shores			0	3	3.5	3
MI-4	Semi-exp. cobble & mixed coarse beaches			0	3.2	3.2	3.2
MI-5	Semi-exposed gravel beaches			0	3.2	1.4	2
MI-6	Exposed sandy beaches			0	2.9	1.3	1.8
MI-7	Semi-protected mixed-fine beaches			0	3.2	2.6	3.7
MI-8	Protected mud flats - kelp/eelgrass			0	5.7	4.05	6.45
				0			
	Marine Subtidal (MS) Habitats						
MS-1	Shallow subtidal rock & boulder - kelp/eelgrass			0	5.55	5.55	4.65
MS-2	Deep subtidal rock and boulder			0	2.7	2.7	3.3
MS-3	Deep subtidal cobble & mixed coarse - kelp/eelgrass			0	2.25	3.3	3.3
MS-4	Shallow subtidal mixed-coarse to mixed fine - kelp/eelgrass			0	5.4	5.4	5.4
MS-5	Shallow subtidal gravel or mixed fine			0	2.8	1.6	2.3
MS-6	Deep subtidal sand			0	1.6	2	1.6
MS-7	Deep subtidal mixed-fine			0	1.5	2.6	3.1
MS-9	Open water - kelp			0	7.5	4.8	3.3
MS-9	Open water			0	5	3.2	2.2

	Estuarine Intertidal (EI) Habitats	Percent	Oil(ac)	Oil(mech)	Oil(pers)
EI-1	Open rocky shores	0	3	3.5	3
EI-1	Open rocky shores (k/eg)	2	4.5	5.25	4.5
EI-2	Open mixed-coarse beaches & low marsh	0	3.7	3.2	3.2
EI-2	Open mixed-coarse beaches & low marsh (k/eg)	3	5.55	4.8	4.8
EI-3	Open gravel beaches	2	3.4	1.5	2.2
EI-4	Open sandy beaches	2	3.3	2.8	2.3
EI-4	Open sandy beaches (k/eg)	1	4.95	4.2	3.45
EI-5	Sandy low marshes		3.5	3	3
EI-6	Mixed-fine beaches and low marshes		4.3	4.3	4.3
EI-7	Saline lagoons		3.7	3.7	4.1
EI-8	Low-salinity lagoons		3	3.5	3.9
EI-9	Mud flats	1	3.7	2.6	4.1
EI-9	Mud flats (kelp/eelgrass)	2	5.55	3.9	6.15
EI-10	High salt marshes	2	3	3.5	3.9
EI-11	Transition zone wetlands		3	3.5	3.9
	Estuarine Subtidal (ES) Habitats				
ES-1	Shallow subtidal rock and boulders		3.2	3.2	2.6
ES-2	Deep subtidal rock and boulders		2.3	2.3	2.8
ES-3	Shallow subtidal cobble and mixed-coarse	0	2.6	3.2	3.2
ES-4	Deep subtidal cobble and mixed-coarse	0	1.5	2.2	2.2
ES-5	Shallow subtidal sandy or mixed-fine	5	3.2	3.2	3.2
ES-6	Deep subtidal sandy or mixed-fine		2	2.4	2.8
ES-7	Shallow subtidal muddy bays		3	2.4	3.9
ES-7	Shallow subtidal muddy bays (kelp/eelgrass)	5	4.5	3.6	5.85
ES-8	Deep subtidal muddy bays		1.8	1.8	2.9
ES-9	Open water	75	5	3.2	2.2

* The individual habitat vulnerability score is multiplied by 1.5 due to the presence of seagrass or kelp

HVS(ac) =	4.783						
HVS (mech)	3.291						
HVS (pers) =	2.703						
BVS =	6	* The bird vulnerability score is multiplied by 1.5 when state or federal T& E species present					
MVS =	2						
MFVS =	5						
SFVS =	5						
RVS =	4						
SAVS:							
	Habitat type		%	Chinook - Subyr	Ch-sub (adjust)	Chinook - Y	Ch-yr (adjust)
	Intertidal - Rocky		2	1	0.02	1	0.02
	Intertidal - Cobble		3	1	0.03	2	0.06
	Intertidal - Gravel		2	2	0.04	2	0.04
	Intertidal - Sand (vegetated)		1	3	0.03	2	0.02
	Intertidal - Sand (unvegetated)		2	2	0.04	2	0.04
	Intertidal - Mud (vegetated)		2	3	0.06	2	0.04
	Intertidal - Mud (unvegetated)		1	3	0.03	2	0.02
	Subtidal		10	1	0.1	1	0.1
	Pelagic		75	3	2.25	3	2.25
	Total Score				2.6		2.59
	Habitat type		%	Pink	Pink (adjust)	Coho	Coho (adjust)
	Intertidal - Rocky		2	1	0.02	1	0.02
	Intertidal - Cobble		3	1	0.03	2	0.06
	Intertidal - Gravel		2	3	0.06	2	0.04
	Intertidal - Sand (vegetated)		1	5	0.05	4	0.04
	Intertidal - Sand (unvegetated)		2	3	0.06	3	0.06
	Intertidal - Mud (vegetated)		2	5	0.1	4	0.08
	Intertidal - Mud (unvegetated)		1	3	0.03	3	0.03
	Subtidal		10	1	0.1	1	0.1
	Pelagic		75	2	1.5	3	2.25
	Total Score				1.95		2.68

	Habitat type		%	Chum	Chum (adjust)	Sockeye	Sockeye (adj)
	Intertidal - Rocky		2	1	0.02	1	0.02
	Intertidal - Cobble		3	1	0.03	1	0.03
	Intertidal - Gravel		2	3	0.06	1	0.02
	Intertidal - Sand (vegetated)		1	5	0.05	1	0.01
	Intertidal - Sand (unvegetated)		2	3	0.06	1	0.02
	Intertidal - Mud (vegetated)		2	5	0.1	1	0.02
	Intertidal - Mud (unvegetated)		1	3	0.03	1	0.01
	Subtidal		10	1	0.1	1	0.1
	Pelagic		75	2	1.5	2	1.5
	Total Score				1.95		1.73
Pink salmon are absent:		SAVS =	2.211				
* The SAVS is multiplied by 1.5 due to the presence of state or federal T& E species							
Final SAVS =	3.32						
SVS(at) =	30.0995		OIL (at) =	0.9			
SVS (mi) =	28.6075		OIL (mi) =	3.6			
SVS (per) =	28.0195		OIL (per) =	5			
$/gallon =	0.1 x	[(OIL (at) x SVS (at)] +		[(OIL (mi) x SVS (mi)] +		[(OIL (per) x SVS (per)]	
=		27.08955		102.987		140.0975	
=	$27.02						
	TOTAL $ =	**$102,676,000**					

APPENDIX F
CHAPTER 6

TABLE F-1, PAGE 1

HAZARDS / UNIVERSAL MEASURES	COLL HOE	PGRND HOE	COLL OPS	PGRND ENV	COLL ENV	PGRND POSIT	PGRND VCON	DGRND VCON	DGRND HOE	COL VCON	PGRND OPS
UM1 - CREW PROFICIENCY AND VESSEL MANNING											
IMO											
STCW	x	x							x		
ISM	x	x							x		
Federal											
33 CFR 164.13 Navigation, Tankers. Bridge watch.	x	x							x		
46 CFR (B) - Merchant Marine Officers and Seamen	x	x							x		
OPA 91-211 Licensing and Registry	x	x							x		
Washington Administrative Code (WAC):											
317-21-230 & 317-21-320 Personnel Policies – Training & drills	x	x							x		
317-21-235 & 317-21-325, Drug and Alcohol Use.	x	x							x		
317-21-245 & 317-21-330, Work Hours.	x	x							x		
317-21-255 & 317-21-335, Record Keeping.	x	x							x		
317-21-260 & 317-21-340 Management. (Tankers & Tank Barges)	x	x							x		
317-21-315 Tow vessel crewing.	x	x							x		
317-21-250– Language proficiency.	x	x							x		
UM2 - SYSTEM REQUIREMENTS											
Federal											
33 CFR 26 - Bridge-bridge communications			x			x					x
46 CFR (D) - Tank vessels inspection, equipment requirements,							x	x		x	
Washington Administrative Code (WAC):											
317-21-265, GPS and two radar systems			x			x					x
UM3 - VESSEL SCREENING											
Federal											
46 CFR 4 - Marine casualties and Investigations.	x	x							x		
Washington Administrative Code (WAC):											
317-21-130 & -31-240 Event Reporting.	x	x							x		
317-21-540, etc, Advance notice of entry , safety reports	x	x							x		
317-21-550 & 317-31-250, Inspections and investigations	x	x							x		
317-21-560 Exceptional Compliance, incentives	x	x							x		
317-31-100 Vessel screening.	x	x							x		
317-31-210 Determination of substantial risk.	x	x							x		
317-31-300 Vessels posing substantial risk, denial of entry	x	x							x		
317-31-110 Advance Notice of Entry.	x	x							x		

TABLE F-1, PAGE 2

UNIVERSAL MEASURES / HAZARDS	COLL HOE	PGRND HOE	COLL OPS	PGRND ENV	COLL ENV	PGRND POSIT	PGRND VCON	DGRND VCON	DGRND HOE	COL VCON	PGRND OPS
UM4 - SYSTEMS STATUS, TESTING/INSPECTION AND											
Washington Administrative Code (WAC):											
317-21-210, Engineering							x	x		x	
317-21-215, Pre-arrival tests and inspections							x	x		x	
UM5 - VESSEL OPERATIONS											
IMO											
STCW						x					
COLREGS			x								x
Code of Federal Regulations (CFR):											
33 CFR 164.13 Navigation underway: tankers			x			x	x	x		x	x
33 CFR (D) - International navigation rules			x			x					x
33 CFR (E) - Inland navigation rules			x			x					x
OPA 91-202 Escorts for Certain Tankers								x	x		
Washington Administrative Code (WAC):											
317-21-200 & -300– Watch Practices (Tankers & Tank Barges),	x	x	x			x	x	x	x	x	x
317-21-205 & -305– Navigation procedures (tankers & tank barges)			x			x					x
UM6 - POSITIONAL INFORMATION											
Weather reporting by National Weather Service				x	x						
Aids to navigation by United States and Canadian Coast Guards				x	x	x					
UM7 - CENTRAL VESSEL CONTROL											
VTS by United States and Canadian Coast Guards			x	x	x	x					x
Traffic separation schemes			x	x	x	x					x
Federal											
33 CFR 150.313 Clearances for Tankers						x					
33 CFR 165.1301 Puget Sound Regulated Navigation Areas			x								x
33 CFR (P) - Ports and Waterways Safety						x					
UM8 - EMERGENCY PROCEDURES											
Washington Administrative Code (WAC):											
317-21-220 & 310 Emergency Procedures, tank vessels								x			
International tug of opportunity system								x			

APPENDIX G
CHAPTER 8

Contents

- List of potential measures for enhancing safety in Puget Sound

LIST OF POTENTIAL MEASURES FOR ENHANCING SAFETY IN PUGET SOUND

Explanation

This list has been compiled from several sources, including public meeting transcripts and available literature, and categorized into the "universal and non-universal measure" bins set up for the risk analysis. Where entries apply to multiple categories, they are placed in each and the pertinent portion of the cite appears in bold print. This list has not been screened and may contain items which conflict with each other and others which may serve to increase risk.

UM1- Crew proficiency and vessel manning

- Implementation of requirements that all vessels entering the Straits of Juan de Fuca meet the Standards of Training Certification and Watchstanding (STCW).(b)
- Work to establish minimum international training standards for prevention and response to incidents other than those already required under international conventions. (Fire, man overboard, abandon ship, and emergency steering are already required.) (b)
- Ensure these standards include preventative measures for all general causative risk elements of marine incidents (b)
- Improved training and higher qualifications for ships' crews (i)
- Simulator training for mariners responsible for tanker operations (both shop handling and engine room emergencies) (i)
- Bridge Team Management training for crew (j)
- Bridge Team Management training for pilots (j)
- Limitation of crew work hours, mandatory rest periods
- Two officers on bridge (including pilot)
- Improved certification of mariners (by vessel type, size, route)
- Two pilots on the bridge
- Adoption of ISO 9000
- Manned engine room (c)
- Improve English proficiency (h)
- Qualify fishermen in Rules of the Road and Stability (future) (h)
- Establish watch and duty time limitations for crew members on board inspected passenger vessels (j)
- Enforce 46 USC 8104(a) to ensure watch officers during departures from ports have at least 6 hours of off-duty time in previous 12 hours
- Establish international emergency training standards for passenger ship crew members(j)

- Establish international firefighting training standards for passenger ship crew members(j)
- IMO require more realistic crew emergency drills for passenger ships (j)
- Require all licensed deck officers on board vessels equipped with ARPA be certified in their use (j)
- Require all first class pilots on board vessels equipped with ARPA become knowledgeable in operation of ARPA systems (j)
- Require people assigned to firefighting teams be trained in proper firefighting procedures and emergency equipment use (j)

UM2- System requirements

- Work within the International Maritime Organization to establish location and vessel type identification transponder requirements for all vessels over a certain size traveling within certain limits of shore.(a)(b)
- Integrated Bridge management systems
- ECDIS (c)
- GPS, DGPS (c)
- GPS transponders (h)
- CAS (c)
- Expert bridge systems (c)
- Thrusters (c)
- Twin Screws (c)
- Operation of emergency generator (c)
- Electronic charts - standards (h)
- National distress system (VHF radio) (h)
    - New internal standard - digital secret calling
- International standards long term (communications) (h)
- US/Canada short term standards (communications) (h)
- AIS technology (particularly for areas with minimal VTS coverage) (h)
- Fishing gear better marked (h)
- Proper navigation lights for fishing vessels (h)
- Mandatory trailing towlines for barges (i)
- Mandatory use of twin screw tugs for oil barges (i)
- Review and re-evaluate basis for stability criteria in 46 CFR 170.170 (maximum wind speeds) (j)
- Remove fault/ground (monitoring system) cut-out of emergency diesel engine (j)
- Require fire control system on tank vessels to have individual controls in protected fire control room for each monitor (j)
- Establish requirements for foam monitors aft of cargo block on tank vessels (j)
- Require installation of valved pressure gage to indicate operating pressure at discharge of each hydraulic steering gear pump on self-propelled vessels > 1600 gross tons (j)

- Require sensor to indicate power units not responding to rudder command from wheelhouse controls on self-propelled vessels > 10,000 gross tons (j)
- Require commercial tugs and towboats operating on navigable waters of U.S. be equipped with suitable compass (j)
- Require vessels install spray shields between lube and fuel oil strainers and potential ignition sources (j)

<u>UM3- Vessel screening</u>

- Screen for high risk vessels and require them to engage a tug escort as a condition of entry.(a)
- Expand existing trend analysis within the Cooperative VTS to include more specific vessel profile data. Ensure the expansion defines and captures "near miss" data.(b)
- Denial of vessel entry due to screening
- Improve coordination between U.S./Canada port state control measures (h)
- Provide port state incentives (Green Award) (h)

<u>UM4- Systems status, testing/inspection, and checks</u>

- Require a regulatory project for annual reporting of all voluntary Tug of Opportunity Systems and a provision for retention of certain minimum documents and availability for examination upon demand by the U.S. Coast Guard.(b)
- Require minimum levels of programmed maintenance for all vessels entering the Straits based upon failure rate trend analysis and active interaction with Classification Societies.(b)
- Modify applicability of pre-arrival and pre-departure tests under 33CFR164 to include all vessels over 300 gross tons (International Tonnage Convention).(b)
- Increase the level of boardings for the purpose of conformance checks for all incoming vessels under 33CFR164.(b)
- Exclude the high risk segment of industry from operation within the port region if a risk analysis demonstrates a sufficient need.(b)
- Hold vessel at dock due to deficiencies or require vessel to correct deficiencies prior to sailing
- Require inspection for first time arrivals in Port Angeles (h)
- Establish a Coast Guard Marine Safety Office in Port Angeles.(a)
- Enhanced inspection of aging TAPS fleet tankers (h)
- MSOs in Neah Bay and Port Angeles (add field personnel, not transfer from MSO Puget Sound) (h)
- Expand the Waterways Management Study in the region to periodic review of the entire Marine Safety Regime within the area; this could be undertaken with the Canadian Government.(b)

UM5-. Vessel operations

- Restricting use of auto pilot (c)
- Hydrostatic loading
- Align military vessel with public/private discharge requirements (h)
- Encourage USN compliance with bridge to bridge communications (h)
- Encourage USN compliance with state regulations (h)
- Notice to Mariners (regulatory guidelines on when/where to shift fuels/future) (h)
- Elimination of multiple tows for oil barges (i)
- Shipmasters and mooring masters conduct pre-arrival and pre-departure conference to discuss plan, environment, etc. before mooring
- Rescind requirement to simultaneously operate main steering gear power units (j)
- Require pre-departure and pre-arrival steering gear tests be done while operating each steering gear pump individually (j)
- Rescind IMO requirement for simultaneous operation of all main steering gear pumps where navigation requires special caution (j)
- Incorporate IMO Resolution A.601(15), "Provision and Display of Maneuvering Information on Board Ships" into the SOLAS Convention (j)
- Develop standard phraseology that adheres to inland navigation rules and encourage vessel operators to use it when arranging passing (j)
- Require companies conducting anchor handling activities in vicinity of submarine pipelines to require specific information as to location of pipelines and other known hazards prior to conducting anchor handling activities (j)

UM6- Positional information and weather reporting

- Real time weather, sea state, current, etc. information (h)
- Improve charts, including electronics (h)

UM7- Central vessel locational monitoring and control

- Expand existing trend analysis within the Cooperative VTS to include more specific vessel profile data. Ensure the expansion defines and captures "near miss" data.(b)
- Vessel tracking systems (h)
- VTS coverage area - expand and improve (h)
- Improve coordination between US/Canada port state control measures (h)
- Improve control of presently unregulated traffic, e.g., compliance w/rules of road, training for operators, enforcement of radio frequency regulations (h)
- Haro Strait measures similar to Rosario Strait, e.g, weather limits on transits and no bypass one-way via Haro for tankers bound for Rosario (h)
- Regulate/enforce regulations on small boats (h)

- Fishing management (control of fishing, e.g., where set nets) (h)

<u>UM8- Emergency procedures</u>

- Require vessels to have on-board Emergency Towing equipment.(a)
- Require 'Fly Away' Emergency Towing Packages for all vessels (a)
- Require tugs that are in the ITOS to be equipped with Shoulder Line Throwing Guns.[1] (a)
- Mandatory towing equipment for tankers and pick up lines for barges
- Remote controlled anchor system for barges
- Training for cargo vessel crews on emergency towing (e)
- Strategy for "save" of laden tanker in "upper range of weather conditions" (g)
- Require masters to operate installed inert gas systems when carrying Grade E products (j)
- USCG review fire contingency plans for all U.S. ports (j)

<u>UM9- Outflow mitigation</u>

- Hydrostatic loading

<u>UM10- Spill response planning and capability</u>

- List and Identify tugs suitable for offshore response in severe weather.(a)
- Institute response plans for all vessel types,
- Identify/assure availability of competent marine salvage operations i.e., fire fighting, containment, emergency towing, damage control, strandings, de-watering, product lightering (h)
- Evaluate advanced technology, e.g., in situ burning (h)
- Verify ongoing capability of spill management (h)
- Navy salvage equipment should accompany Navy growth in Puget Sound (h)

UM11- Financial responsibility/liability

UM 12- Government actions/incentives

- Investigate Jones Act as disincentive (h)
- Enforcement capacity (h)
- Speed up regulatory process (h)
- Implement Fatal Accident Reporting System comparable to NHTSA's (j)
- Verify crew competence and company pre-planning for emergencies (j)

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[1] Guns facilitate the making of a towing connection.

NM1-. Bridge manning: crew and pilot

- Require Pilots for laden tankers.(a)
- Require escorts, **pilots**, better coastal response capabilities, dead weight ton limits, speed limits, and weather restrictions to the area of the Sound west of Port Angeles.[2] (a)

NM2- Traffic controls

- Extend the Traffic Separation Scheme to Offshore.(a)
- Move the Line of Demarcation between Sub-area 3 and Sub-area 4 Westward at least 10 miles to the end of the Traffic Separation Scheme.[3] (a)

NM3- Special areas

- Revisit/Revise the boundary and regulations of the ATBA.(a)
- Look at modifications to ATBA (h)
- Clarify designation of Straits of Juan de Fuca as that of internal waters of U.S./Canada.(a)
- Use of stationary tugs at critical points in transit (c)
- Extend Magnuson Line to "J" Buoy (h)

NM4- Activity restrictions

- Set **weather, speed**, and size operating **limits** through the Straits of Juan de Fuca.(a)
- Require escorts, pilots, better coastal response capabilities, dead weight ton limits, **speed limits, and weather restrictions** to the area of the Sound west of Port Angeles.[4] (a)
- Operating restrictions due to weather conditions.(a)
- Monitor and Enforce the ATBA.(a)
- Specific Requirements for vessels and tugs allowed to go off-shore in severe weather.[5](a)
- Institute speed and wake restrictions on transits (h)

---

[2] To be done to bring the outer Strait of Juan De Fuca and the Olympic Coast up to par with the standards of marine safety that the rest of Puget Sound has set.(a)

[3] This would accommodate an additional two to three hours of drift for a vessel disabled in the approaches of the Straits of Juan de Fuca.(a)

[4] To be done to bring the outer Strait of Juan De Fuca and the Olympic Coast up to par with the standards of marine safety that the rest of Puget Sound has set.(a)

[5] Requirements would increase the safety of the crews and vessels.(a)

NM5- Speed limits

- Require escorts, pilots, better coastal response capabilities, dead weight ton limits, **speed limits**, and weather restrictions to the area of the Sound west of Port Angeles.[6] (a)
- Set weather, **speed**, and size operating **limits** through the Straits of Juan de Fuca.(a)

NM6- Operator SOPs

NM7- VTS

- Extend Cooperative VTS radar coverage.(a)
- Modify Vessel Traffic System Puget Sound capabilities with software which allows identification of disabled vessel profiles and initiates a warning to the watchstander.(b)
- Improve the technology of the VTS in the Sound.(a)
- Modify VTS and tugs routinely transiting the area to allow identification paint while transiting the area.(b)
- VTS management of tankers and fishing vessel concentrations (g)
- Look at modifying Traffic Separation Scheme (h)
    - Approaches to Strait (Canada Tanker Exclusion Zone, USN Op. Area)
    - Port Angeles area
    - Dog-leg
- Establish VTS operator skill/knowledge standards

NM8- AtoN

- Mark the Pinnacles of the entrance to Neah Bay.(a)
- Increase the intensity of the RACON on Buoy J.(d)
- Require bridges vulnerable to impact by commercial marine traffic bear unique, readily visible markings (j)

NM9- Tanker size limit

- Set weather, speed, and size operating limits through the Straits of Juan de Fuca.(a)

[6] To be done to bring the outer Strait of Juan De Fuca and the Olympic Coast up to par with the standards of marine safety that the rest of Puget Sound has set.(a)

NM10- Tug Escorts

- Require Rescue Tugs and/or Tug Escorts for laden tanker traffic through the Entire Straits of Juan de Fuca.(a)
- Require Tug Escorts on vessels going through the Haro Strait to Canada.(a)
- Extend tanker escorts to Cape Flattery since the population of suitable tugs in these areas is not sufficient to meet the response time criteria in the C.G. Interim ITOS report.(d)
- Require Rescue Tugs and/or Tug Escorts for laden tanker traffic throughout their In-shore Transits.[7] (a)
- Appropriate U.S. Coast Guard owned and operated or leased escort tugs in the area for the Strait of Juan de Fuca.(b)
- Enforce/Use of Tugs in the existing Double Tug Escort Rule.[8] (a)
- Extend westward the waters where oil tankers must have Tug Escorts (perhaps to the J buoy).[9] (a)
- Extend tanker escorts as far as the Juliet buoy.(a)
- Increase Tug Escorts between J buoy and Port Angeles.(d)
- Screen for high risk vessels and require them to engage a Tug Escort as a condition of entry.(a)
- Require **escorts**, pilots, better coastal response capabilities, dead weight ton limits, speed limits, and weather restrictions to the area of the Sound west of Port Angeles.[10] (a)
- Use of adequately powered tugs at critical points in transits (c)
- **Tug escorts for double hulled tankers**
- **Tug escorts for tank barges**
- Account for technological developments (large tractor tugs) in two-tug requirement (h)
- Tug escorts for tankers in Haro Strait
- Require towlines on coastwise and ocean towing vessels that tow barges carrying petroleum products or Hazmat in bulk be inspected and certified periodically (j)

---

[7] And require that the rescue capability of these tugs be determined by size of tankers and weather conditions.(a)

[8] OPA 90 rule that applies to laden single hull tankers larger than 5,000 gross tons.(a)

[9] Escort tug requirements could be explored under an act other than the Oil Pollution Act of 1990 (OPA 90) in order to allow single tug escorts and to evaluate the possibility of their application to vessels other than tankers. Under OPA 90 this only applies to laden tankers. The existing escort regulations do not allow escort tugs engaged in escort to divert to assist non-tankers in distress.(b)

[10] To be done to bring the outer Strait of Juan De Fuca and the Olympic Coast up to par with the standards of marine safety that the rest of Puget Sound has set.(a)

NM11- ITOS

- ITOS (International Tug of Opportunity System)[11] (a)
- **Mandatory ITOS participation (e)**
- **Coast Guard VTS authority to order use of ITOS (f)**
- Adopt the Crash Stop Performance Criteria for ITOS tugs.(a)

NM12- Rescue tug

- Require Dedicated Tugs.(a)
- Require Rescue Tugs and/or Tug Escorts for laden tanker traffic through the Entire Straits of Juan de Fuca.(a)
- Require Rescue Tugs and/or Tug Escorts for laden tanker traffic throughout their In-shore Transits.[12] (a)
- Establish alternated U.S. Canadian harbor patrols throughout the region of interest and establish a cooperative agreement for this purpose with a vessel capable of response to disabled vessels of the largest size entering the port.(b)
- Provide a dedicated assist or salvage vessel at Neah Bay.[13] (b)
- Require towlines on coastwise and ocean towing vessels that tow barges carrying petroleum products or HAZMAT in bulk be inspected and certified periodically (j)

NM13-. Local response measures

- Deploy a vessel stationed in Neah Bay to deploy and do spill response work at the Separation Scheme which C.G. finds to be the most difficult sector to manage in the entire 13th District.(d)
- Position a pollution response vessel at a critical environmentally sensitive location for optimum response. Take account of the lessons learned in the Prince William Sound Study which is soon to be released.(b)

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[11] Section 401 of the Alaska Power Administration Asset Sale and Termination Act, Nov. 28, 1995, PL 104-58, directs the Coast Guard to submit a plan to Congress on the most cost-effective means of implementing an international private-sector tug of opportunity system. Such a system will be a voluntary private-sector system. The plan is to include a coordinated system of communication, using existing tugs (that may already be towing other vessels) to provide timely emergency response to a vessel in distress transiting the waters within the boundaries of the Olympic Coast Marine Sanctuary and the Strait of Juan de Fuca.

[12] And require that the rescue capability of these tugs be determined by size of tankers and weather conditions.(a)

[13] This will prevent drift groundings for most vessels in waters at the entrance to the Strait, the western portion of the Strait and the northern Washington coast. It appears that it would have no impact on the eastern end of the Strait due to the substantial transit from the western entrance of the Strait to the eastern end of the Strait, on the order of 80 nautical miles.(b)

- Oil spill response off coast and in Strait of Juan de Fuca (improve time and capability) (h)
- Require dedicated vessel for deploying pre-positioned skimmers, booms, and other containment equipment.(a)
- Require escorts, pilots, **better coastal response capabilities**, dead weight ton limits, speed limits, and weather restrictions to the area of the Sound west of Port Angeles.[14] (a)

Sources of Proposed Measures for Enhancing Safety in Puget Sound:

(a) U.S. Coast Guard, "U.S. Coast Guard Public Meeting on the International Private-Sector Tug of Opportunity System for the Waters of the Olympic Coast National Marine Sanctuary and the Strait of Juan de Fuca", October 17, 1996 (Jackson Federal Building, Seattle, Washington).
(b) U.S. Coast Guard, Report To Congress "International Private-Sector Tug of Opportunity System for the Waters of the Olympic Coast National Marine Sanctuary and the Strait of Juan de Fuca", Draft, December 10, 1996, pp. 73-75.
(c) State of Washington, Office of Marine Safety, "Evaluating and Monitoring Maritime Risk, The Development of a Vessel Risk Model for Puget Sound and the Straits of Juan de Fuca", Draft Final Report, January 1994, Table 10, p. 28 (Table 10 originally appeared in BC/States Task Force Reports, Washington OMS Advisory Committee Reports, USCG Tanker Study, MOB First Report).
(d) U.S. Coast Guard, "U.S. Coast Guard Public Meeting on the International Private-Sector Tug of Opportunity System for the Waters of the Olympic Coast National Marine Sanctuary and the Strait of Juan de Fuca", November 26, 1996 (7600 Sand Point Way Northeast, Seattle, Washington, both the 9:00 a.m. and the 6:00 p.m. meetings).
(e) Washington OMS letter to Coast Guard G-LRA/3406, 6/28/96
(f) Conversation w/VTS Seattle personnel
(g) Similar to recommendation of Prince William Sound Risk Study
(h) Public workshop, Seattle, Washington, 6 March 1997.
(i) Appendix V of the Final Report of the States/BC Oil Spill Task Force, "Prevention Alternatives Subcommittee Technical Report", 1990.
(j) National Transportation Safety Board recommendations to U.S. Coast Guard, pending file.

#

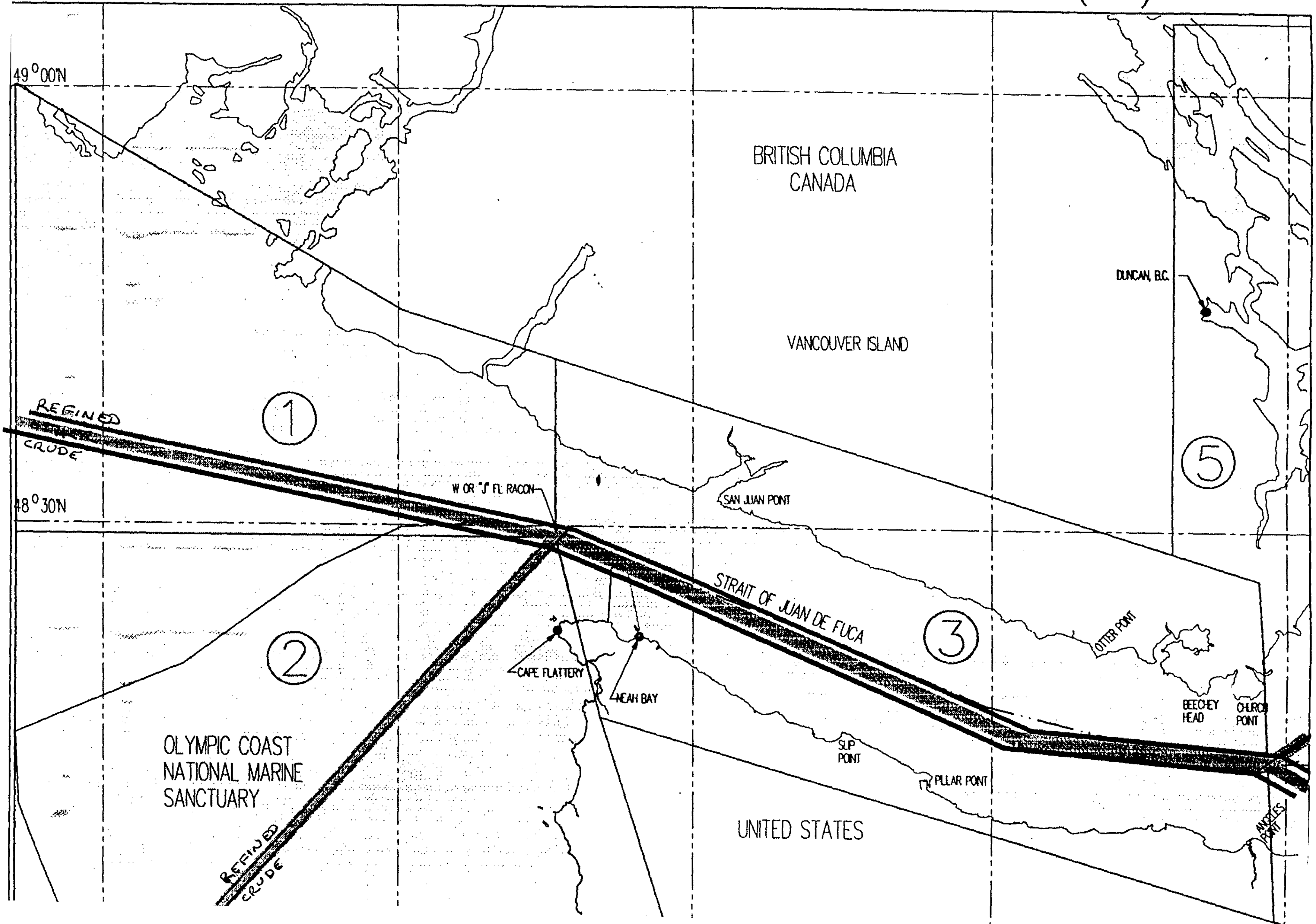
[14] To be done to bring the outer Strait of Juan De Fuca and the Olympic Coast up to par with the standards of marine safety that the rest of Puget Sound has set.(a)

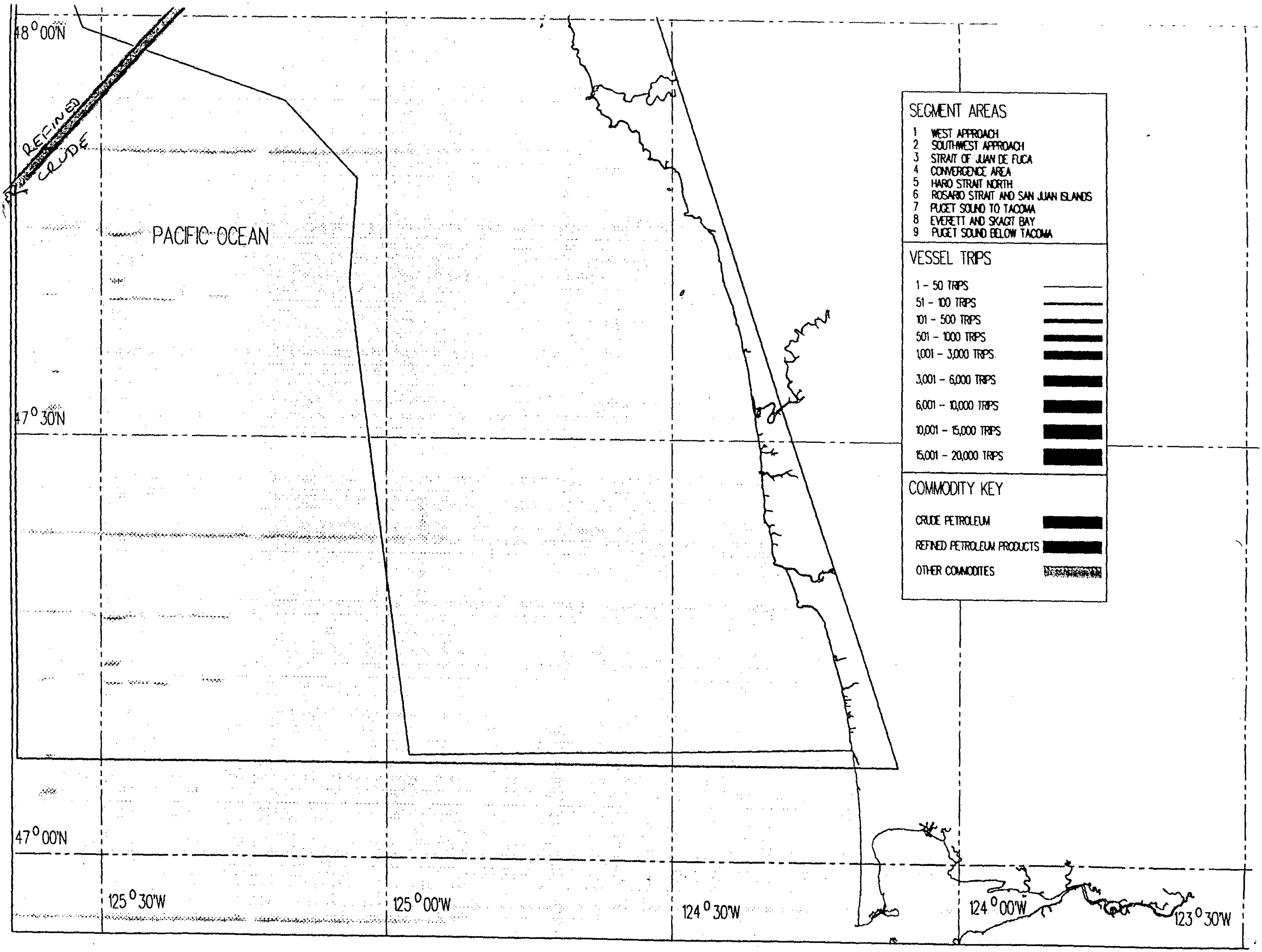
Appendix H: Chartlets

Contents:

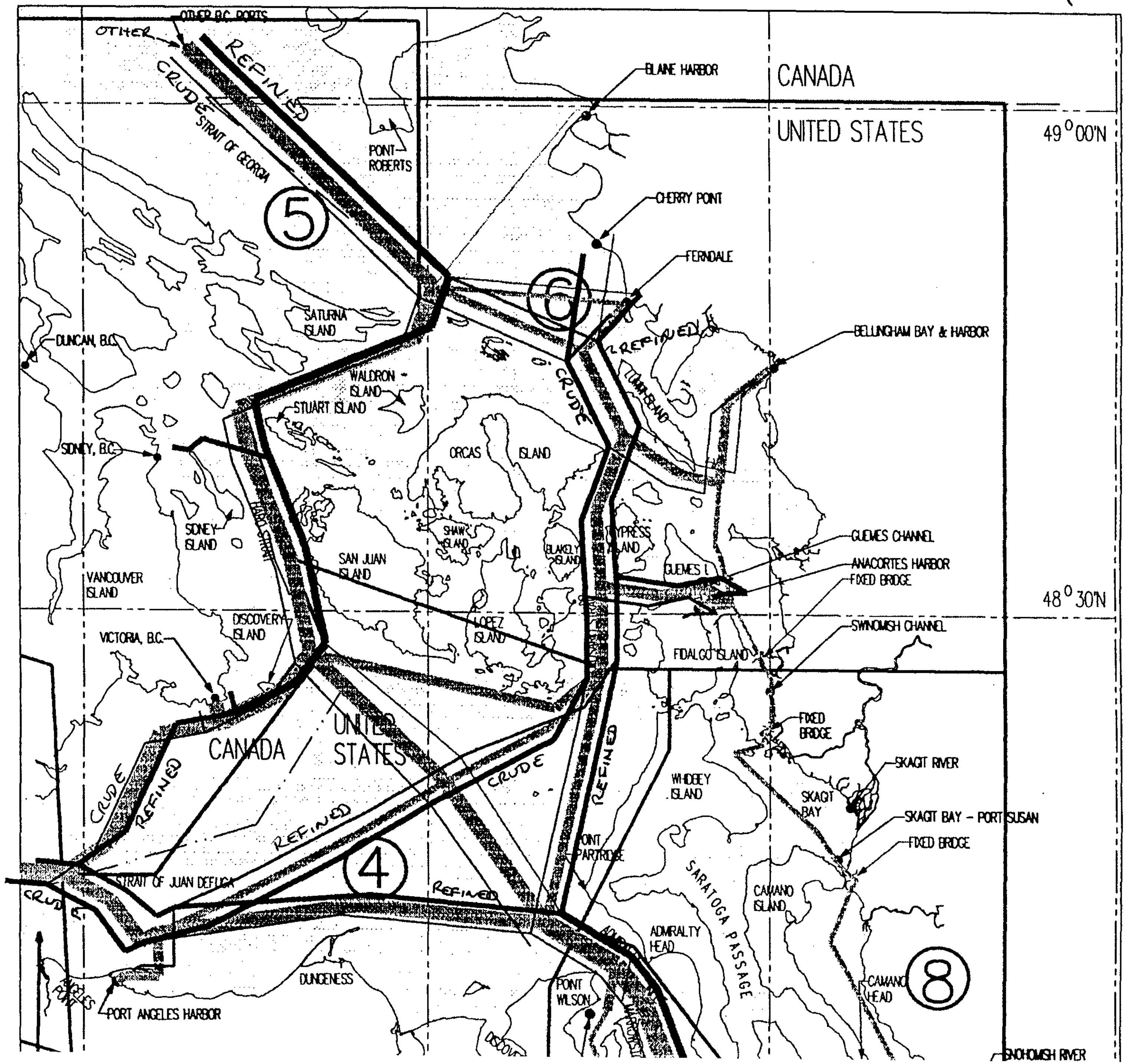
- Vessel Trips by Commodity
- Petroleum Tonnage by Commodity
- Passenger Vessel Trips
- Casualties and Spills by Accident Type
- Casualties and Spills by Vessel Type

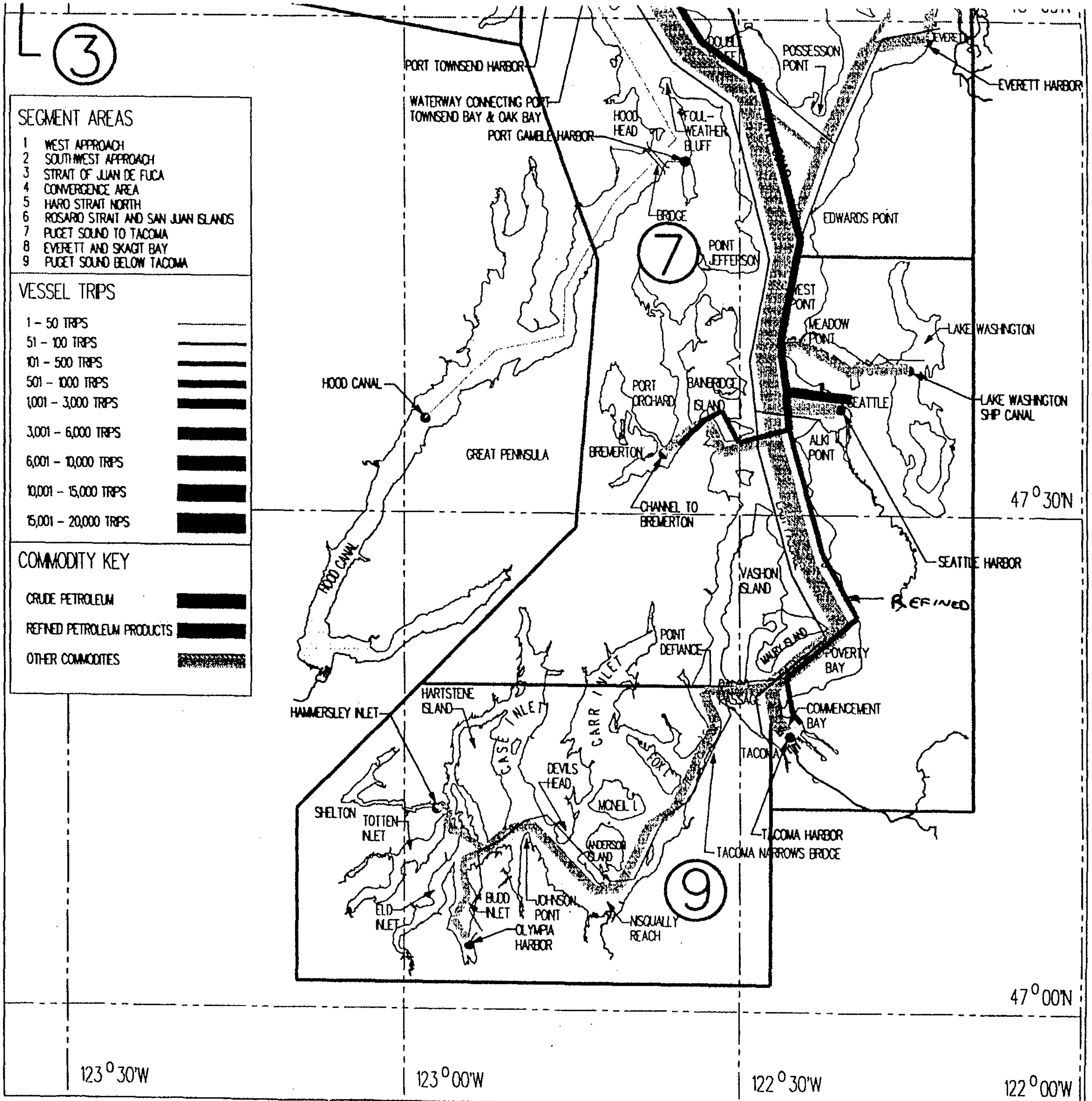
CHARTLET 3-1 VESSEL TRIPS BY COMMODITY (1/2)



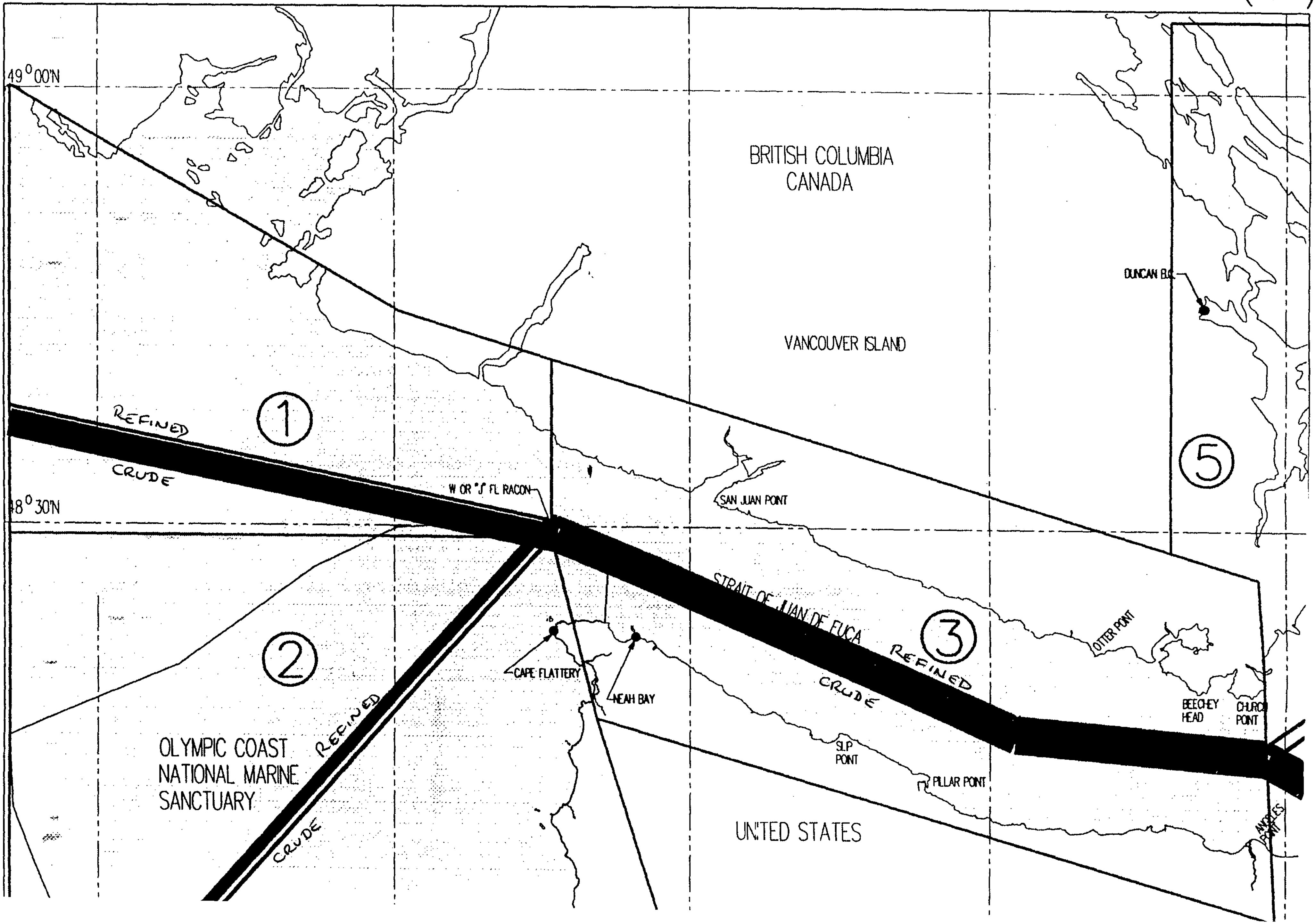

48° 00'N
47° 30'N
47° 00'N
125° 30'W
125° 00'W
124° 30'W
124° 00'W
123° 30'W
PACIFIC OCEAN
REFINED
CRUDE
SEGMENT AREAS
1 WEST APPROACH
2 SOUTHWEST APPROACH
3 STRAIT OF JUAN DE FUCA
4 CONVERGENCE AREA
5 HARO STRAIT NORTH
6 ROSARIO STRAIT AND SAN JUAN ISLANDS
7 PUGET SOUND TO TACOMA
8 EVERETT AND SKAGIT BAY
9 PUGET SOUND BELOW TACOMA
VESSEL TRIPS
1 - 50 TRIPS
51 - 100 TRIPS
101 - 500 TRIPS
501 - 1000 TRIPS
1,001 - 3,000 TRIPS
3,001 - 6,000 TRIPS
6,001 - 10,000 TRIPS
10,001 - 15,000 TRIPS
15,001 - 20,000 TRIPS
COMMODITY KEY
CRUDE PETROLEUM
REFINED PETROLEUM PRODUCTS
OTHER COMMODITIES

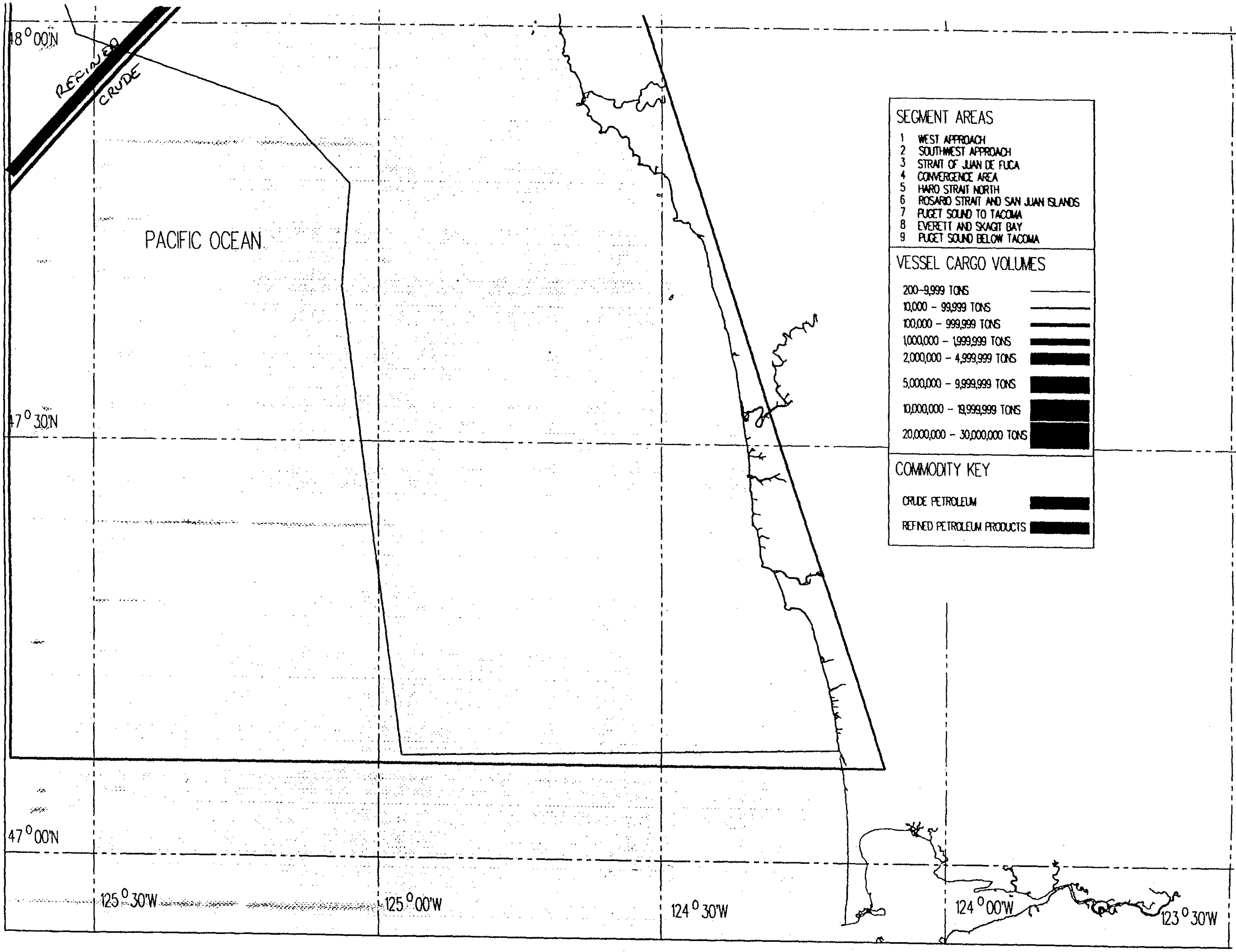
CHARTLET 3-1 VESSEL TRIPS BY COMMODITY (2/2)




3
SEGMENT AREAS
1 WEST APPROACH
2 SOUTHWEST APPROACH
3 STRAIT OF JUAN DE FUCA
4 CONVERGENCE AREA
5 HARO STRAIT NORTH
6 ROSARIO STRAIT AND SAN JUAN ISLANDS
7 PUGET SOUND TO TACOMA
8 EVERETT AND SKAGIT BAY
9 PUGET SOUND BELOW TACOMA
VESSEL TRIPS
1 - 50 TRIPS
51 - 100 TRIPS
101 - 500 TRIPS
501 - 1000 TRIPS
1,001 - 3,000 TRIPS
3,001 - 6,000 TRIPS
6,001 - 10,000 TRIPS
10,001 - 15,000 TRIPS
15,001 - 20,000 TRIPS
COMMODITY KEY
CRUDE PETROLEUM
REFINED PETROLEUM PRODUCTS
OTHER COMMODITIES
PORT TOWNSEND HARBOR
WATERWAY CONNECTING PORT TOWNSEND BAY & OAK BAY
PORT GAMBLE HARBOR
HOOD HEAD
FOUL-WEATHER BLUFF
POSSESSION POINT
EVERETT HARBOR
EDWARDS POINT
BRIDGE
7
POINT JEFFERSON
WEST POINT
MEADOW POINT
LAKE WASHINGTON
LAKE WASHINGTON SHIP CANAL
SEATTLE
ALKI POINT
PORT ORCHARD
BAINBRIDGE ISLAND
HOOD CANAL
GREAT PENINSULA
BREMERTON
CHANNEL TO BREMERTON
47° 30'N
SEATTLE HARBOR
VASHON ISLAND
REFINED
POINT DEFIANCE
MAURY ISLAND
POVERTY BAY
CARR INLET
HARTSTENE ISLAND
CASE INLET
HAMMERSLEY INLET
COMMENCEMENT BAY
TACOMA
FOX I.
DEVILS HEAD
MCNEIL I.
ANDERSON ISLAND
SHELTON
TOTTEN INLET
TACOMA HARBOR
TACOMA NARROWS BRIDGE
9
BUDD INLET
JOHNSON POINT
ELD INLET
OLYMPIA HARBOR
NISQUALLY REACH
47° 00'N
123° 30'W
123° 00'W
122° 30'W
122° 00'W

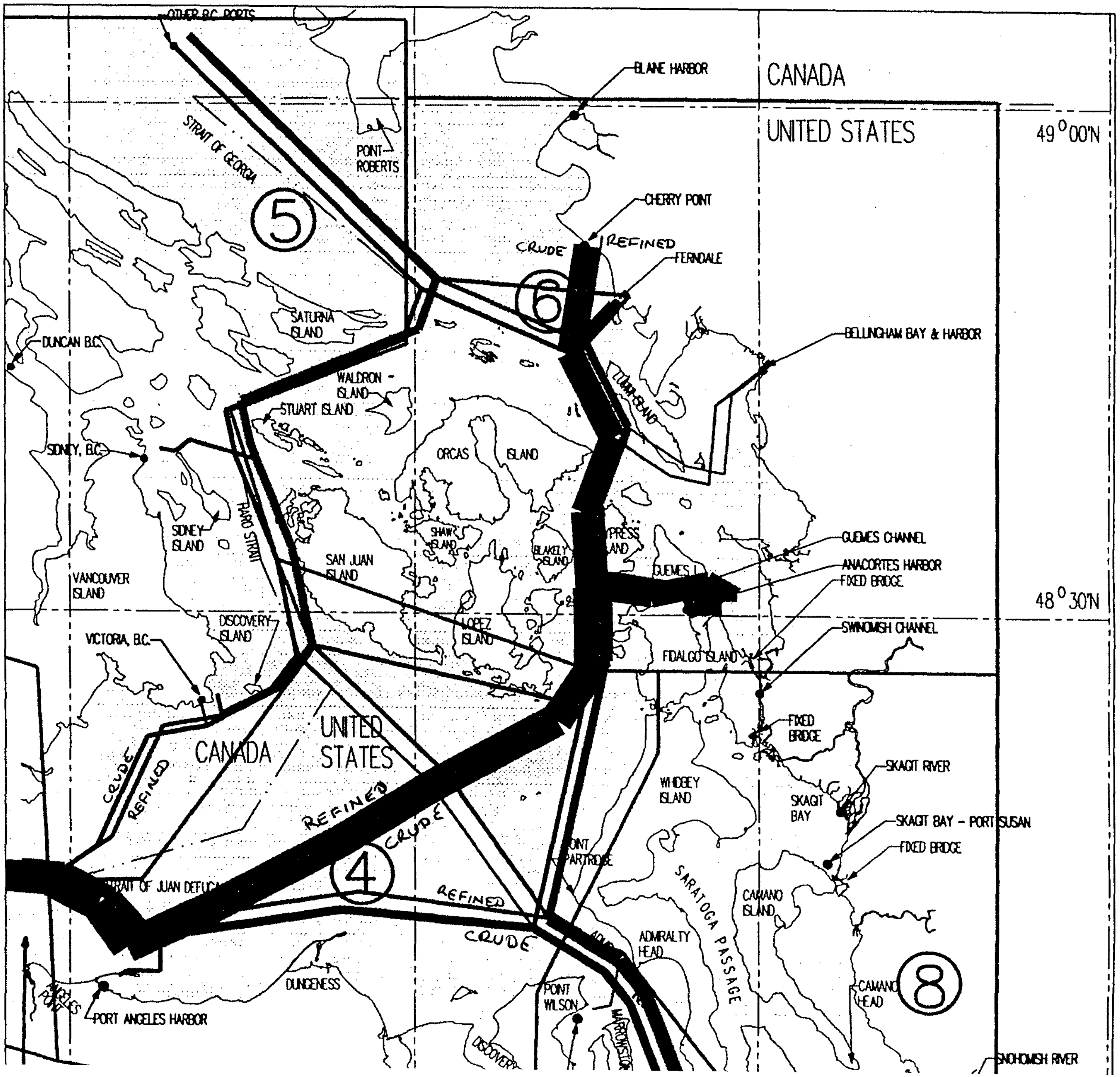
CHARTLET 3-2 PETROLEUM TONNAGE MOVED BY COMMODITY (1/2)

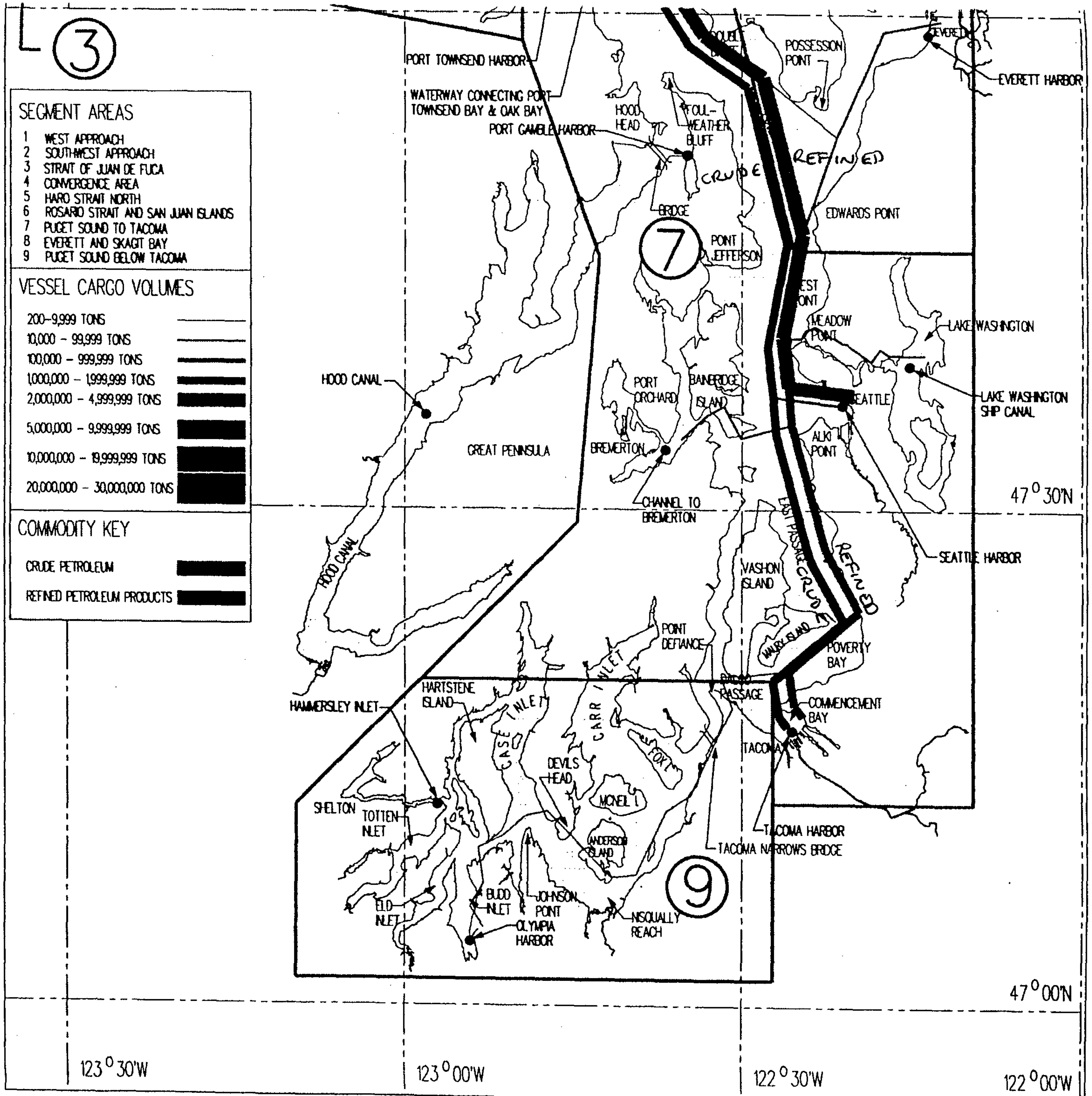




48° 00'N
REFINED
CRUDE
PACIFIC OCEAN
47° 30'N
47° 00'N
125° 30'W
125° 00'W
124° 30'W
124° 00'W
123° 30'W
SEGMENT AREAS
1 WEST APPROACH
2 SOUTHWEST APPROACH
3 STRAIT OF JUAN DE FUCA
4 CONVERGENCE AREA
5 HARO STRAIT NORTH
6 ROSARIO STRAIT AND SAN JUAN ISLANDS
7 PUGET SOUND TO TACOMA
8 EVERETT AND SKAGIT BAY
9 PUGET SOUND BELOW TACOMA
VESSEL CARGO VOLUMES
200-9,999 TONS
10,000 - 99,999 TONS
100,000 - 999,999 TONS
1,000,000 - 1,999,999 TONS
2,000,000 - 4,999,999 TONS
5,000,000 - 9,999,999 TONS
10,000,000 - 19,999,999 TONS
20,000,000 - 30,000,000 TONS
COMMODITY KEY
CRUDE PETROLEUM
REFINED PETROLEUM PRODUCTS

CHARTLET 3-2 PETROLEUM TONNAGE MOVED BY COMMODITY (2/2)




3
SEGMENT AREAS
1 WEST APPROACH
2 SOUTHWEST APPROACH
3 STRAIT OF JUAN DE FUCA
4 CONVERGENCE AREA
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VESSEL CARGO VOLUMES
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10,000 - 99,999 TONS
100,000 - 999,999 TONS
1,000,000 - 1,999,999 TONS
2,000,000 - 4,999,999 TONS
5,000,000 - 9,999,999 TONS
10,000,000 - 19,999,999 TONS
20,000,000 - 30,000,000 TONS
COMMODITY KEY
CRUDE PETROLEUM
REFINED PETROLEUM PRODUCTS
PORT TOWNSEND HARBOR
WATERWAY CONNECTING PORT TOWNSEND BAY & OAK BAY
PORT GAMBLE HARBOR
HOOD HEAD
FOUL-WEATHER BLUFF
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REFINED
BRIDGE
EDWARDS POINT
7
POINT JEFFERSON
MEADOW POINT
LAKE WASHINGTON
HOOD CANAL
PORT ORCHARD
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SEATTLE
LAKE WASHINGTON SHIP CANAL
GREAT PENINSULA
BREMERTON
ALKI POINT
47° 30'N
CHANNEL TO BREMERTON
EAST PASSAGE
SEATTLE HARBOR
VASHON ISLAND
POINT DEFIANCE
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POVERTY BAY
HARTSTENE ISLAND
PASSAGE
COMMENCEMENT BAY
HAMMERSLEY INLET
CASE INLET
CARR INLET
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DEVILS HEAD
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SHELTON
TOTTEN INLET
ANDERSON ISLAND
TACOMA HARBOR
TACOMA NARROWS BRIDGE
9
BUDD INLET
JOHNSON POINT
ELD INLET
OLYMPIA HARBOR
NISQUALLY REACH
47° 00'N
123° 30'W
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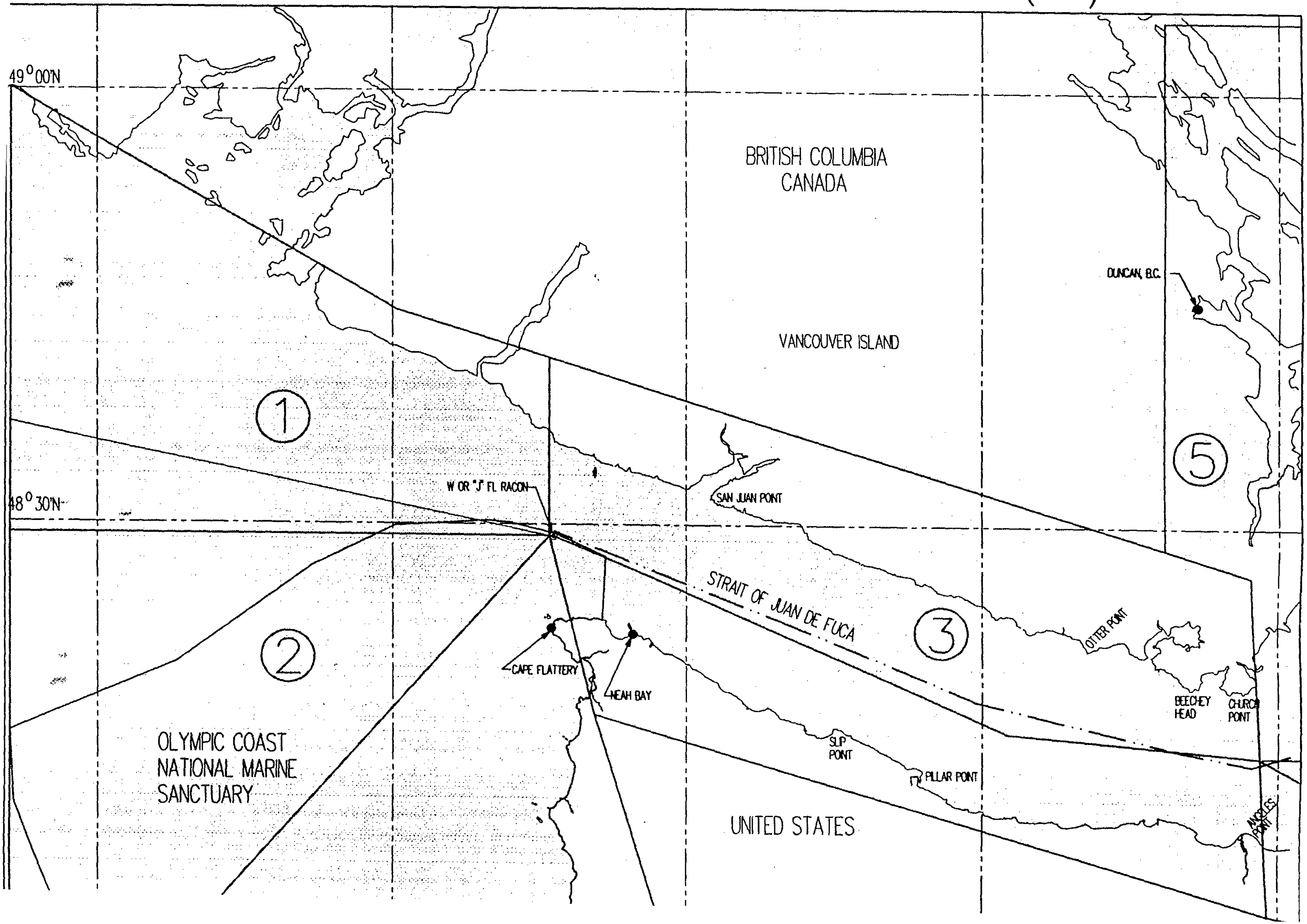
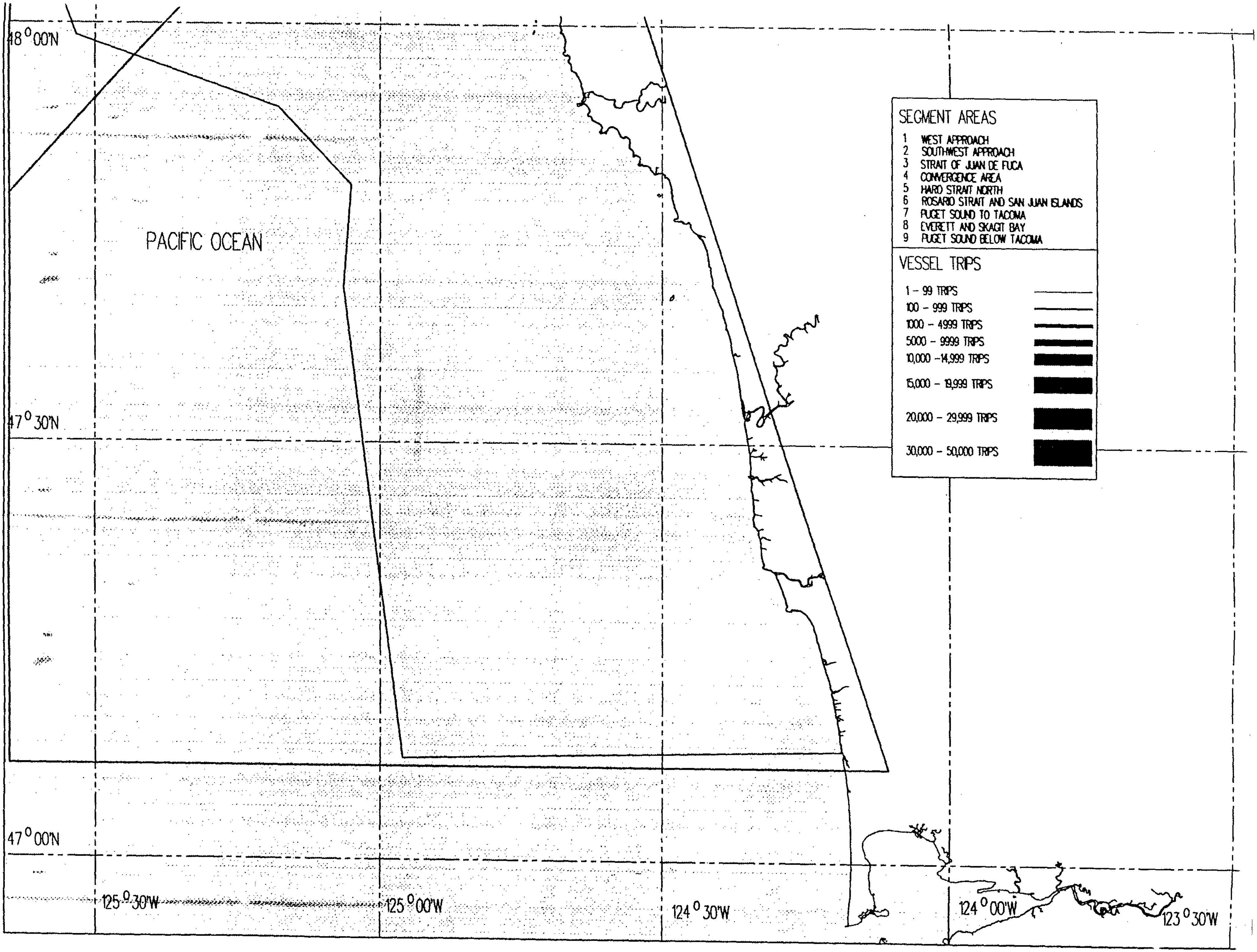
122° 30'W
122° 00'W

CHARTLET 3-3 PASSENGER VESSEL TRIPS (1/2)





48° 00'N
47° 30'N
47° 00'N
125° 30'W
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124° 30'W
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PACIFIC OCEAN
SEGMENT AREAS
1 WEST APPROACH
2 SOUTHWEST APPROACH
3 STRAIT OF JUAN DE FUCA
4 CONVERGENCE AREA
5 HARO STRAIT NORTH
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8 EVERETT AND SKAGIT BAY
9 PUGET SOUND BELOW TACOMA
VESSEL TRIPS
1 - 99 TRIPS
100 - 999 TRIPS
1000 - 4999 TRIPS
5000 - 9999 TRIPS
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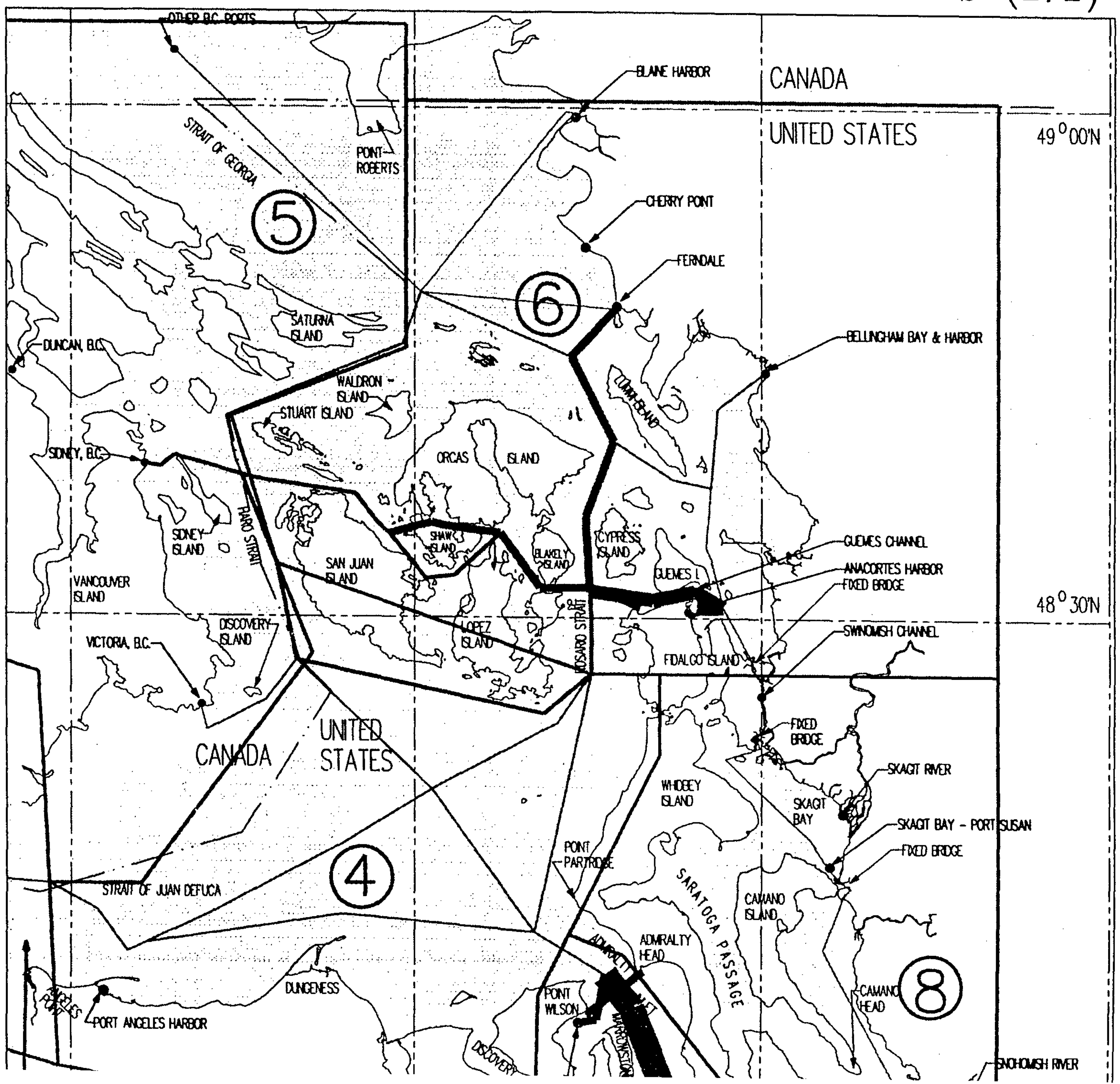
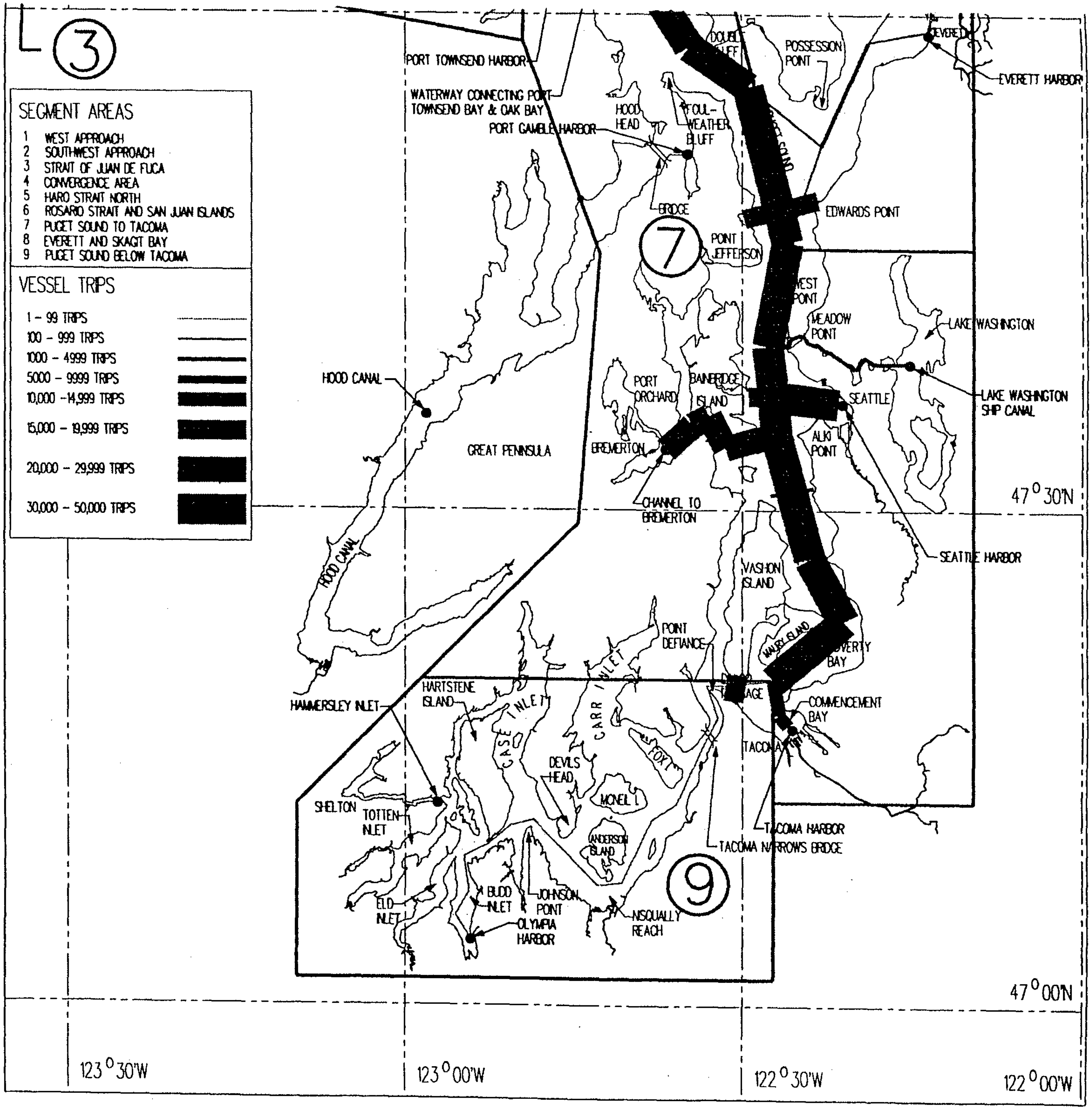
15,000 - 19,999 TRIPS
20,000 - 29,999 TRIPS
30,000 - 50,000 TRIPS

CHARTLET 3-3 PASSENGER VESSEL TRIPS (2/2)





L 3
SEGMENT AREAS
1 WEST APPROACH
2 SOUTHWEST APPROACH
3 STRAIT OF JUAN DE FUCA
4 CONVERGENCE AREA
5 HARO STRAIT NORTH
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1 - 99 TRIPS
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1000 - 4999 TRIPS
5000 - 9999 TRIPS
10,000 - 14,999 TRIPS
15,000 - 19,999 TRIPS
20,000 - 29,999 TRIPS
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PORT TOWNSEND HARBOR
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ANDERSON ISLAND
TACOMA HARBOR
TACOMA NARROWS BRIDGE
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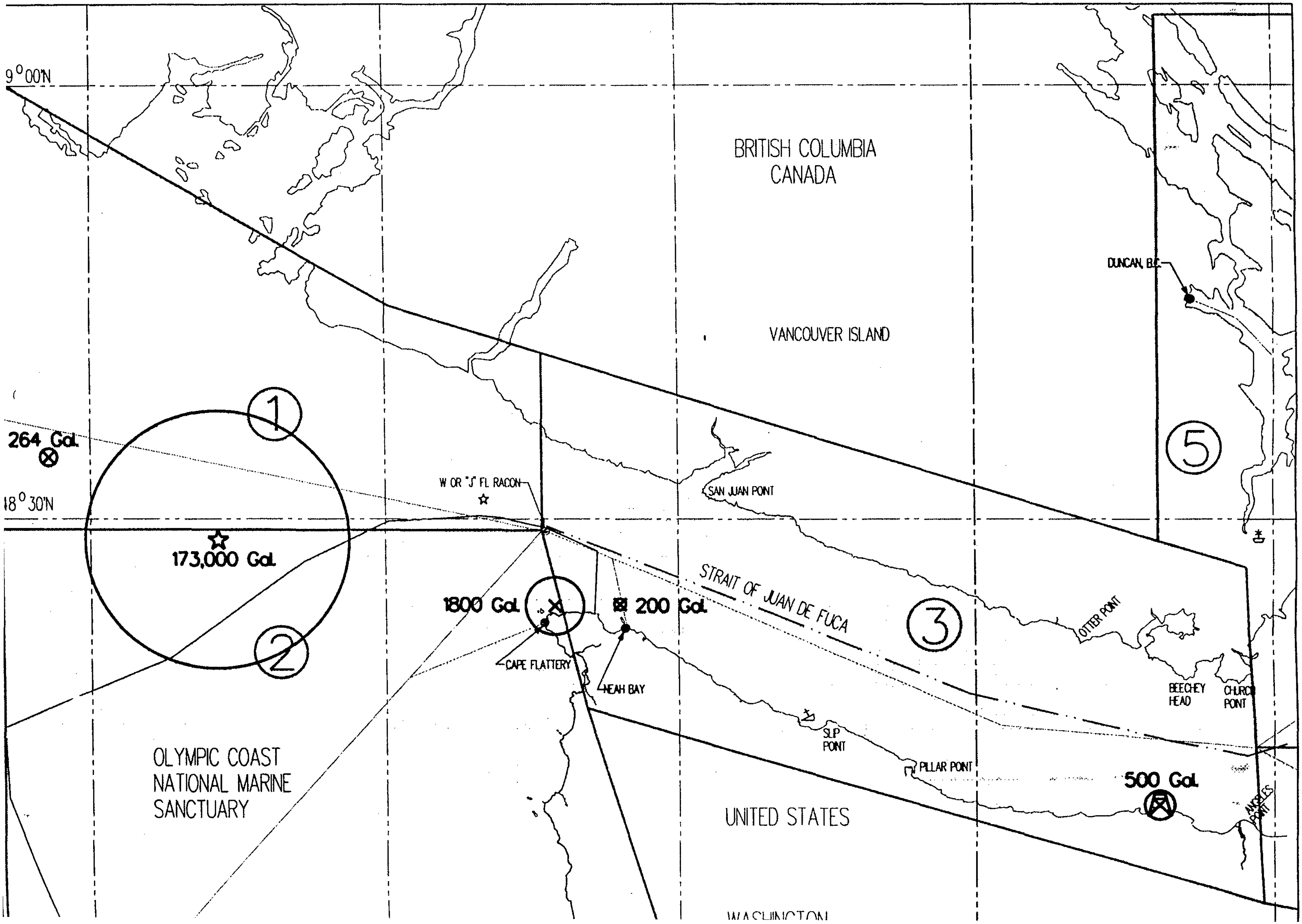
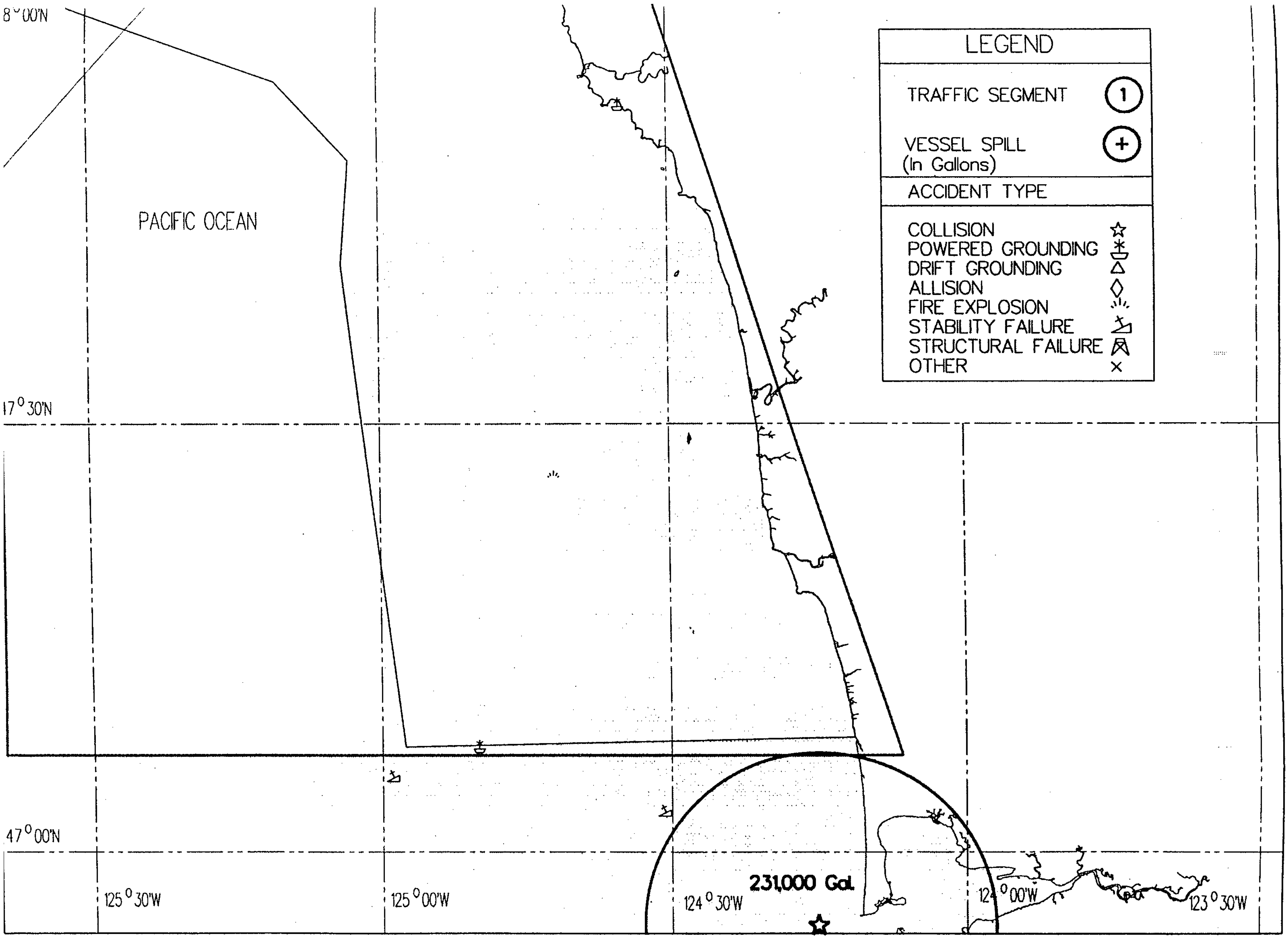
ELD INLET
BUDD INLET
JOHNSON POINT
OLYMPIA HARBOR
NISQUALLY REACH
47° 00'N
123° 30'W
123° 00'W
122° 30'W
122° 00'W

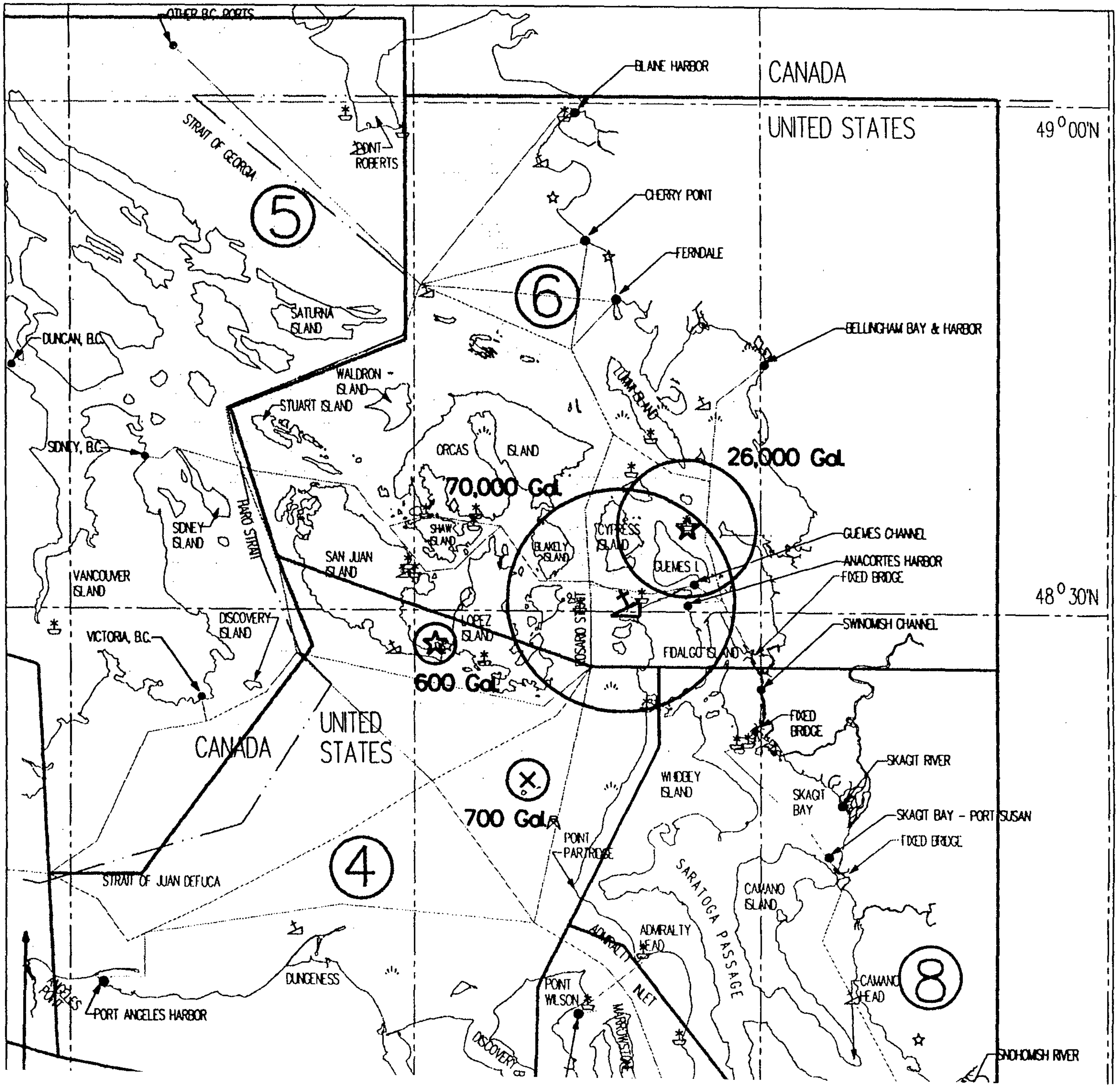
CHARTLET 4-1 CASUALTIES AND SPILLS BY ACCIDENT TYPE (1/2)

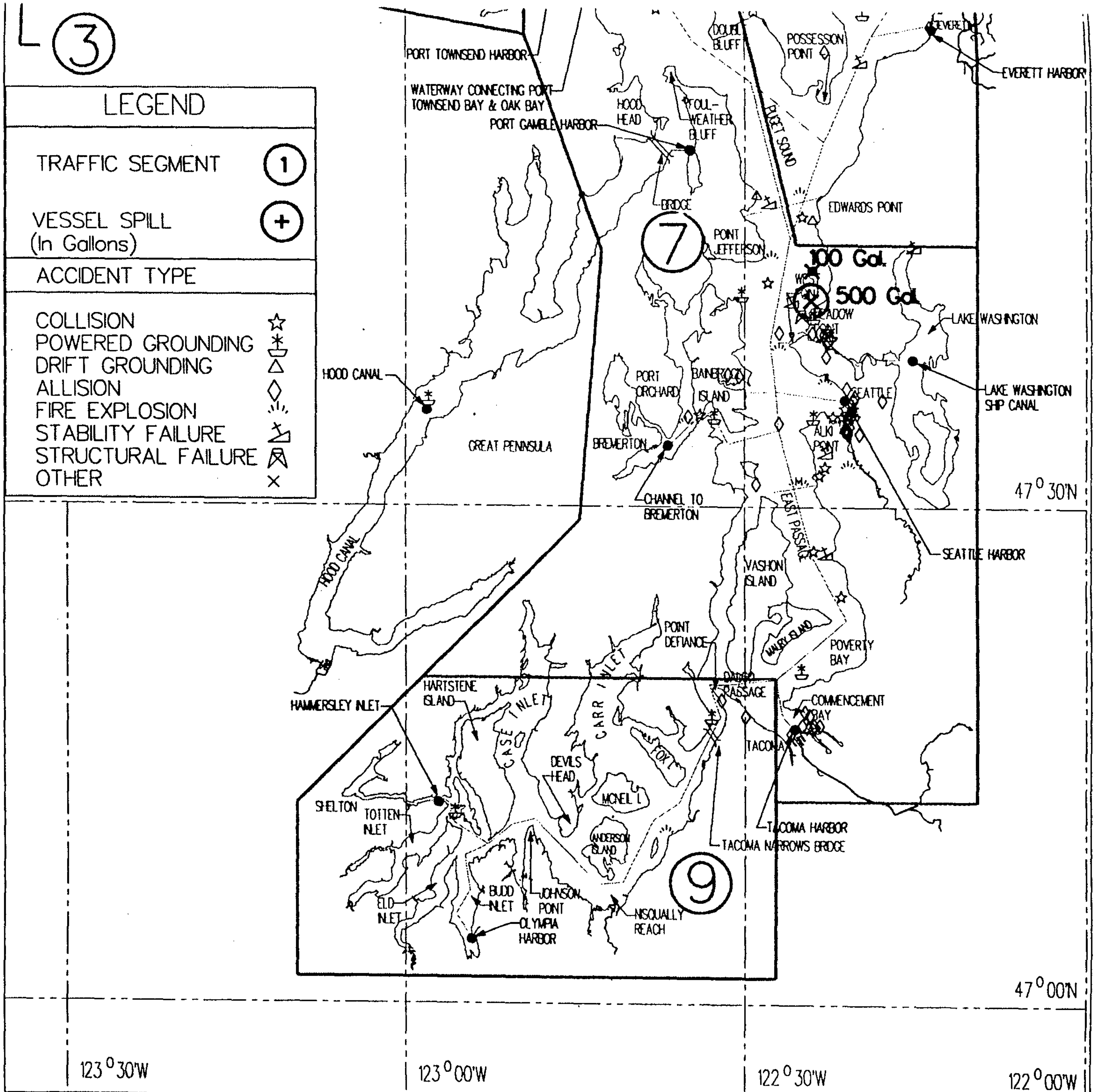




LEGEND
TRAFFIC SEGMENT
1
VESSEL SPILL
(In Gallons)
+
ACCIDENT TYPE
COLLISION
POWERED GROUNDING
DRIFT GROUNDING
ALLISION
FIRE EXPLOSION
STABILITY FAILURE
STRUCTURAL FAILURE
OTHER
PACIFIC OCEAN
17° 30'N
47° 00'N
125° 30'W
125° 00'W
124° 30'W
124° 00'W
123° 30'W
231,000 Gal.

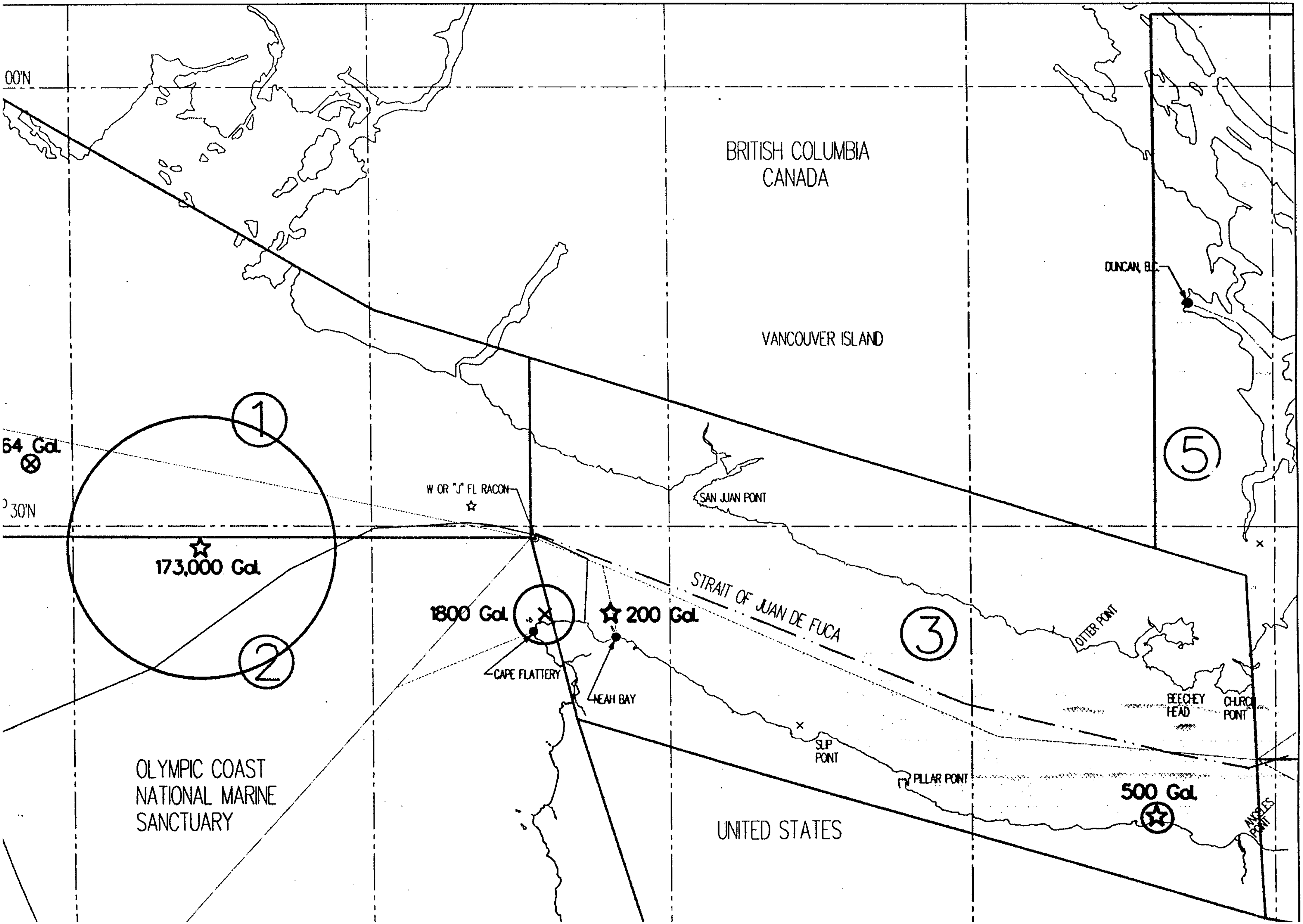
CHARTLET 4-1 CASUALTIES AND SPILLS BY ACCIDENT TYPE (2/2)

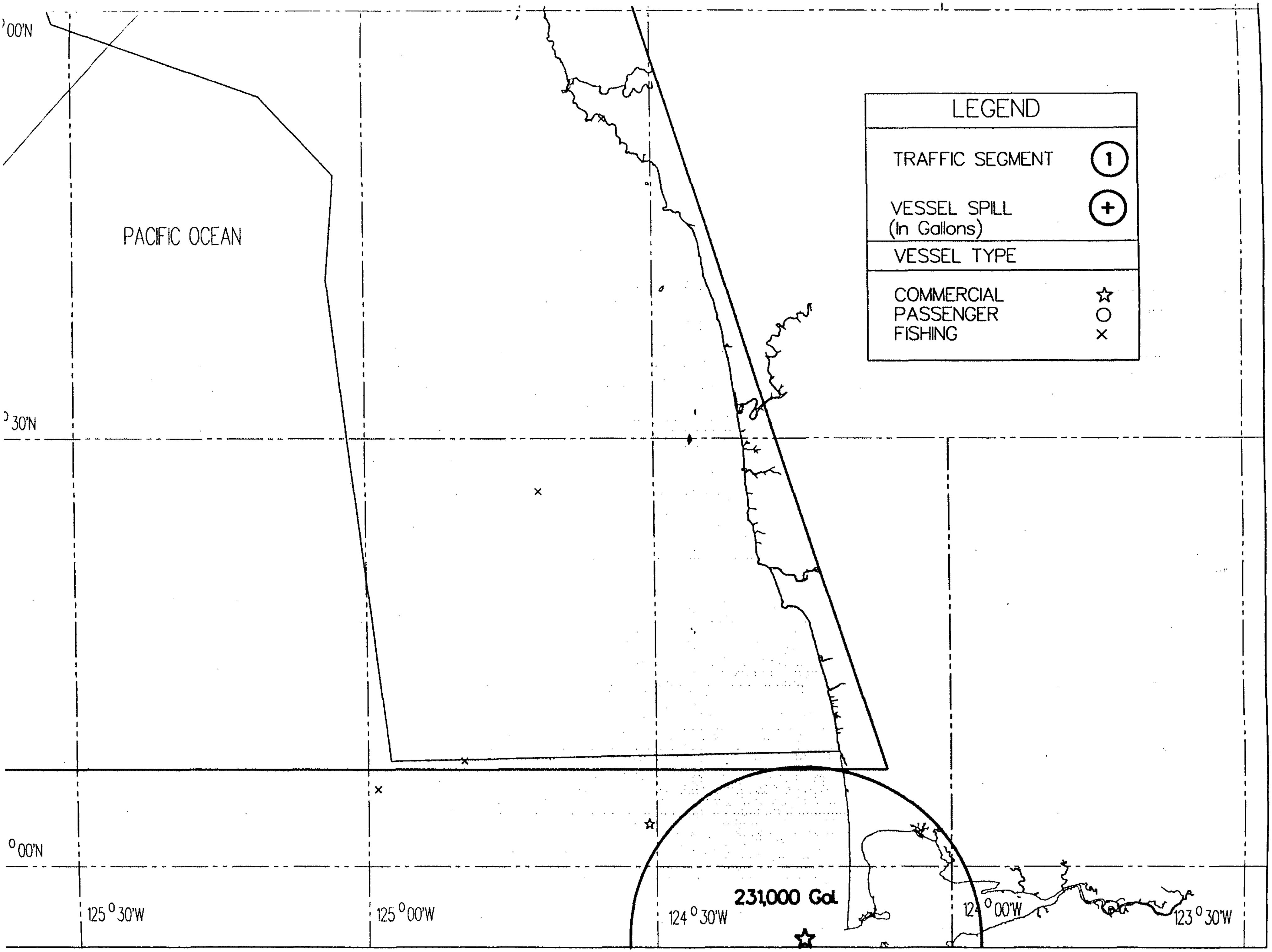




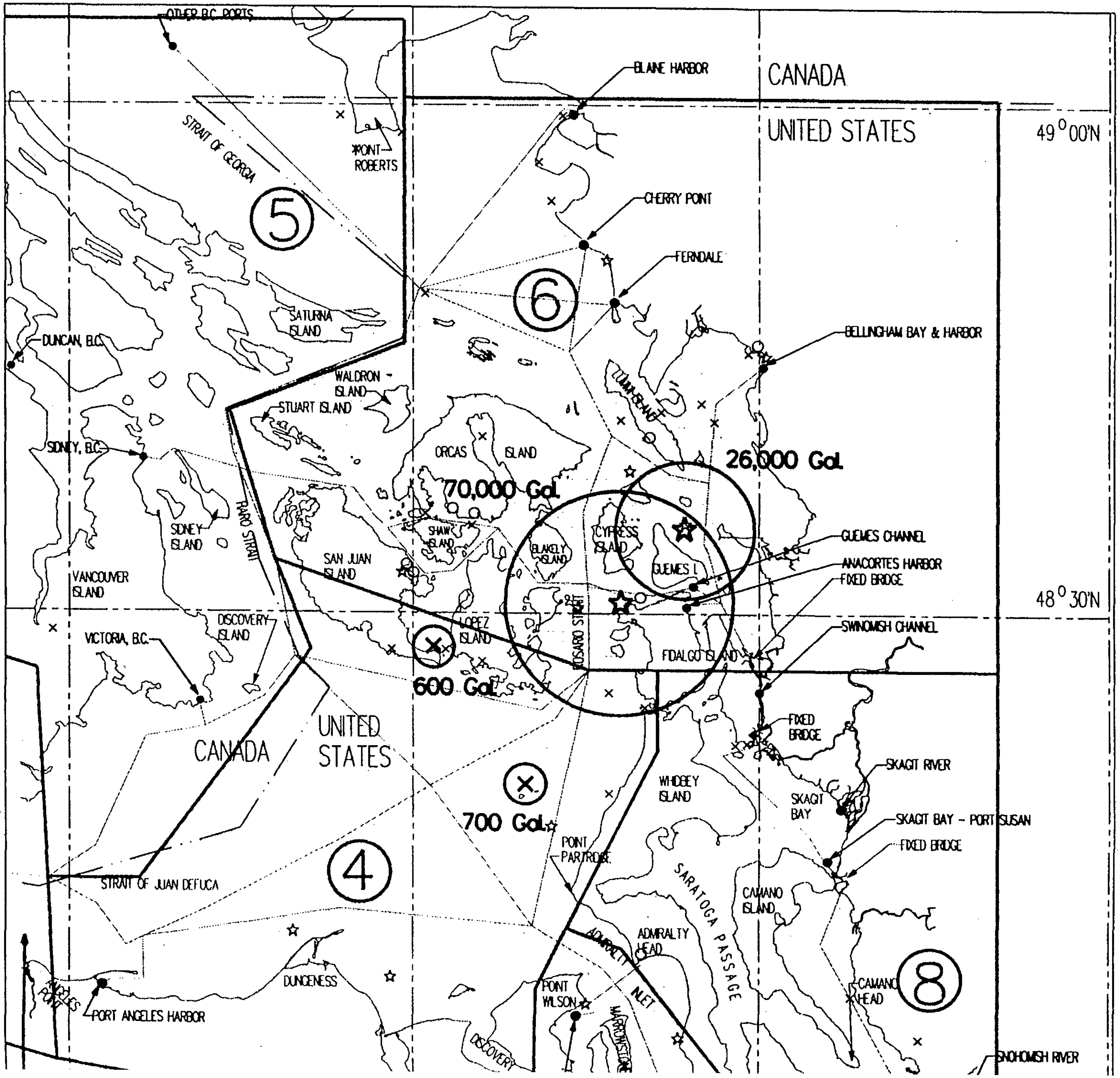
L 3
LEGEND
TRAFFIC SEGMENT 1
VESSEL SPILL (In Gallons) +
ACCIDENT TYPE
COLLISION
POWERED GROUNDING
DRIFT GROUNDING
ALLISION
FIRE EXPLOSION
STABILITY FAILURE
STRUCTURAL FAILURE
OTHER
PORT TOWNSEND HARBOR
WATERWAY CONNECTING PORT TOWNSEND BAY & OAK BAY
PORT GAMBLE HARBOR
HOOD HEAD
FOUL-WEATHER BLUFF
DOUBLE BLUFF
POSSESSION POINT
EVERETT HARBOR
PUGET SOUND
EDWARDS POINT
BRIDGE
7
POINT JEFFERSON
100 Gal.
500 Gal.
LAKE WASHINGTON
LAKE WASHINGTON SHIP CANAL
HOOD CANAL
PORT ORCHARD
BAINBRIDGE ISLAND
SEATTLE
ALKI POINT
GREAT PENINSULA
BREMERTON
CHANNEL TO BREMERTON
47° 30'N
EAST PASSAGE
SEATTLE HARBOR
VASHON ISLAND
POINT DEFIANCE
MAURY ISLAND
POVERTY BAY
DALCO PASSAGE
COMMENCEMENT BAY
TACOMA
HAMMERSLEY INLET
HARTSTENE ISLAND
CASE INLET
CARR INLET
FOX I.
DEVILS HEAD
MCNEIL I.
ANDERSON ISLAND
SHELTON
TOTTEN INLET
TACOMA HARBOR
TACOMA NARROWS BRIDGE
9
ELD INLET
BUDD INLET
JOHNSON POINT
OLYMPIA HARBOR
NISQUALLY REACH
47° 00'N
123° 30'W
123° 00'W
122° 30'W
122° 00'W

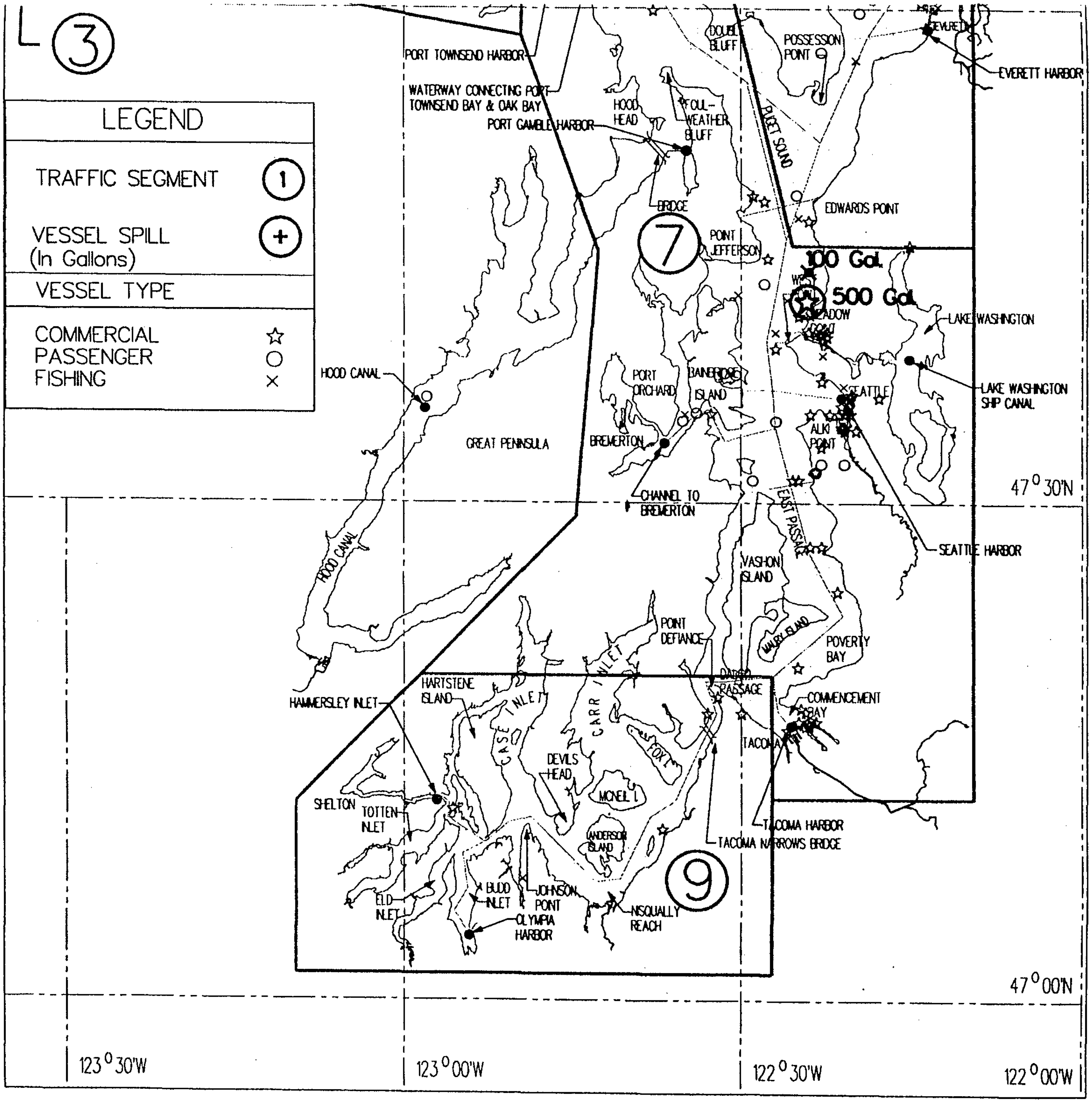
CHARTLET 4-2 CASUALTIES AND SPILLS BY VESSEL TYPE (1/2)




LEGEND
TRAFFIC SEGMENT
1
VESSEL SPILL
(In Gallons)
+
VESSEL TYPE
COMMERCIAL
PASSENGER
FISHING
PACIFIC OCEAN
00'N
30'N
00'N
125 ° 30'W
125 ° 00'W
124 ° 30'W
124 ° 00'W
123 ° 30'W
231,000 Gal.

CHARTLET 4-2 CASUALTIES AND SPILLS BY VESSEL TYPE (2/2)




L 3
LEGEND
TRAFFIC SEGMENT
1
VESSEL SPILL
(In Gallons)
VESSEL TYPE
COMMERCIAL
PASSENGER
FISHING
PORT TOWNSEND HARBOR
WATERWAY CONNECTING PORT TOWNSEND BAY & OAK BAY
PORT GAMBLE HARBOR
HOOD HEAD
FOUL-WEATHER BLUFF
DOUBLE BLUFF
POSSESSION POINT
PUGET SOUND
EVERETT HARBOR
BRIDGE
EDWARDS POINT
7
POINT JEFFERSON
100 Gal.
500 Gal.
LAKE WASHINGTON
HOOD CANAL
PORT ORCHARD
BAINBRIDGE ISLAND
SEATTLE
LAKE WASHINGTON SHIP CANAL
GREAT PENINSULA
BREMERTON
ALKI POINT
47° 30'N
CHANNEL TO BREMERTON
EAST PASSAGE
SEATTLE HARBOR
VASHON ISLAND
POINT DEFIANCE
POVERTY BAY
HARTSTENE ISLAND
CASE INLET
CARR INLET
PASSAGE
COMMENCEMENT BAY
HAMMERSLEY INLET
TACOMA
DEVILS HEAD
FOX I.
MCNEIL I.
SHELTON
TOTTEN INLET
ANDERSON ISLAND
TACOMA HARBOR
TACOMA NARROWS BRIDGE
9
BUDD INLET
JOHNSON POINT
ELD INLET
OLYMPIA HARBOR
NISQUALLY REACH
47° 00'N
123° 30'W
123° 00'W
122° 30'W
122° 00'W

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