

ALASKA LEGISLATURE SPECIAL COMMITTEE / SUBJECT FILE 8672

1971 SCOMM 76: HOUSE SPEC. COMM. EXXON VALDEZ OIL SPILL. 1991-92

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Comment: It is unclear whether gas chromatograph methods described in Technical Services 1 can be used to distinguish between weathered EVOS oil and oil from other sources for studies Air/Water 2 and 6. (ESC)

Response: The compounds analyzed under Technical Services No. 1 will include aromatic compounds and the C10-C34 alkanes, which will provide sufficient analytical information to describe different weathered states of oil and distinguish North Slope crude oil from other sources.

Comment: Although the description of samples to be taken and the methodology to be employed are much more complete than that presented in the 1989 plan, the actual number of samples that will be eventually analyzed is not stated. (UM)

Response: Currently, 385 sediment samples are being or have been analyzed from those collected in 1990. Additional samples may be submitted for analysis once the results from these initial samples are available.

Comment: Statistical tests of hypotheses are vaguely defined, and it is not clear how abundance and biomass are to be tested. (ESC)

Response: A Kruskal-Wallis and a multiple comparison test for significance will be used to test for differences in total abundance and biomass between stations sampled each year and in multi-year data sets. The tests will be made on the abundance and biomass of selected predominant taxa at stations. Analysis of variance (ANOVA) has been added to the statistical analysis. ANOVA will be used to test differences in abundance and biomass between predominant taxa for stations at similar depths within oiled and unoled bays.

Comment: It is unlikely that the statistical analysis of the benthic infauna will have much meaning considering the numbers of both oiled (6) and unoled (6) sites to be sampled. Furthermore, because the geochemical techniques being employed will not discriminate the various sources of hydrocarbons (biogenic, pyrogenic, and other petrogenic) the statistical analysis will be unable to correlate any effects observed with EVOS oil or its weathering products. (ESC)

Response: Sample size is minimal. However, it is expected to be adequate to detect major faunal differences between sites. It will be possible to correlate effects with EVOS oil because chemical analysis of sediments at sample sites will allow identification of oil.

Comment: It is proposed that injury determination will be accomplished by correlating the results of the chemical analyses (HPLC) with the Microtox measurements (as a measure of toxicity) and with the deep benthos biological statistics for oiled and unoled sites. It will be impossible to determine EVOS-imposed injury in this manner because: (1) it will not be possible to quantitatively discriminate an EVOS signature from other hydrocarbon sources, and (2) the Microtox tests are invalid tests of toxicity as explained above. (ESC)

Response: Preliminary tests with Microtox in 1990 indicated low sensitivity to Exxon Valdez oil in sediments and this technique was discontinued. The analysis for aromatic compounds and the C10-C34 alkanes in sediments under Technical Services 1 will allow the separation of North Slope crude oil from other sources of oil.

Comment: The site selection procedure, the number of sites selected, and the hydrocarbon chemistry methods to be used, preclude the use of deep benthos infaunal species diversity, species abundance, and total biomass from being used to assess EVOS-related injury to subtidal marine resources. Further, the site selection procedure precludes extrapolation of the site data to the entire region. (ESC)

Response: The site selection procedure is appropriate for assessment of total abundance and biomass using Kruskal-Wallis and multiple comparison tests. The results will be useful for investigating major faunal differences between oiled and unoled sites. The study was not designed to enable extrapolation to the entire region. Subtidal benthic systems differ sufficiently so that area-wide extrapolation is not possible. However, common fauna between benthic sites are typically found, and differences in these predominant and ubiquitous faunal components may be extrapolated.

Comment: Objectives A-H. The small number of sites and the method of their selection are such that it is unlikely that the major objectives will be realized in a manner that will permit them to be extrapolated to the region as a whole. Therefore, it will not be possible to obtain one of the main goals in the study which is to "evaluate the extent of subtidal hydrocarbon contamination in PWS, along the lower Kenai Peninsula, and near Kodiak Island." (ESC)

Response: Sampling was conducted in a paired design (treatment/control pairs of sites). The number of pairs was limited by the number of adequate control sites. The main objective of Air/Water 2 is to determine the distribution, composition, persistence, and toxic effects of petroleum

hydrocarbons in bathymetric space. Air/Water 2 is not designed to extrapolate sampling results "to the region as a whole." This requires a random stratification approach and a sampling effort that is cost prohibitive for the required subtidal sampling.

Comment: One study uses the Microtox test for toxicity. This method is not accepted as a sole indicator and should be used in conjunction with other methods to determine the toxicity of sediments and the effect of oil exposure. Microtox bacteria would not be expected to be a part of the sediment infauna, thus the relationship of the test to the environment is not clear. (API)

Comment: The Microtox assay, although very quick and relatively inexpensive to perform, is at best a very crude barometer of the relative toxicity of these sediments. Comparisons between toxicity estimated with Microtox and more routine acute toxicity yield highly variable correlation coefficients depending on species compared. Attempts to use the Microtox assay as a direct measure of sediment toxicity have indicated that toxicity results are highly dependant on the method used to obtain an aqueous sample from the sediment under consideration and suggest that further method development is needed. Even the study by Schiewe et al. (1984) cited in the plan points out many of the limitations of this assay in addressing sediment toxicity. (UM)

Comment: When compared experimentally, the Microtox assay was found to be less sensitive than either the *Daphnia magna* 48-hour lethality assay or the *Hexagenia limbata* 168-hour lethality assay in assessing the toxicity of a freshwater sediment contaminated with aromatic hydrocarbons and metals. (UM)

Comment: The Microtox bioassay, based on the response of a marine bacterium to methylene chloride extracts of sediments (used in Studies AW2 and AW6) is not an appropriate method for estimating the toxicity of in-place oiled sediments to marine organisms. Recent studies of sediments from Puget Sound show that results from Microtox bioassays of methylene chloride sediment extracts do not correlate with the toxicity of the sediment interstitial water or to concentrations of polycyclic aromatic hydrocarbons in the sediments. (ESC)

Comment: Microtox bioassay is considered a poor indicator of the toxicity of the lipophilic organic compounds, such as petroleum hydrocarbons. (ESC)

Comment: The microtox bioassay is an EPA water quality test and its application to sediment extracts is inappropriate. (ESC)

Comment: The Microtox measurements proposed will be unable to attribute dose response relationships to an EVOS component. (ESC)

Response: This responds to the preceding 7 comments. Preliminary tests with Microtox in 1990 indicated low sensitivity to Exxon Valdez oil in sediments and this technique was discontinued.

Comment: Bioaccumulation, toxicity, and growth should be assessed in a number of representative benthic organisms, as is suggested in the proposed update of the EPA ecological evaluation of dredged material. (UM)

Response: Sediment toxicity and its effect on test organisms will be addressed in 1991 in Subtidal #3.

Comment: The HPLC/fluorescence method chosen to estimate petroleum hydrocarbon concentrations has the advantage of allowing large numbers to be processed relatively quickly and inexpensively, but it is not very specific. Will it be used only as a screening tool to identify samples with elevated levels to be analyzed by more conventional methods with better accuracy? If not, erroneous conclusions on levels of hydrocarbon contamination could be made. (UM)

Response: Under Air/Water 2, the HPLC/fluorescence method will only be used as a screening tool.

Comment: There is no reason given for the fact that detailed sediment sampling is scheduled to take place three times while the biological samples will only be collected in June/July. It is questionable whether measurable differences in sediment concentrations over that short a time period exist that long after the spill. If they do, the frequency of biological sampling should be increased. (UM)

Response: The expense of collection and laboratory processing of the infaunal samples rendered the cost of seasonal assessments of the deep benthos prohibitive. Collection and analysis (in conjunction with HPLC/fluorescence) of sediment samples is much less expensive, and is providing for the opportunity for seasonal hydrocarbon sediments collections.

Comment: Using a 1 mm sieve on the benthic infaunal sampling will miss many of the numerically dominant species, including most invertebrate larvae and some very important meiobenthic prey species for salmon fry such as harpacticoid copepods. Many investigators of soft-bottom community structures require 0.5 mm mesh sizes or smaller. (UM)

Response: Both 1.0 and 0.5 mm sieves have been incorporated into the sampling. The benthic study was designed to assess macrofauna, and was not intended to examine meiofauna quantitatively. However, use of the 0.5 mm screen should allow quantitative examination of the larger meiofaunal taxa.

Comment: The total number of sites, the manner in which they were selected, and the numbers of samples to be collected may be inappropriate for a statistically based study. (ESC)

Response: Sampling was conducted in a paired design (treatment/control pairs of sites). It was not the goal of the study to extrapolate results over the entire spill-impacted area. This is cost prohibitive considering the extensive subtidal sampling that is required.

Comment: Since only 6 oiled and 6 non-oiled sites will be investigated for effects on the structure of subtidal benthic communities, it is extremely important that the control and oiled sites be well matched for sediment characteristics, depth, light and nutrient conditions if potential effects of the EVOS are to be assessed adequately. Potential effects on benthic community structure should be a key component of the NRDA. (UM)

Response: Although it is difficult to match completely all sites with all characteristics, sea grass beds at the heads of bays were chosen as the common denominator that is expected to have an important influence on the benthic environment of all sites. A sea grass system can be expected to flux a sizable and annually reliable amount of organic carbon to the subtidal environment. Similar benthic faunal components responding in a roughly similar manner would then be expected in the subtidal sites selected.

Comment: The field program is very inefficient and is therefore not cost effective. The total number of sites, the manner in which they were selected, and the number of samples to be collected may be inappropriate for a statistically based study. Non-random site selection can yield biased results. (ESC)

Response: The field program was greatly increased in efficiency in 1990 by combining the sampling needs of all Air/Water 2 (including previous Air/Water 4) and Air/Water 6 program components into the same cruises.

Comment: The biological sampling plan for the intertidal zone (along a 30 m transect parallel to the shoreline in the range +1m to -1m relative to mean lower low water) is inappropriate due to the pronounced stratification of biota in that zone. (ESC)

Response: It was appropriate to sample the intertidal zone as this zone is most likely to contain infauna in association with fine sediments.

Air/Water Study No. 3 - Geographic and Temporal Distribution of Hydrocarbons

Comment: Sediment traps will be deployed at only a very limited number of locations and can only assess the concentrations of petroleum hydrocarbons on particulate material settling out of the water column. (UM)

Response: The sediment trap study is designed to monitor suspended particulates and hydrocarbons settling out of the water column. With the exception of control sites, the traps are located at sites believed to be most likely to still have detectable, mobile hydrocarbons in the water column. Sediment traps will measure both adsorbed hydrocarbons and hydrocarbon "globules." Previous studies have shown both forms to be important components of hydrocarbon mobilization and subsequent deposition.

Comment: Although use of caged mussels is a well accepted approach, particularly in areas with more heavily oiled sediments, some analysis of the concentration and patterns of petroleum hydrocarbons in the dissolved or whole fraction of the water column would seem to be warranted. Measurements of this type will be of particular importance to calculate the flux of hydrocarbon material out of sediment reservoirs. (UM)

Response: By 1990, water column concentrations of petroleum-derived hydrocarbons were below detection limits using practically sized samples (i.e., up to about 5 liters) in PWS.

Comment: Objective 1. Sediment traps are not appropriate for determining particulate transport of hydrocarbons in shallow-water environments. (ESC)

Response: The sediment traps have been designed to account for a range of environmental conditions encountered in nearshore subtidal areas where they are deployed. While the traps are not designed to quantify flux rates, they are effective at capturing particulates to determine the presence or absence of hydrocarbons.

Comment: Objective 2. This objective does not relate ambient water quality or mussel hydrocarbon burdens to EVOS. (ESC)

Response: Methodology relating PAH concentrations in sediments and in mussels due to the EVOS with resource injury and lost services is not within the scope of Air/Water 3, although it is within the scope of the overall NRDA process and is based on the integrated results of the individual projects. Project investigators have coordinated studies to the extent considered necessary to facilitate an integrated assessment of resource damage. The linkage of this study to other NRDA studies consists primarily of demonstrating the transport and availability of spilled oil from the beach and surface waters to the water column and subtidal sediments where it is available to marine organisms.

Comment: The depth(s) of deployment of the sediments traps are not given. Justification for why three sampling periods were chosen instead of one deployment, possibly for a longer period, should be given. For some compounds four weeks is too short a time period. (UM)

Response: The depth of deployment was given as less than 20 meters below MLLW. In practice, the traps were deployed at approximately 10 meters. Sampling periods were chosen to correlate with naturally occurring erosional and depositional events. The length of deployment is intended to maximize deposition while minimizing naturally occurring degradation of any hydrocarbons present.

Comment: The field extraction method for the sediment trap samples is not described. Other than attempting to determine differences in hydrocarbon concentrations between samples and sites, no methods describe how any of the results from these efforts can be attributed to EVOS. (ESC)

Response: The field extraction method for sediment trap samples are described in the 1991 plan. Clear differentiation of sources of hydrocarbon burdens will be accomplished using details provided by the GC/MS analyses, and by comparison of these details with historical data on hydrocarbon burdens of various compartments within PWS.

Comment: Because body burdens of hydrocarbons in mussel tissue can change fairly rapidly, levels in caged mussels will only be indicative of ambient water column concentrations if the concentration of these components in the water column is somewhat constant during the exposure period. (UM)

Response: From the definition and magnitude of the bioconcentration factor of polynuclear aromatic hydrocarbons (PAH) for mussels, the rate of depuration is several orders of magnitude less than the rate of uptake. In particular, accumulated PAHs have an apparent half-life on the order of 2 weeks in mussels. A 4-week exposure period was chosen as a sufficient time period for accumulation of some PAH to occur. The study objectives do not include an attempt to calculate absolute seawater PAH concentrations on the basis of concentrations found in mussels.

Comment: Use of sediment traps to measure transport of petroleum hydrocarbons to offshore sediments will not produce information enabling the Trustees to relate hydrocarbon levels to population impacts on benthic organisms because sediment traps are not useful for predicting the rate of flux of suspended particles to the bottom and, if they are mounted near the bottom, they measure mainly sediment resuspension. (ESC)

Response: The sediment trap study is designed to determine the continuing mobilization of hydrocarbons. This study will be integrated with the results from other studies to address the question of continuing temporal and spatial exposure of benthic organisms to hydrocarbons. The sediment traps are designed to minimize capture of resuspended sediments.

Comment: The geographic distribution of study sites is not adequate: Only 5 of 20 sediment-trap sites are listed and referenced figures for caged mussel sites are not included in the document. The use of sediment traps for measuring flux to the subtidal region is not a valid or standard technique in shallow-water environments. Neither the sediment trap-design nor the periods of deployment are set forth. No field chain-of-custody is described nor are QA/QC procedures for field-extraction of the particulates. (ESC)

Response: The geographic distribution of study sites is adequate to monitor suspended particulates and hydrocarbons settling out of the water column. With the exception of control sites, the traps are located at sites believed to be most likely to have detectable, mobile hydrocarbons in the water column. The sediment traps are not designed to measure flux rates but rather the presence or absence of hydrocarbons. This study follows the standard chain-of-custody procedures for all NRDA studies. Standard QA/QC procedures have been established.

Comment: These injury pathway studies do not attempt to differentiate hydrocarbon burdens found from EVOS, pyrogenic, natural sources (seeps), or other (boating) sources. (ESC)

Response: Clear differentiation of sources of hydrocarbon burdens will be accomplished using details provided by the GC/MS analyses, and by comparison of these details with historical data on hydrocarbon burdens of various compartments within PWS.

Comment: No methodology is provided which will tie differences in hydrocarbon concentrations in the sediment traps and mussels to resource injury and lost services. The few sites that are proposed to overlap with Coastal Habitat Study No. 1 and Air/Water Study No. 2 will not "provide a comprehensive picture of damage." (ESC)

Response: This study will provide documentation of the pathway of hydrocarbon contamination that eventually reached a number of marine organisms. This study, in concert with other NRDA studies, will tie hydrocarbon contamination to resource injury.

Comment: The linkage between this study and the other injury-related studies is not apparent. (ESC)

Response: Close coordination between this study and other studies has been carried out throughout the NRDA process.

Comment: Only two control sites are listed for the caged-mussel studies and none are specified for the sediment trap deployments, making it impossible to evaluate whether the baseline determination will be adequate. (ESC)

Response: In addition to the control sites in PWS, mussels collected from an uncontaminated site on Admiralty Island in S.E. Alaska will provide a reference.

Air/Water Study No. 6 - Fate and Toxicity of Oil

Comment: Objectives A-C. The study is of limited value in estimating injury from weathered crude oil in sediments. Because of the study design, these objectives will not be accomplished in a scientifically defensible manner. (ESC)

Response: Because the information on the persistence and toxicity of oil and its oxidation products in the marine environment is very limited, this study was initiated in 1990 to provide this type of documentation. The information developed will support other studies by confirming or eliminating potential sources of injury to marine organisms.

Comment: Objectives D. This study cannot be performed in a technically sound fashion and is of no use for identifying restoration needs or quantifying injury to natural resources. (ESC)

Response: The establishment of an understanding of the fate of the EVOS oil over time and space, in concert with other NRDA studies, will help further the understanding of how the environment was affected by the EVOS. The cost of meeting this objective is minimal as existing information from other sources will be used to construct the fates model.

Comment: Air/Water 2, 3, and 6 are not well integrated internally or with each other or with Coastal Habitat 1. (ESC)

Response: Air/Water 2 and Air/Water 6 are closely coordinated with each other and the Coastal Habitat studies. Subsamples of the same sediments from the same suite of sites are subjected to chemical analysis and toxicity testing. See also response to this same comment in the general comments in this section.

Comment: It is not possible to ascertain from the Plan whether there is duplication of effort in the studies of petroleum hydrocarbon concentrations in Coastal Habitat 1 and Air/Water 6. (ESC)

Response: Although sediments are sampled under the Coastal Habitat study, they are subjected to more detailed testing for toxicity and the presence of oxidation derivatives of oil in Air/Water 6.

Comment: Air/Water 6 does not contain sufficient specificity regarding the construction of a "summary budget or 'mass balance' summarizing the fate of spilled oil." It fails to indicate when this calculation will be made and to explain how the calculation will be utilized in the assessment of damages. (NWF)

Response: Primary sources of information have been identified for the synthesis of a budget for the fate of oil, and contacts have been made to help ensure the compatibility of the data to be synthesized. The budget will represent a best synthesis effort with the information that is available. While not directly documenting damage, this information will support damage assessment by providing an overall picture of how the oil was distributed in the environment.

Comment: The data generated by Air/Water 6 will not be sufficient to construct an accurate mass balance of the spilled oil. It is extremely unlikely that a mass balance, even if constructed, would be sufficient for quantifying injury to natural resources. (ESC)

Response: The primary sources of information that have been identified for use in constructing the budget are detailed enough so that a representation of the general distribution of oil in the environment can be produced. While not directly documenting damage, this information will support damage assessment by providing an overall picture of how the oil was distributed in the environment and was available to organisms.

Comment: There is no statement in the study plan as to how the mass balance would be used in restoration or injury determination and quantification. Because of the imprecision of the fate estimates, the results of this mass balance will not be useful for injury determination. (ESC)

Response: Although the oil fates budget will not have a direct use in documenting injury to organisms, the background information on spatial and temporal distribution of oil in the environment it provides will aid in understanding how and when oil was available to various organisms and in extrapolating injury beyond immediate study areas.

Comment: The introduction to the study states that effects of petroleum hydrocarbons themselves are well enough documented in previous work to allow accurate predictions in the case of EVOS without additional study, but this is questionable. Although a substantial body of work does exist on the WSF and OWD of different petroleum products in laboratory conditions, these studies may not adequately assess the long-term, sublethal effects of petroleum hydrocarbons on all key components of the ecosystems. (UM)

Response: Not everything is known about the long-term sublethal effects of oil on all components of the ecosystem. However Air/Water 6 is designed to address two fundamental issues: 1) whether residual oil exerts acute toxicity on test organisms, and 2) whether polar breakdown products contribute to any of the observed toxicity.

Comment: There are no details regarding how the mass balance will be attempted. The Plan states that recognized experts will be consulted in its execution, but that progress will be heavily influenced by timely reporting of data from other groups, and the suitability of these data for constructing the mass balance. The timely reporting of data from different members of the damage

assessment team, and the compatibility of the different data sets were one of the major concerns with the original 1989 damage assessment plan. (UM)

Response: Primary sources of information have been identified for the synthesis of the "oil fates" budget. Not all of these are within the damage assessment arena. Current plans are for this budget to be completed by the fall of 1991.

Comment: This study lacks baseline measurements, so it will not be possible to compare toxicity of polar fractions of organic extracts of oiled and unoled sediments. Therefore, the increment in toxicity of sediments due to oil cannot be measured. (API, ESC).

Response: Where baseline data does not exist, a comparison of the toxicity of sediments from oiled and unoled sites has been utilized. The measurement of oil in the sediments (from the same sample) from Air/Water 2 are being used to confirm whether oil is present at a sampling site.

Comment: The analytical methods will not allow definitive identification of EVOS oil as the material causing toxicity in sediments. Therefore, there will not be a clear link established between the injury (toxicity of intertidal and subtidal sediments) and the EVOS. (ESC)

Response: The sampling for the sediment toxicity survey included 7 sites designated as unoled or very lightly oiled. For the polar fractionation/toxicity study, one unoled site was included for comparison. The detailed chemical information from all the sites will provide further basis for determining the sources of any toxicity that may be found.

Comment: Twenty "heavily oiled" sites were chosen for this study, but no other information is given: Are these sites representative? If so, of which of the oiled habitats? What range of grain size or organic carbon content was chosen? (UM)

Response: Sites were selected under Air/Water 2 to represent a broad range of characteristics and geographic coverage. Unoled reference sites are included to permit assessment of oil-related toxicity.

Comment: Use of the Microtox test to assess sediment toxicity is of value only as a screening tool. This is a source of concern in

this study especially because it will be used to assess whether or not the polar fraction is more or less toxic than the complete sediment. (UM5)

Response: Microtox is used only as a screening device. It is expected that Microtox will respond to epoxides and free radicals, if present, even though the microorganism does not generate those compounds itself.

Comment: Only the toxicity study (Objectives A-C) includes field methods that are a part of this study plan. Sampling is restricted to the intertidal/subtidal areas of 20 heavily oiled sites and, therefore, probably is most representative of the worst case situation. (ESC)

Response: Results should not and will not be extrapolated from either the 2 heavily oiled sites used for the fractionation and toxicity testing of polar constituents or the 20 oiled sites used for the field toxicity survey. However, objective inferences may be drawn from these results regarding the magnitude and extent of potential toxicity to marine organisms and the relation of the toxicity, if any, to polar constituents.

Comment: Samples for whole animal sediment toxicity tests are not the same as those used for extraction, fractionation, and testing with the Microtox bioassay. Therefore, the results of these two phases of the project cannot be compared and extrapolations cannot be made about the contribution of polar degradation products of petroleum to the toxicity of oiled sediments to marine animals. (ESC)

Response: Objective inferences may be drawn from these results regarding the magnitude and extent of potential, if any, toxicity to marine organisms and the relation of the toxicity to polar constituents.

Comment: There is no explanation given for using *Mytilus edulis* instead of *Mytilus trossulus*, the species that was used in the bioaccumulation studies and that presumably is indigenous to the area. (UM)

Response: The purpose of the bioassays is to verify whether residual oil might exert some acute toxicity to indigenous organisms. *Crassostrea gigas*, not *Mytilus*, was used in the Air/Water 6 bioassays because of the availability of spawning stock at the time. *M. Trossulus* is the correct name for Pacific mussels previously referred to as *M. edulis*.

Comment: Although the authors state that well-established protocols exist for this assay, it is unclear from the references listed what they are basing this information on. Varying results are obtained in sediment toxicity bioassays depending on whether whole sediment, diluted sediment, pore waters, or elutriate are used. (UM)

Response: The purpose of the bioassays is to verify whether residual oil might exert some acute toxicity to indigenous organisms. Standard bioassay species and protocols are used for this purpose.

Comment: In determining the toxicity of sediments, a test with benthic larvae, which would be most likely exposed to these sediments, should be employed. The *Ampelisca* sediment toxicity study is well documented, but toxicity to additional species should also be assessed. (UM)

Response: It is desirable to work only with organisms that are indigenous to the spill area. However, the availability of test organisms and the fact that the protocols for certain historically used species are well established ruled out the use of local organisms.

Comment: One primary aspect of the toxicity of hydrocarbon metabolites concerns their susceptibility to be metabolized to electrophilic epoxides, a reaction prokaryotic microorganisms such as those used in the Microtox assay cannot perform. Consequently, the appropriateness of using the Microtox assay to assess the toxicity of metabolites is questionable. It is questionable whether methylene chloride will extract sufficient quantities of polar metabolites to address adequately their contribution and toxicity in these sediments. (UM)

Response: Microtox is only used as a screening device. It was expected that Microtox would respond to such epoxides and free radicals, if present, even though the microorganism does not generate those compounds itself. Mixtures of ethyl acetate and methylene chloride were used in the final study to ensure more complete extraction of polar constituents.

Comment: It is unclear whether gas chromatograph methods described in Technical Services 1 can be used to distinguish between weathered EVOS oil and oil from other sources for studies Air/Water 2 and 6. (ESC)

Response: The compounds analyzed under Technical Services 1 will include aromatic compounds and the C10-C34 alkanes, which will provide sufficient analytical information to describe different weathered states of oil and distinguish Prudhoe Bay crude oil from other sources.

TECHNICAL SERVICES

Comments on Technical Services - General

Comment: Most technical services studies are not detailed enough to be evaluated. (API, ESC)

Response: The Trustees disagree. Detailed documentation on analytical procedures, including: 1) data documentation and reporting and 2) quality control measures and the acceptance criteria associated with these procedures, as implemented by each laboratory analyzing NRDA samples, have been developed. The QA/QC standards are contained in Appendix A.

Comment: Technical Services appears to be little modified from the 1989 plan. (UM)

Response: The nature of the support provided by the technical services projects has not varied from the originally established quality control measures and procedures for data control, sampling, and reporting.

Comment: Technical Services is very limited in scope, providing descriptions of the chemical and histopathological analysis of samples only. Similar sections are needed for the other measurements being made, as well as some mechanisms to insure coordination between methods and sampling between different parts of the plan. (UM)

Response: Technical Services currently encompasses chemical analysis and mapping. Histopathology has been discontinued as a separate support service although continuing analysis of histopathology samples will be conducted as part of specific NRDA studies. Descriptions of protocols and methods for sampling and other measurements being made by NRDA studies are contained within the specific studies, cited references, and appendices to this document. Technical Services is intended to provide support of a kind required by many NRDA studies and this can best be accomplished by a single support function.

Comment: Due to concerns regarding the invasive tests conducted, the benefits of the histopathology study are questionable. (API)

Response: Histopathology is no longer addressed by a separate Technical Service program. Histopathology continues to be considered within specific studies as needed. Every effort is being and continues to be made to ensure that the number of animals collected is kept to a minimum and that individual takes are essential to assess injury.

Comment: The proposed audits of field and laboratory procedures, as described, are inadequate: only chemistry audits are mentioned. Other areas should be audited as well, such as sample analysis, biological observations, database input, chain of custody, and mapping. (ESC)

Response: Sufficient detail for adequate review is provided in Appendices A & B, and Technical Services Studio 1, 2, and 3.

Comments on Technical Services - Specific

Technical Services No. 1

Comment: Technical Services 1 will make extensive use of UV fluorescence, which is not always conclusive in distinguishing between aromatic compounds from the EVOS and the petrogenic or biogenic aromatic hydrocarbons from other sources. (ESC)

Response: UV fluorescence is being used extensively only for the analysis of bile for petroleum hydrocarbon metabolites and for the determination of oiled versus unoiled sites in Coastal Habitat. This method is well documented as an indicator of exposure to petroleum hydrocarbons (Varanasi et al.)

Comment: It is unclear whether gas chromatograph methods described in Technical Services 1 can be used to distinguish between weathered EVOS oil and oil from other sources in Air/Water Studies 2 and 6. (ESC)

Response: The compounds analyzed under this study will include aromatic compounds and the C10-C34 alkanes, which will provide sufficient analytical information to describe different weathered states of oil and distinguish Prudhoe Bay oil from other sources.

Comment: Insufficient information is given in Technical Services 1 and Appendix A to allow evaluation of analytical methods, adequacy of the number of samples analyzed, or sample identification procedures. (ESC)

Response: Detailed documentation of analytical procedures, including data documentation, reporting, quality control measures, and the acceptance criteria associated with these procedures, as implemented by each laboratory, has been developed. The number of samples to be analyzed is determined on a project by project basis by the Project Leaders in consultation with biometricians using the Technical Services 1 procedures.

Comment: The statement in the Quality Assurance plan for chemical analyses in Technical Services 1 and Appendix A that "unacceptable performance in the intercalibration exercise will result in the discarding of associated data" is unclear. Intercalibration after samples have been analyzed may result in the discarding of valuable data and may bias results. Data should instead be reported with qualifications. (ESC)

Response: To date, no laboratory analyzing NRDA samples has performed unacceptably in the intercomparison exercises. If this occurs, the data associated with that laboratory for that time frame will be flagged in such a manner that they will not automatically be incorporated into data retrieval.

Comment: The list of calibration compounds in Technical Services 1 is insufficient to distinguish Exxon Valdez oil from hydrocarbons from other sources. It focuses on C12-C20 alkanes and ignores the C21-C31 alkanes that can indicate whether sediment hydrocarbons are predominantly biogenic rather than from the oil spill. (ESC)

Response: The list provided in the plan is a minimum. Analytical data are being collected on C10-C34 alkanes.

Comment: The analytical methods of Objective A cannot be judged since no details were provided, other than a minimum list of compounds, which are probably calibration standards. (ESC)

Response: Detailed documentation on analytical procedures including data documentation, reporting, quality control measures, and acceptance criteria associated with these procedures, as implemented by each laboratory, has been developed.

Comment: Details of the QA/QC plan for sample collection procedures were not provided in Objective B and cannot be fully evaluated. It is unclear how the sample labeling plan guarantees "unique" sample numbers across the entire 1990 program. (ESC)

Response: See Previous Response.

Comment: Data should not be excluded or discarded simply because unnecessarily tight performance standards are being applied in Objective C. It is not clear from this objective what "associated data" means. (ESC)

Response: Data that do not conform to the established standards are flagged in such a manner that they will not be automatically retrieved into a data sort. Associated data means those data developed by the indicated laboratory during that time.

Comment: The audits proposed in Objective D are incomplete. (ESC)

Response: The audits proposed meet federal standards. Refer to the Toxic Substances Control Act, part 792, Good Lab Practices Standards.

Comment: Construction of a material balance on the fate of spilled oil is a complex task that will be compounded by the use of data generated by possibly inadequate analytical techniques. (ESC)

Response: The methods that will be used to construct a material balance on the oil are well represented in the literature. For references see Boehm, McKay, or Payne.

Technical Services No. 3

Comment: Although the necessity and goals of the geographic information system (GIS) are clearly laid out, no information is given as to how this is to be accomplished or what specific products will be available. Considering that in the Coastal Habitat study much of the 1990 activities will involve completion of processing of samples taken in 1989, data completion and management is clearly a problem. (UM)

Response: Implementation of Technical Services 3 objectives will be accomplished with an interdisciplinary mapping and analysis team using state of the art mapping science methods and technology. Both hard copy and digital map products are being made available to ongoing study participants.

Comment: Insufficient information is given in Objective 1 regarding the specific types of maps and analytical products to determine whether this program will provide valuable products in monitoring geographic distributions of data pertinent to the assessment of injury from the EVOS. (ESC)

Response: Map types and analytical products are litigation sensitive; however, accepted mapping science methods will be used recognizing all data limitations.

Comment: The specific objective concerning the type of database(s) to be developed and organization of data is not provided. (ESC)

Response: Development of database(s) will include a geographic component that will provide for commonality of data types.

Comment: There is insufficient information given to allow the reader to determine the adequacy of quality control on the inputting of data to the mapping process. There is nothing that indicates how the data, once it is in the mapping database, compares to the original data. (ESC)

Response: Technical Services 3 adheres to accepted mapping methods using state-of-the-art technology that includes quality assurance steps that compare data input with source information and with subsequent iterations of database development.

Comment: No information is given regarding the statistical treatment to be used to average data values for input to the mapping process. Similar problems exist with respect to database quality control. (ESC)

Response: Real data will be inputted to the mapping process. Source data will be used to verify database input and output.

Comment: It cannot be determined from the Plan whether objective, "multi-thematic atlases of pre-spill data" exist on the same scale as post-spill data. Thus, it is not possible to assess whether this work will contribute to the objective quantification of injury to resources or whether it is cost-effective. (ESC)

Response: Objective "multi-thematic" atlases of pre-spill data exist and are central to the objectives of Technical Services 3.

ARCHAEOLOGICAL RESOURCES

Comments on Archaeological Resources

Comment: The studies evaluating and quantifying injuries to archaeological resources are beyond the scope of the Trustees' authority as these resources are man-made under the definitions found in CERCLA and the Clean Water Act. Under these federal statutes, costs cannot be recovered for restoration, replacement, or lost use of such resources. Archaeological resources are addressed in other federal statutes, such as the Archaeological Resources Protection Act, and study of damages to these resources should not be funded under the NRDA. (API, ESC)

Response: A valuation of the committed use of the cultural attributes of natural resources, as well as the natural components of cultural sites, is properly within the CERCLA/Clean Water Act damage assessment process. While other statutes may address injuries to archaeological resources, they do not preclude damage assessment activities undertaken pursuant to the CERCLA/Clean Water Act.

Comment: This study is poorly discussed and supported. Objectives and field, analytical, and statistical methodologies are not adequately described to allow review and comment. (API, ESC)

Response: The objective of this study is clearly stated to be the assessment of injuries to archaeological resources as a result of the EVOS. The study design is to request proposals from the professional community to meet the objective of injury assessment most efficiently and then to award a contract to perform the study. Because archaeological investigations are by nature labor intensive and therefore costly, the approach adopted is to use sample sites and statistically project the results to the population. This statistical approach is similar to the stratified approaches adopted in other damage assessment studies. Final approval of the methodology will occur when competing proposals to perform the study are evaluated.

Comment: This study does not take into account data gathered during beach cleanup. Much of the information to be generated by this study is already available to the Trustees because of the extensive beach surveys undertaken as part of Exxon's clean-up operations. Site survey and site selection efforts will duplicate Exxon's existing documentation. (API, ESC)

Response: The principal purpose of Exxon's beach survey work was to identify sites for cleanup. Archaeological investigations of the sites was limited. However, the data gathered by Exxon in 1989 and 1990 contributed to the development of a list of archaeological resource sites that were injured, from which selected study sites

were chosen. This study will intensively examine injuries through subsurface testing of sites and sampling of deposits to determine the extent of oiling contamination. Information obtained from Exxon-generated reports will be made available to investigators.

Comment: There is no explanation as to why surveys will be made in non-oiled areas. Site injury is a function of many factors (shoreline type, stratigraphy, location, degree of oiling, cleanup techniques and artifacts present) and the unique nature of individual sites, the range of their distribution and the diversity of time span make it inappropriate to extrapolate from control sites to oiled areas. (ESC)

Response: Archaeological sites are individually unique. As a result, the cost of investigating archaeological sites is high and the funds available to determine injuries are limited. Therefore, archaeological sites will be defined by site types and injuries will be determined from a statistically derived sample. In order to describe the population of sites most accurately and to give a basis for statistical treatment, a sample of study sites located in the general spill area was selected rather than biasing the study by only looking at oiled sites.

Comment: The costs of the study appear excessive. (ESC)

Response: Archaeological investigations are labor intensive and involve complicated and expensive laboratory analyses. Tests necessary to identify the presence of oil are costly. Additionally, the geographic study area is extremely remote. This factor causes very high logistical costs both for access and safety reasons.

Comment: There is insufficient information provided in the Plan to determine whether the methods to be employed will meet the standards and guidelines for archaeology and historic preservation set forth in 48 Federal Register 44716-44740 (September 29, 1983). (ESC)

Response: Because the Trustees are required to comply with applicable federal regulations, the procedures and investigators used to perform the study will be required to meet the standards presented by the Secretary of the Interior.

Comment: There is insufficient information to evaluate how the significance of historical properties, typologies, site

investigations, impacts resulting from interviews, soil column characteristics and analysis, radiocarbon dating of artifacts, vandalism, and erosion rates will be determined. (ESC)

Response: The significance of historic and prehistoric properties will be determined using processes outlined in existing federal regulations. The issue of site significance was addressed in the Memorandum of Agreement signed by Exxon, Federal agencies, the State Historic Preservation Officer, and Native Corporations. The validity of typologies, adequacy of site investigations, and effects of archaeological investigations will also be addressed following existing federal procedures and normal scientific archaeological standards. The degradation of spill-affected historic properties will be compared with properties that have not suffered oil spill-related injuries to arrive at rates of degradation.

Comment: There is no indication of methods for preventing bias from response workers and government employees who are interviewed from entering this study. Nor is there any information on how results will be used to quantify injury. (ESC)

Response: Information received from interviews will be evaluated for bias and verified. One of the goals of the study is to document injury to sites both quantitatively and qualitatively. Once the types of injury are estimated, those injuries can be projected statistically to the total body of archaeological data in the study area.

ECONOMICS

Comments on Economics Studies - General

Comment: Although some investigation of loss of private use values may be undertaken for reference, the NRDA process does not allow for recovery of such damages or for investigation for private interests. (API)

Response: The Federal Trustees do not intend to include loss of purely private use values in their damage claim.

Comment: The economic studies do not appear to be tied in any way to the Clean Water Act standards for measurement of damages based on cost of restoration. These studies attempt to estimate foregone use and non-use values without applying the results to the determination of whether restoration costs are grossly disproportionate to the value of the injured resource or the identification of the most cost-effective restoration alternative. The NRDA regulations do not permit the Trustees to recover for lost use values. (ESC)

Response: The Federal Trustees have not determined the extent to which the economic damage assessment will adhere to the NRDA regulations (43 C.F.R. Part 11). It is the Federal Trustees' intention, however, to base their claim on the cost of restoration, replacement and the acquisition of equivalent resources plus the interim lost use value of the injured natural resources as authorized in Ohio v. Department of the Interior.

Comment: It is not reasonable for the Trustees to expend large sums of money on studies of lost use before determining whether natural recovery will be chosen as the means of restoring the environment. (ESC)

Response: Lost use will continue to occur until natural and/or man-made recovery of the natural resources takes place. The Federal Trustees will continue to expend such funds as are necessary to accurately measure those lost uses for as long as it is prudent to do so. Length of recovery and restoration options are being studied in other components of this NRDA process and are communicated to the economic experts regularly.

Comment: Several of the economic studies are double-counting alleged damages: those relating to non-use losses of natives; changes in property values which include separately measured use value effects; and separately alleged losses in sport fishing and charter boat operations. There is no mention in the Plan of any methods for accounting for double-counting, which implies that the Plan will lead to an inflated damage award. (ESC)

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Response: The steps that are necessary to eliminate all double-counting in the estimates of lost value will be taken. There will be no double-counting in the federal economic damage claim.

Comment: Since the State's economic studies are not included in the Plan, there is a great likelihood that the federal and state economic studies are not coordinated or overlap. This will inflate assessment costs, reduce study quality and will double-count losses. Failure to include the State's studies in the Plan makes comment on the federal economic studies meaningless. Studies not contained in the Plan are "not reimbursable or admissible in the NRDA under federal law." (ESC, NRDC)

Response: The Federal Trustees are not aware of the contents of the State of Alaska's economic studies plans. Furthermore, the State of Alaska has chosen not to include any information about their economic studies in this document. The Federal Trustees do not view comments on their own economic studies plans as meaningless in the absence of information about the State of Alaska's economic studies plans.

Comment: The economic studies lack sufficient description of study objectives and methodologies to permit a thorough evaluation. (ESC, API)

Response: The economic study plans are intended to provide general notice of the types of economic studies that are being carried out or are contemplated. The Federal Trustees believe that the descriptions of the studies are adequate for that purpose.

Comment: Since the assumptions, tasks and objectives identified in the 1989 and 1990 Plans were the same and a budget of \$2.8 million was allocated for the economic studies in 1989, the status of the 1989 economic studies and expenditures made should be made available for evaluation of the 1990 study plans. (ESC)

Response: Information about the status of the previous years' efforts is litigation sensitive. The Trustees cannot reveal detailed information about that subject.

Comment: Many of the economic studies are undertaking expensive efforts to obtain data that should be available without cost from government and business sources. These include the demand for cruise ship tours, subsistence use data, identification of research studies underway before the spill, and data on the quantity and quality of fish. (ESC)

Response: All data necessary for estimating economic damages is being obtained at the least possible cost.

Comment: The Plan does not indicate that available substitutes for services affected by the spill, such as those existing in the unaffected areas of Alaska, Prince William Sound and the Gulf of Alaska, will be considered. Without this evaluation, the economic analysis will not be valid. (ESC)

Response: Where appropriate, availability of substitute resources and services will be taken into consideration in all of the economic studies.

Comment: The Trustees, in responding to public comment on the 1989 Plan, recognized that the NRDA regulations require the use of a 10% discount rate, but the 1990 Plan does not indicate that this rate is being used or, if it is not, how a different discount rate can be used. (ESC, APSC)

Response: The Trustees recognize that the NRDA regulations by reference to an Office of Management and Budget directive, require a 10% discount rate. Nevertheless, the NRDA regulations are optional, and there is no consensus among economists which would specify a particular discount rate as the only correct one.

Comment: The Trustees cannot select those portions of the regulations, such as the contingent valuation methodology, that inflate their claims and ignore others, such as the willingness-to-pay methodology. Willingness-to-pay is the only acceptable methodology for estimating damages using the contingent valuation technique. (ESC)

Response: The Trustees have selected economic methodologies that will result in the most accurate valuation of natural resource injury. The Trustees have not selected only those methodologies that will inflate their claims.

Comment: Economics 4, 8 and 9 are measuring speculative or potential, rather than committed, uses. Expenditures for this purpose are contrary to 43 C.F.R. Section 11.83(b). (ESC)

Response: The Federal Trustees will not include purely speculative damages in their natural resource damage claim.

Comments on Economics Studies - Specific

Economics Study No. 1 - Commercial Fisheries

Comment: This study fails to explain how it will exclude from consideration damages which are the subject of private economic claims. Hence double-counting will occur. They are not compensable under the laws and regulations that govern natural resource damage assessment. (ESC)

Response: The Federal Trustees have taken all steps necessary to eliminate double-counting from their final economic damage estimates. The Federal Trustees do not intend to include private damages in their claim.

Comment: There is no description of the methods to be used to measure the economic loss to seafood consumers. (ESC)

Response: The purpose of this plan is to provide public notice of the types of economic studies contemplated by the Federal Trustees. It is not intended to provide detailed descriptions of the specific methods being used owing to the litigation sensitive nature of the study.

Comment: The losses this study purports to measure are known already to be negligible. Salmon supply increased significantly in 1989 and prices decreased for reasons not associated with the spill. The net result did not have a detectable influence on consumer surplus. (ESC)

Response: The Federal Trustees are not aware of any studies that show that the EVOS caused only negligible losses to consumers of seafood products.

Comment: Modelling of the effects of the spill on seafood quality and quantity changes on consumers is unnecessary because quantity was substantially higher at every market level and because the State of Alaska assured that no quality-deficient seafood reached the market. (ESC)

Response: Appropriate data sets on the landings and values of Alaskan seafood products will be analyzed for evidence of quantity and quality changes caused by the EVOS. Other data, as appropriate, will also be collected and analyzed. Since it may be several more years before the spill's long-term effects on fish populations is known, it is premature to draw firm conclusions about the potential damages to consumers of seafood products.

Comment: There appears to be no relationship between this study and the numerous fish injury assessment studies. (ESC)

Response: This study will make use of the results of the fish injury studies, as appropriate.

Comment: Much of the data necessary to estimate commercial fisheries losses is available from state and federal sources, so the efforts to collect such data in this study are unnecessarily costly and duplicative. (ESC)

Response: The Trustees will use all accurate available data sources. No unnecessarily costly or duplicative data will be collected by the Federal Trustees.

Economics Study No. 4 - Public Land Effects

Comment: Nothing in the Clean Water Act or the NRDA regulations permits the Trustees to recover for damages such as those being measured by Economics 4: the purported losses are those to the commercial value of public lands if those lands are sold to a third party by the government. They are not natural resource losses. (ESC)

Response: The Federal Trustees believe that public lands constitute public natural resources. Thus, any change the EVOS caused in the value of public lands is a natural resource injury.

Comment: Description of the methodology of this study is extremely vague and insufficiently detailed to permit a thorough evaluation. (ESC)

Response: The purpose of this Plan is to provide notice to the public of the types of studies being carried out or contemplated. This notice is not intended to provide information sufficient for a thorough evaluation of all aspects of the studies.

Comment: The study does not identify the public lands to be included in the assessment. Damages cannot be assessed for lands not directly impacted by oil. (ESC)

Response: The study will identify all public lands that the Trustees believe were impacted by the EVOS.

Comment: The study cannot meet its objective of determining the change in market value of public lands simply by estimating pre-

and post-spill prices. It must take into account factors unrelated to the spill such as changes in interest rates, but there is no indication of the method by which this will be done. (ESC)

Response: This study will take into account all relevant factors appropriate for estimating damages. It is not the purpose of this Plan to present detailed information about the methods and data being used to estimate damages for this (or any other) category of loss.

Comment: The study must also factor in the effects of spill-related increases in land values. Land values in the affected area are influenced by the dominant role of public lands, use restriction, severe weather, poor access and low population density. Also, there is nothing in this study indicating methods for determining whether lands affected by previous spills are comparable to lands in this area or for determining the comparability of EVOS to prior spills. (ESC)

Response: This study will take into account all relevant factors appropriate for estimating damages. It is not the purpose of this Plan to present detailed information about the methods and data being used to estimate damages for this (or any other) category of loss.

Comment: This study will lead to the double-counting of some damages because damages for some uses of public lands will be covered by other studies, e.g., recreation and foregone use. (ESC)

Response: This study will not necessarily lead to double-counting of damages. The Federal Trustees will ensure that the final damage estimate does not contain any form of double-counting.

Comment: Reduced land values become actual losses only to the extent that sales actually occur during the period of depressed value, so the study must focus only on losses actually incurred, not hypothetical losses. (ESC)

Response: Property values in the region affected by the EVOS may have been damaged, regardless of whether the losses were actually realized through transactions which occurred during the period of depressed land prices.

Comment: The Plan incorrectly assumes that losses in sale prices of public land leased or sold in 1989 apply to all public land in the affected area. (ESC)

Response: The economic methodology contemplated for this study does not necessarily assume that all public land in the region has been adversely affected by the EVOS.

Comment: There is a great number of near substitutes for almost any parcel of land in Alaska, so compensable damages to land values should be very low, due in part to the fact that a large percentage of land in the state is publicly owned and is rarely subject to sale. Given these facts, it is likely that the study costs will be unreasonable. (ESC)

Response: There are many factors that contribute to the value of any given parcel of land. All relevant factors will be taken into consideration in the assessment of damages to public lands. The Federal Trustees will not incur unreasonable costs in the pursuit of the NRDA for this or any other category of loss.

Comment: Paired-sale data should not be used since it is not appropriate to compare pre-and post-spill selling prices. (ESC)

Response: Paired-sale data will be used in this assessment only when doing so is consistent with appropriate economic and legal theories.

Comment: There is no provision for the recovery of land value that stems from cleanup and restoration. (ESC)

Response: All damages to land values consistent with appropriate economic and legal theories will be estimated.

Comment: The status of the 1989 study and the corresponding expenditures should have been made available for review of the 1990 Plan since there was so little change in the study premises and objectives between the two years. (ESC)

Response: The purpose of this Plan is to provide the public with a general notice of the types of studies being carried out or contemplated for the NRDA. Hence, unless the type of study described in the Plans of earlier years has changed, there is no reason to revise the general description provided previously. Detailed information about the status of the studies and expenditures to date is litigation-sensitive and therefore has not been included in this public document. The Trustees believe that they have provided adequate information to achieve the intended purpose of this Plan.

Economics Study No. 5 - Recreation

Comment: This study fails to explain how it will exclude from consideration damages which are the subject of private economic claims. Hence double-counting will occur. (ESC) Nor does it explain how double-counting of recreational fishing and boat charters for sport fishing and sea kayaking and boat charters for kayak transportation will be avoided. Also, damages included in this study duplicate in part those included in Economics 4. (ESC)

Response: No duplication or double-counting will be permitted in the estimation of natural resource damages caused by the EVOS.

Comment: Economics 5 does not define "natural resource services" precisely, which may result in the underestimation of damages: recreational fishing is defined from the global perspective rather than by species of fish; no distinctions are made for the wide variety of camping activities in Prince William Sound. The categorization of recreationists is unrealistically simple and not useful. Visitors to the Sound normally engage in a multiplicity of activities that overlap rather than individual ones. Placing each recreationist into one category lowers the value of the experience of that recreationist in the wilderness of the Sound, which can underestimate damages. (NWF)

Response: The Federal Trustees have never suggested that they intend to categorize recreationists in such a way as to be "unrealistically simple" for purposes of the economic assessment. Recreation damages will be estimated using state-of-the-art methods consistent with sound economic theory.

Comment: The study's assumptions ignore the facts that the most popular sea kayak and charter boat destinations (College Fjords and Columbia Glacier areas) were unaffected by the spill and the fact that increased escapement due to closure of commercial salmon fisheries led to increased sport fishing catches. If considered, these facts would influence study design and scope. (ESC)

Response: The study design and scope have been influenced by all relevant information about factors such as salmon fishing, recreational use patterns, and areas impacted and non-impacted by the EVOS.

Comment: Without details concerning its application to this study, it is not possible to ascertain whether the use of contingent valuation will provide valid or reliable results. It is an unproven and controversial methodology. (ESC)

Response: The Federal Trustees believe that contingent valuation is an appropriate method for valuing natural resource injuries. Use of contingent valuation methodology was approved by the court in Ohio v. Department of the Interior.

Comment: It is not clear from this study whether losses to commercial providers of recreational services will be estimated. They should not be since compensation is available to the Trustees only for foregone public use of publicly owned natural resources. (ESC)

Response: The Trustees do not contemplate estimating purely private losses.

Comment: There is no description of the methodology to be used for determining the spill's effect on the demand for cruise ship tours to Prince William Sound. (ESC)

Response: This Plan is not intended to provide detailed descriptions of the various economic studies. The Federal Trustees believe that the study descriptions provided are sufficient to provide general notice of the types of studies contemplated.

Comment: There is not enough detail to assess how substitution will be accommodated. (ESC)

Response: The availability of substitutes will be considered in all studies that measure the value of goods for which substitute goods are available.

Comment: The Plan indicates that virtually no work on this study was carried out in 1989. It is important to obtain data relevant to the purposes of this study while it still can be recalled accurately by the source. (ESC)

Response: The Federal Trustees agree that much of the data is time-sensitive. The Trustees have made every effort to gather all data as expeditiously as possible.

Comment: There is no reference to which "existing model for recreational fishing in the KP area" will be considered, the criteria that will be used to determine its applicability, what will be done in the event that the model is determined to be inapplicable or the geographical area to be examined. (ESC)

Response: The Federal Trustees do not intend for this Plan to include all details of the damage assessment methods they will be using.

Comment: Much of the data to be acquired in this study, such as cruise line bookings and sport fishing catch rates, is available from federal, state and business sources. Duplicating this data is unnecessary and costly. (ESC)

Response: The Federal Trustees will use the most cost effective sources they can identify to obtain data necessary for the estimation of economic damages.

Economics Study No. 6 - Subsistence

Comment: Documentation of the study plan is inadequate and there is no explicit objective stated in the Plan. Methods are not provided. (ESC)

Response: The economic study plans are intended to provide general notice of the types of economic studies that are being carried out or are contemplated. The Federal Trustees believe that the descriptions of the studies are adequate for that purpose.

Comment: This category of alleged losses is the subject of other claims, including those by native groups. This study may double-count these losses. (ESC)

Response: The Federal Trustees will take all necessary steps to eliminate double-counting from their economic damage estimates.

Comment: Alleged losses of non-use values by subsistence communities are included in Economics 7 and 9. There is no method described in this study for distinguishing subsistence populations from the relevant populations in Economics 7. Nor is there a method provided for quantifying archaeological-based non-use values referred to in Economics 9 or reducing the non-use values estimated in other studies accordingly. These deficiencies will produce double-counting. (ESC)

Response: The Federal Trustees will take all necessary steps to eliminate double-counting from their economic damage estimates.

Comment: To the extent that contingent valuation will be used in this study, it should be noted that this is an unproven and controversial technique and there are not sufficient details in the

study description to determine whether its use will produce reliable or valid results. (ESC)

Response: The Trustees believe that contingent valuation is an appropriate method for valuing natural resource injuries. Use of contingent valuation methodology was approved by the court in Ohio v. Department of the Interior.

Comment: There is no indication that the study will take into account the actions undertaken by Exxon Shipping Corporation, such as delivery of food and materials and payment for cleanup employment, to offset losses sustained by subsistence groups and to explain why they ceased to rely on traditional sources. (ESC)

Response: The Federal Trustees will take into consideration all relevant factors appropriate for accurately measuring economic damages.

Comment: The description contained in the 1990 Plan indicates that virtually no work was done on this study in 1989. The Trustees should make available the expenditures and status of this study. (ESC)

Response: Detailed information about the status of the studies and expenditures to date is litigation-sensitive and therefore is not included in this public document.

Economics Study No. 7 - Contingent Valuation

Comment: To the extent the State is conducting a contingent valuation study, the rationale for the Federal government to conduct a similar one is not apparent. (NRDC)

Response: The state and federal governments are pursuing separate claims that are likely to be heard in separate courts. The federal government has no control over, or information about, the state economics studies. Therefore, the Federal Trustees are performing their own economic studies.

Comment: The Trustees are using contingent valuation techniques to determine the value of some resources which appear to be non-public. (API)

Response: The Trustees will not use contingent valuation, or any other economic methodology, to measure injury to any purely private resources.

Comment: Contingent valuation's reliability for non-use values, such as intrinsic value, is controversial. Such methods are not supported by the literature. Unless the Trustees exercise care in their design and implementation, the results of these studies may not be reasonable. They are not likely to provide valid or reliable estimates of damages in the circumstances of this case. (API, ESC,) The difficulty of separating the use and non-use components of a contingent valuation response dictate against use of contingent valuation in this study. (ESC)

Response: The Trustees are proceeding very carefully with their contingent valuation study which is being performed by recognized experts in the field and which will be peer reviewed by nationally renowned economists. There is no need to separate the use and non-use components of contingent valuation responses.

Comment: The public is poorly informed as to actual conditions in Prince William Sound. Before contingent valuation questions are asked, it is important to assure that the respondents are given accurate information. (API)

Response: Contingent valuation respondents will be provided the amount and type of information deemed most appropriate for accurately measuring the natural resource damages.

Comment: Economics 7 does not describe: the survey plan; the survey design; the methods by which survey results will be analyzed; the type of research to be conducted to determine the accuracy of survey instruments; the type of preliminary testing that will be done; the basis for conducting a nationwide survey; or the type of econometric analysis that will be used. (APSC, API)

Response: The economic study plans are intended only to provide the public with general information about proposed and ongoing studies. The Trustees believe that the published plans achieve that goal.

Comment: There is no explanation as to how Economics 7 will exclude the lost public land, recreation, subsistence, research, and archaeological values that Economics 4, 5, 6, 8, and 9 purport to measure. (ESC)

Response: The economic study plans are intended only to provide the public with general information about proposed and ongoing studies. The Trustees believe that the published plans achieve that goal.

Comment: The description of Economics 7 implies that that study will duplicate some portion of the state's economic studies. (ESC)

Response: The state economics studies are proceeding separately from the federal studies.

Comment: There is no legal basis for recovery of damages based on "intrinsic values." (ESC)

Response: The Trustees are obligated to study and to recover for all lost value to natural resources caused by the oil spill. Intrinsic values are a well-recognized component of the total value of a good, and the court in Ohio v. Department of the Interior held that use value is not the sole component of natural resource value.

Comment: Bequest values will not be reduced because full restoration of the natural resources will occur within a relatively short period of time. There cannot be losses of existence or bequest values for temporary injuries to natural resources. And option value losses should be small because future use is not expectedly to be adversely affected by the spill. (ESC)

Response: Bequest, option, and existence values may have been reduced by the EVOS because complete restoration of the injured natural resources may not occur and public perception of the value of the injured natural resources may be altered for an extensive time period.

Comment: Non-use value losses have been confined in the relevant literature to permanent, irreversible injury to unique resources. The extension in this study of non-use loss concepts to temporary injury to resources for which there are vast numbers of substitutes is contrary to the basic principles underlying these concepts. (ESC)

Response: There may have been permanent and irreversible injury to natural resources affected by the EVOS. Even if complete recovery does occur, contingent valuation is an appropriate methodology to use to measure decreased value of injured natural resources from the time of injury to the time of recovery.

Comment: Natural resource economists generally no longer consider option value to be a separate source of value. Hence the Trustees should not include option values as a component of value. Nor should the present discounted value of future use be included within the category of use value losses. Otherwise, double-counting will occur. (ESC)

Response: The Federal Trustees believe that all aspects of intrinsic value of the injured natural resources are recoverable. The Trustees do not believe that including present discounted value of any future lost use values will result in double-counting.

Comment: Use of willingness-to-accept measures in this study would contradict the NRDA regulations which provide that the only acceptable contingent valuation methodology requires use of willingness-to-pay measures. (ESC)

Response: Both willingness to pay and willingness to accept will be considered in the contingent valuation study. The Federal Trustees will use the measure that most accurately values the loss.

Comment: There is not an adequate description of the statistical design or quality assurance provisions of this study or any indication of the method for defining the sample population or drawing a representative sample. (ESC)

Response: The economic study plans are intended only to provide the public with general information about proposed and ongoing studies. The Trustees believe that the published plans achieve that goal.

Comment: The budget is inadequately explained. Of note is the \$670,000 for supplies and equipment. (ESC)

Response: The economic study plans are not intended to provide detailed information about the budgets for various studies.

Comment: Because the 1989 and 1990 descriptions of this study are so similar, the Trustees should make known the progress and expenditures made to date. (ESC)

Response: The economic study plans are intended only to provide the public with information about proposed and ongoing studies. Detailed information about progress and budgets is litigation sensitive and cannot be provided in this public document.

Economics Study No. 8 - Affected Research

Comment: Loss of information associated with the interruption of scientific studies does not constitute a natural resources injury compensable under relevant statutes or DOI regulations. (API)

Response: The Trustees believe that the relevant statutes and the DOI regulations entitle them to recover for losses to the various services provided by the natural resources. One such service is the provision of scientific information that may be learned through scientific studies.

Comment: This study is to account for the cost of resources expended on research programs affected by the spill, but these expenditures should be the subject of private claims by the research program sponsors, not the Trustees. They are not natural resource injuries for which recovery can be had under the relevant statutes or the DoI regulations. And whatever losses in knowledge might have occurred will be offset by the knowledge gained as a result of spill-related research. (API, ESC)

Response: The loss of scientific information provided by public natural resources is a public loss that the Federal Natural Resources Trustees should value. The Trustees do not view the research expenditures necessitated by the EVOS as a public benefit.

Comment: There is no identification of the research activities that were delayed or canceled as a result of the spill. Thus, it is not possible to determine whether the study costs are reasonable. (ESC)

Response: The study of affected research programs will inventory the research activities that were damaged or destroyed by the EVOS. These study plans and their budgets were intended only to provide the public with general information about the studies, not to reveal detailed information about the plans themselves or about the corresponding budgets.

Comment: The Plan does not set forth the criteria that will be applied to assure that assessment is directed to committed uses of the resource. (ESC)

Response: The "committed use" requirement derives from the NRDA regulations which are optional. Thus, the Trustees need not limit their studies to committed uses of the injured natural resources. Nevertheless, the Trustees do not intend to measure losses associated with purely speculative uses.

Comment: The Plan fails to set forth how the "total project costs, extra sums expended amounts spent on each study" will be used to evaluate research losses. (ESC)

Response: The economic study plans are intended only to provide the public with general information about proposed and ongoing studies. The Trustees believe that the published plans achieve that goal.

Comment: Because the 1989 and 1990 descriptions of this study are so similar, the Trustees should make known the progress and expenditures made to date. (ESC)

Response: The economic study plans are intended only to provide the public with information about proposed and ongoing studies. Detailed information about progress and budgets is litigation sensitive and cannot be provided in this public document.

Economics Study No. 9 - Archaeological Damage

Comment: There is no explanation for inclusion of the remains of past human activity within the definition of "natural resources." (ESC)

Response: A valuation of the committed use of the cultural attributes of natural resources, as well as, the natural components of cultural sites is properly within the natural resources damage assessment process.

Comment: The Plan contains no methods for assuring that double-counting will be avoided. This study potentially will double count the following alleged loss of value of archaeological resources as tourist attractions, which is also being studied in Economics 5, and archaeological science value, which is also being assessed in Economics 8. As to the latter, "intrinsic values" held by native groups will be counted three times unless there is some available method for dividing this value into subcomponents for existence values of archaeological resources, existence values for cultural heritage and culturally-derived intrinsic values held by native groups as members of the general population. (ESC)

Response: The Trustees note these concerns and intend to perform their studies so as to avoid double-counting.

Comment: There is no description of the methods for measuring economic damages and no explanation for valuation of allegedly damaged sites. (ESC)

Response: The economic study plans are intended only to provide the public with general information about proposed and ongoing studies. The Trustees believe that the published plans achieve that goal.

Comment: There is no identification of the unique archaeological sites that have value as tourist attractions. (ESC)

Response: All archaeological sites are unique and may have a use value as tourist attractions.

Comment: Because the 1989 and 1990 descriptions of this study are so similar, the Trustees should make known the progress and expenditures made to date. (ESC)

Response: The economic study plans are intended only to provide the public with information about proposed and ongoing studies. Detailed information about progress and budgets is litigation-sensitive and cannot be provided in this public document.

RESTORATION PLANNING

Comments on Restoration Planning - General

Comment: The Restoration Planning Project does not provide enough information on objectives or on field, analytical and statistical methodologies to permit adequate review. (ESC)

Response: The objective of the 1990 plan was to provide summary information on individual studies, adequate for reviewers to understand the scope of the study and the interrelationships between studies, as well as the scope of the overall damage assessment program.

Comment: In order for the public to effectively participate in the restoration process, the results of the feasibility studies are needed. (NRDC)

Response: The information in the 1990 plan was provided to give the public a general understanding of restoration activities to be conducted in 1990. Additional information on the results of the feasibility studies will be published in a Federal Register Notice.

Comment: Many of the components of the restoration program are actually research. The program develops and tests unproven methods, such as the murrelet dawn detection technique, that do not focus on restoring the ecosystem. (ESC)

Response: Identifying and developing technically feasible restoration procedures for natural resources and services affected by the spill is an objective of restoration planning. Restoration will focus broadly on the recovery of ecosystems as well as individual components.

Comment: There is no information in the Restoration Planning Project as to the extent to which results of the technical studies were considered, if at all, in creating its objectives. Without such coordination, the undertaking of restoration studies is premature. (ESC)

Response: The restoration process is a dynamic process that allows for the incorporation of new information as it becomes available. The objectives for restoration include incorporating the results of technical studies in the selection of any restoration measures.

Comment: The Plan inadequately deals with the role to be played by natural recovery in the restoration process. The literature regarding historical spills indicates that natural recovery is a viable restoration option and one to be preferred. And the

extensive natural recovery that has already occurred makes natural recovery the most cost-effective and environmentally sound restoration option. (API; APSC; ESC)

Response: Natural recovery monitoring will help determine the nature and extent of any natural recovery that is occurring. If natural recovery appears to be adequate, and within a reasonable time-frame, no direct restoration projects will be implemented. Information on the adequacy of natural recovery is central to determining whether to implement restoration actions or to allow injured resources to recover on their own.

Comment: The Plan assesses damages regardless of the prospects for natural recovery. Many of the studies are designed to demonstrate only that there are differences between oiled and unoiled areas without any consideration of whether these differences result in lost use or whether it would be desirable to correct these differences with restoration measures. (ESC)

Response: Identifying injured resources is the first step in the restoration process. Additional steps include determining the need for restoration, identifying potential restoration alternatives, evaluating potential restoration alternatives, implementing restoration alternatives on a continuing basis and evaluating the effectiveness of restoration activities. Even if natural recovery is deemed adequate, the Trustees are authorized to recover the lost use value of the resource during the period of recovery.

Comment: There is no connection between the restoration alternatives set forth in the Plan and the economic work evaluating the need for restoration and determining whether any of these projects are supportable in light of natural recovery. (ESC)

Response: An integral component of the restoration planning process is to determine the nature and pace of natural recovery of injured resources, and identify where direct restoration measures may be appropriate. All proposed restoration alternatives will undergo economic and environmental analyses to determine whether these projects are justified in light of natural recovery.

Comment: Restoration studies are only necessary if technical studies show that a resource will be adversely affected for a long period of time. Restoration studies that are being conducted before the results of the assessment studies are available must assume that all resources are injured and will require restoration measures. This approach requires the unnecessary expenditure of monies for feasibility studies and literature searches concerning resources that are later determined not to require active restoration measures. While this approach may shorten

implementation time once the damage assessment process is over, it unwisely expends resources with little, if any, hope of benefit. (ESC)

Response: The Trustees disagree that restoration studies are only necessary if a resource will be adversely affected for a long period of time. Restoration studies may concern any degree of injury to a natural resource in order to determine whether to enhance natural recovery. During the course of the NRDA studies, where the nature of the resource injury is reasonably clear, and where no alternatives would be foreclosed, it may be desirable to begin implementation of certain restoration activities prior to the conclusion of the NRDA studies and a final restoration plan.

Comment: The focus of the Plan should be redirected toward the identification of alternative restoration strategies. The Plan incorrectly assumes that all resources were injured and that additional research is needed. (ESC)

Response: The Trustees have determined that in some instances they can begin identification of restoration strategies, but they have not obtained a full picture of injuries to all resources and for this reason will continue to study certain resources. When appropriate, further study of particular species will be discontinued. The Plan does not assume that all resources were injured; rather the Trustees are obligated to uncover injuries to all natural resources.

Comment: The Plan fails to focus on restoration. The restoration section of the plan is too cursory and the assessment therefore will not be cost-effective or produce a usable result. Cost-effectiveness does not appear to be a criterion of the Plan and does not play a role in the identification and selection of feasible restoration measures. (API, APSC)

Response: Restoration is receiving increased emphasis as the results of the damage assessment studies are analyzed. Cost-effectiveness is one of several criteria used to determine the appropriateness of a restoration option.

Comment: Thus far the Trustees have attempted to identify restoration approaches that have been used in the past, and then have pursued feasibility studies for other methods which may be costly or less proven. (API)

Response: Restoration options that have worked in the past or have known potential are the first options that were evaluated. Feasibility studies focus on identifying methods that are not as well-established in the sub-arctic conditions of the oil spill area.

Comment: Implementation of restoration strategies should only be undertaken at this stage if their funding does not diminish that available for damage assessment and they are limited to funding urgently needed acquisition projects or initiating pilot restoration projects that have a firm foundation in restoration studies that have been completed and analyzed. (NWF, NRDC)

Response: The Trustees and EPA view the entire restoration process as dynamic and evolving. As information about injuries, resource recovery, restoration methods or costs becomes available, certain activities may be recommended and implemented prior to completion of all damage assessment studies.

Comment: Any restoration projects conducted before the assessment is complete should be funded separately. Although the plan refers to pilot restoration projects, many of the experts consulted have stated that only after several years of damage assessment have been completed can a decision be made regarding the restoration measures to be undertaken. (NRDC)

Response: Any restoration projects that may be implemented prior to the completion of the assessment process will not be funded with monies appropriated for damage assessment activities, but will be funded separately. Restoration projects that are urgently needed to protect or restore injured resources may be implemented if they do not disturb ongoing damage assessment studies.

Comment: The types of restoration projects considered in the Plan are limited. More attention should be paid to acquisition of equivalent assets such as reacquiring timber rights in Prince William Sound and buying back the Bristol Bay oil leases. (NWF, NRDC)

Response: Acquisition of equivalent resources is one restoration option being evaluated.

Comment: Although Ohio v. Department of the Interior indicated that restoration or replacement of resources is the object of damage assessment, it also recognized where costs were grossly disproportionate to loss, such restoration should not be undertaken. (API)

Response: The value of the resource being restored, and the cost of restoration options, will be evaluated before any recommendations to conduct restoration projects are made.

Comment: Few restoration projects are scheduled for action. Restoration projects now consist primarily of workshops, public meetings and comment, and additional feasibility studies. Most of the restoration research remains piecemeal. (API)

Response: As more information becomes available on the nature and extent of damaged resources, additional restoration options will be identified. Workshops, public meetings and comments were, and will continue to be, solicited to help identify possible restoration options.

Comment: Feasibility studies are supported in advance of more expensive restoration activities when restoration has been justified and the realistic means for restoration have been found. Feasibility studies should be realistically selected from methods that have been successfully used in the past. (API)

Response: Due to the dearth of restoration information related specifically to the spill area, feasibility studies may be conducted in the oil spill area using methods that previously have not been employed in the sub-arctic environment as well as well-established methods that have been identified through the damage assessment process.

Comment: The 1990 Plan improperly focuses on potential injuries to natural resources without analyzing the need for restoration or the means to restore damaged resources, replace those that cannot be restored or acquire equivalent resources if restoration is required. Thus, the Plan does not provide a reasonable basis for recovering damages under the Clean Water Act or the NRDA regulations. (ESC)

Response: Before appropriate restoration activities can be fully implemented, it is necessary to make a tentative conclusion regarding natural resources injury. Restoration under the DOI regulations is a four step process: (1) The injured resources are identified; (2) The extent of injury is quantified; (3) A restoration methodology plan is developed to the level of detail required to determine the cost of restoration; and (4) After litigation or settlement, a final restoration plan is developed. The Trustees are acting in a manner consistent with these regulations.

Comment: Section 311(f)(4) and (5) of the Clean Water Act clearly makes the cost of restoration, replacement or acquisition of equivalent resources the exclusive measure of damages. There is no authority for recovery of lost use values. Lost use values can be used only to determine whether proposed restoration techniques are grossly disproportionate to the value of the injured resource and/or to determine the cost-effectiveness of various alternatives for achieving restoration. The Plan ignores this concept. (ESC)

Response: While lost use values may be used for the purposes suggested above, Ohio v. Department of the Interior, 880 F.2d 432 (D.C. Cir. 1989), makes it clear that lost use values may also serve as a measure of damages under section 311 of the CWA.

Comment: The Clean Water Act and the NRDA regulations refer only to "acquisition of equivalent resources." There is no authority for the Plan's expansion of this concept to include acquisition of equivalent goods and services. (ESC)

Response: While the use of NRDA regulations is optional, the regulations generally define "acquisition of the equivalent" as the substitution of an injured resource with a resource that provides the same or substantially similar services. 43 C.F.R. § 11.14(a).

Thus, any restoration option that includes the acquisition of equivalent resources therefore, properly may consider the services those resources provide, both to the ecosystem and to humans.

Comment: The Plan contemplates calculation of natural resource damages independent of the cost of reasonable restoration activities for the recovery of natural resources affected by the spill. This contradicts the fundamental purpose of the damage assessment, which is restoration. (ESC)

Response: The Trustees are directing the damage assessment and restoration planning processes with the objective of restoring injured resources. As indicated in Ohio v. Department of the Interior, the cost of restoration is not the sole measure of damages.

Comment: The Plan fails to include cost-effectiveness criteria in its evaluation of restoration alternatives. It refers on page 333 only to the identification of costs of implementation of restoration measures without referring to the benefits associated with those measures. And on page 336, the list of criteria for selecting restoration feasibility projects makes no reference to any requirement that restoration be more cost-effective than natural recovery. (ESC)

Response: The services provided by the resource, as well as the cost of implementing the restoration measure, will be evaluated before any restoration option is selected. The requirements for restoration include cost-effectiveness and the standard that the cost of the restoration measure not be grossly disproportionate to the value of the resources or services restored.

Comment: The Plan seems to assume that the environment must be restored to a pristine state. Support for this is not found in the Clean Water Act, the NRDA regulations or in Puerto Rico v. S.S. Zoe Colocotroni. Restoration measures should simply return or replace resource services to their baseline condition. (ESC)

Response: The intent of the restoration process is to return the injured resources to their baseline condition. This includes not only their biological condition but also their ability to provide the previous level of services.

Comment: The Trustees are responsible for selecting a cost-effective restoration program; the public's participation in this process is unproductive since the public does not have any independent knowledge about injuries or restoration needs. Public meetings held to develop lists of restoration ideas create expectations in the public that are not justifiable given the actual state of the environment. (ESC)

Response: The Trustees believe that public involvement is an important part of the restoration process. The commenter's desire to increase the influence of responsible parties while excluding the public is inconsistent with the goals of the restoration process.

Comment: The Trustees alone are responsible for choosing active restoration measures. The restoration project's emphasis on public involvement is contrary to the regulatory requirements since it is not cost-effective and distracts the Trustees from focusing on the technical information needed to identify whether specific restoration measures are needed. (ESC)

Response: While the decision to plan for implement restoration activities does rest with the Trustees, they have determined that public participation is important to the damage assessment and restoration planning process. To invoke the public in this process is not contrary to the assessment regulations and assists the Trustees in identifying information important to the restoration process.

Comments on Restoration Planning Activities - Specific

Restoration Technical Support Project No. 1

Comment: The Introduction's statement that "an additional more formal round of peer review is not possible" implies that the "comments received at the technical workshop and series of public meetings" were part of a review process. These meetings were part of an informational effort, not a review process. This statement also implies that the projects were conceived and initiated hastily. They should have been conceived during the winter and aired for comment by interested parties before they were undertaken. (ESC)

Response: Comments received during public technical workshops and meetings were considered during the process of proposing feasibility studies for the 1990 field season. In addition, experts were consulted during other non-public technical workshops.

Comment: The peer review process described appears to be flawed and may generate biased comments. Some of the peer reviewers may have a vested interest in the outcome since they are part of the NRDA process. No information about the reviewers is provided to ensure that such bias does not occur and that a thorough technical review will be made. (ESC)

Response: It is not necessary to list the names of individuals providing expertise in order to review the validity of the studies. Every effort has been made to ensure that a balanced, objective review occurs for each study.

Comment: The cost-effectiveness of this project's review of 1990 feasibility study results is questionable given that those projects are not justified. (ESC)

Response: The cost of this study is reasonable. The peer review process ensures that proposed feasibility studies are appropriate for implementation.

Restoration Technical Support Project No. 2

Comment: This project should have as its objective natural recovery. (API)

Response: The goal of this project is to create a database of information that will help identify areas where direct restoration is appropriate.

Comment: Acquisition-based restoration studies, such as Project No. 2, are premature and unwarranted since there has been no showing that impacted resources and their respective services cannot be restored or replaced. (ESC)

Response: This project is designed to provide information necessary to determine appropriate restoration procedures that are not limited to acquisition.

Comment: This project is neither cost-effective nor focused. It obtains, translates and analyzes data for all the major resources instead of concentrating only on those resources that are in need of restoration efforts. This study's support of off-site habitat acquisition is premature since it has not been shown that impacted habitats cannot be restored. (ESC)

Response: It is appropriate to have a database that shows the status of all resources potentially impacted by the oil spill so that all reasonable restoration options can be analyzed. It is intended to provide a base from which candidate sites for restoration or acquisition can be identified.

Comment: No information is given for evaluation of the type, amount or usefulness of the information to be integrated, the procedure to be used or any quality assurance checks to be employed. And it is unclear whether natural recovery processes will be incorporated into the final result. (ESC)

Response: The information is being reviewed to ensure that it is in an appropriate format for use in the overall restoration planning process. The information provided may also prove advantageous for documenting natural recovery processes that may be occurring.

Restoration Technical Support Project No. 3

Comment: There is no basis for this type of study given that there has not been an identification of injuries requiring restoration. This approach to identifying and developing restoration plans is neither focused nor cost-effective. And there is no consideration given to the ability of the natural resources damaged to recover naturally. (ESC)

Response: This project established a process for developing and reviewing feasibility studies to be considered for implementation in 1991. No decisions have been made about which studies to actually carry out, pending further evaluation of damage assessment.

study results. The ability of natural resources to recover naturally is being taken into account; one of the feasibility studies considered would explore methods for monitoring of natural recovery rates.

Comment: There is not enough information given to evaluate the nature and content of the meetings or how future project plans will be more fully developed. (ESC)

Response: More information will be provided about feasibility study proposals prior to implementation in the field.

Comment: There is no way to determine whether and how cost-effectiveness criteria will be considered and whether the focus is solely on restoring oil-spill related injury. The artificial reef project is suspect because there are no confirmed fish kills, reefs were not impacted by oil, and water quality is good. (ESC)

Response: Cost-effectiveness criteria will be considered before implementation of any restoration project, and one of the purposes of conducting feasibility studies is to establish the costs associated with implementation. Construction of artificial habitats for fish and shellfish can enhance productivity and may be one means of restoring damaged population. No decisions have been made about the for, or appropriateness of, such measures in the oil-spill environment. It was cited here as an example of the type of restoration project for which a feasibility study might be need.

Feasibility Study No. 1

Comment: This feasibility study is unnecessary since there is evidence that this resource is recovering rapidly. Recruitment has proven to be effective for restoring oiled shoreline areas, so the benefits of natural recovery will far outweigh those of any of these restoration efforts. (ESC)

Response: Based on further surveys conducted prior to actual field work, the study was modified to determine the causes of variation in fucus recovery and document the extent of natural recruitment in areas disturbed by oil and cleanup efforts. Understanding the causes of natural variation in recruitment may suggest restoration measures to enhance the natural process.

Comment: The majority of this study appears to be research and should not be funded under the NRDA program. Objectives B, C, D and E should only be considered if Objective A reveals that there is a definite need. Otherwise, implementing all of these objectives at the same time is not cost-effective. (ESC)

Response: Objective A was the primary focus of the 1990 study. Objectives B, C, D, and E were modified based on the results of natural recovery monitoring.

Comment: Objective A may overlap with, or duplicate, work being performed in Air/Water 2 or Coastal Habitat 1.

Response: Objective A was similar to objectives in Coastal Habitat 1. However the studies looked at different aspects of the environment and close coordination prevented overlap and duplication.

Comment: Considering the potential for natural recovery, the advantages of transplanting *fucus* are not well discussed. The success of this project is questionable. (API)

Response: The project was modified and no transplanting occurred in 1990.

Comment: Objective C is confusing since *fucus* has spores rather than seeds. And the high energy environment of Prince William Sound will create a dispersal of planted spores greater than the 1 meter noted in the study. (API, ESC)

Response: The word seeding was used in a general sense to mean artificial establishment of *fucus* in barren areas. *Fucus* embryos are dispersed from the parent plant.

Comment: The dispersal test for oiled areas treated with differing cleanup methods is basic, general and unnecessary research. (API)

Response: The study was modified to eliminate this part of the project in 1990.

Comment: There is insufficient information given regarding field methodologies. Although three methods are referred to in the field tests, only two are specifically mentioned. The lack of detail on types of habitat, measured parameters and statistical methods will leave the findings of this study open to challenge. (ESC)

Response: The field methodologies and statistical methods were subject to evaluation to ensure they were valid.

Comment: There is insufficient information concerning the laboratory experiments to evaluate them. (ESC)

Response: The study was modified, and laboratory experiments were conducted as part of this study.

Comment: The statement in the introduction to this study regarding the reduction of *fucus* over large areas fails to consider the vertical distribution of *fucus*. Most *fucus* below the lower intertidal would have suffered little impact from oiling or cleanup. It therefore remains a diversified source of spores for recruitment. (ESC)

Response: The upper edge of the *fucus* zone is in a highly hostile environment where it is difficult for plants to become established. *Fucus* living below the intertidal zone were taken into account in the design and execution of the study.

Feasibility Study No. 2

Comment: The reestablishment of grazers and predators will not restore the ecosystem if primary producers on which the grazers feed are not present. (API)

Response: The study also examines the recolonization of primary producers.

Comment: As the larvae of rocky intertidal species are pelagic, it is likely that the community will recover naturally within a few years, without planting species. (API)

Response: The study examines the rate of natural recovery to determine if it is sufficient or can be enhanced by artificial means.

Comment: The term "enhancement plots" mentioned in the study description is unclear. (API)

Response: Enhancement plots are experimental sites that were established.

Comment: Predator exclusion studies may be basic scientific research beyond the scope of the DOI regulations. (API)

Response: Predators are a variable in the ecosystem that need to be experimentally controlled to identify the potential impacts of EVOS.

Comment: This feasibility study is unnecessary since this resource is recovering rapidly. And cleanup techniques were designed to minimize further injury, thereby leaving a good source of fauna available for recruitment. It is more in the nature of research than damage assessment. (ESC)

Response: The study was conducted to determine if it was reasonable to continue exploring restoration of an intertidal ecosystem heavily impacted by the EVOS. The Trustees disagree with the general assertions of the review that the resource is recovering rapidly and cleanup techniques minimized injuries.

Comment: There is insufficient information given to evaluate how the feasibility of enhancing colonization of key species and recovery rates will be determined and statistically verified. (ESC)

Response: The study was technically and statistically reviewed to ensure its design is valid.

Comment: There is no information on the source or selection of limpets as grazers and *Nucella* and *Leptasterius* as predators to be the key intertidal species as a baseline for measuring recovery. (ESC)

Response: *Nucella* and *Leptasterius* are important predators in the intertidal community and are likely to have an impact on the community structure. They both have limited dispersal capability and are likely to have been impacted by the oil spill. There is ample literature that identifies limpets as critical grazing components in the community structure.

Feasibility Study No. 3

Comment: This feasibility study is unnecessary since this resource is recovering rapidly. And cleanup techniques were designed to minimize further injury, thereby leaving plenty of growth available for recruitment. (ESC)

Response: Beach wild rye appears to be recovering at most locations. At some sites recovery is slow or non-existent. These sites are subject to erosion and will require intervention to mitigate otherwise deleterious effects. The actual number of sites and the type of intervention necessary will be determined after the 1991 spring shoreline assessment. Although cleanup techniques may have been designed to minimize injury, the actual conduct of the cleanup did result in injury to beach wild rye at some locations.

Comment: Restoration methods cannot be evaluated because there is no information given on the "well-established techniques for restoring rye grasses." (ESC)

Response: Only limited information was given on restoring rye grasses since the methods are simple, have been used successfully for years, and are commonly known.

Comment: There is not enough information available to judge the cost-effectiveness of this study. The objectives, even if necessary, should be phased so that B and C are only carried out if it is determined from Objective A that restoration will be necessary. (ESC)

Response: This study determined that there are sites that need restoration and that given the injury observed to date, a pilot project is not necessary before restoration is implemented. Sites to be restored will be determined after the 1991 spring shoreline assessment.

Comment: The information to be gained from this study is not worth a full-scale beach wildrye restoration project. It is not appropriate to identify and prevent erosion which may occur for reasons unrelated to the oil spill. (ESC)

Response: Beach wildrye sites will be restored where there is a danger of further injury if the sites are not restored. There has never been the intent of the Trustees to restore beach wildrye just to study restoration methods. The intent is to identify and prevent erosion for reasons related to the EVOS.

Comment: Too little information is provided to evaluate the criteria used to establish the site potential for wildrye restoration. The mere presence of oil during a site visit does not necessarily mean that there is injured beach wildrye in need of restoration. This grass can grow well even in the presence of oil. (ESC)

Response: The need for wildrye restoration is based primarily on the potential for natural recovery or the lack thereof and the likelihood of continuing erosion if restoration measures are not implemented. The Trustees are aware that beach wildrye can survive in the presence of oil.

Feasibility Study No. 4

Comment: Acquisition-based restoration studies, such as this one, are premature and unwarranted since there has been no showing that impacted resources and their respective services cannot be restored or replaced. (ESC)

Response: Marbled murrelets and harlequin ducks were killed by oil from the spill. Such injury warrants small scale feasibility studies to help determine the need and practicality of possible restoration activities that may be necessary in the future.

Comment: This study is poorly defined. Identification of upland habitats used by murrelets and harlequin ducks is not instructive of habitats used by other species. This study should identify instead scarce habitat types or habitat types used by the greatest number of species (or the species most vulnerable to disturbance or disruption) or those habitats most threatened by human activities. (NWF)

Response: Injury to these species necessitates an understanding of their critical upland and marine habitat.

Comment: Objective E of this study is ambiguous and cannot be evaluated without a definition of the scope of the term "full-scale restoration project concerning upland habitats." If these habitats have not been injured, there is no need for restoration. (API, NWF)

Response: Objective E of restoration feasibility project #4 was not carried out in 1990.

Comment: The budget for Restoration Feasibility Study No. 4 is disproportionately small, especially when compared to that for Restoration Feasibility Study No. 5. (NWF)

Response: The goal of each restoration feasibility project is to accomplish its goals in a cost-effective manner. People and equipment were jointly shared by projects, thus enabling a very modest budget to accomplish the primary tasks.

Comment: Evaluating new research methods such as the dawn detection technique for marbled murrelets is inappropriate. This work is research. (ESC)

Response: The dawn detection technique for marbled murrelets has been used in other west coast areas with some success. Thus, testing its applicability in Alaska was within the scope of

feasibility project guidelines. Because it is not known where marbled murrelets nest in PWS, this must be determined before other more specific restoration projects can be developed.

Comment: Insufficient information is provided to evaluate whether the monitoring of two species of birds can provide sufficient data to develop a feasibility study or full-scale restoration project. (ESC)

Response: The type of data provided in the project descriptions is limited due to the need to keep specific information confidential pending potential litigation.

Feasibility Study No. 5

Comment: Acquisition-based restoration studies, such as this one, are premature and unwarranted since there has been no showing that impacted resources and their respective services cannot be restored or replaced. (ESC)

Response: This study will provide background information on the oil-spill area and adjacent lands and will also serve to identify potential sites for restoration projects.

Comment: The description of Restoration Feasibility Study No. 5 is too vague. It is not possible to ascertain whether it will review an appropriate number of potential equivalent assets. (NWF)

Response: The focus of the study is on the entire area influenced by the EVOS.

Comment: The study indicates that equivalent resources will be acquired. There is no connection between timber land or land proposed for development and lands affected by the spill. (API)

Response: This study is looking at the status of upland resources and the relationship of that land with resources impacted by the EVOS. No decision has been made to acquire upland resources.

Comment: The assessment of alternative cultural sites is not appropriate as they are not natural resources. (API)

Response: Acquisition of cultural sites is one option mentioned by the public as a possible restoration measure. A valuation of the committed use of the cultural attributes of natural resources, as well as the natural components of cultural sites, is properly within the NRDA process.

Comment: Much of this study does not appear to be related to areas affected by the spill; rather, it appears to be data-gathering. Considering the large amount of information that has been gathered, additional mapping is neither warranted nor cost-effective, without knowing which, if any, natural resources should be considered for off-site habitat acquisition. (API, ESC)

Response: The Trustees disagree. The results of this study will help identify the upland resources that may assist in the recovery of injured resources if acquired.

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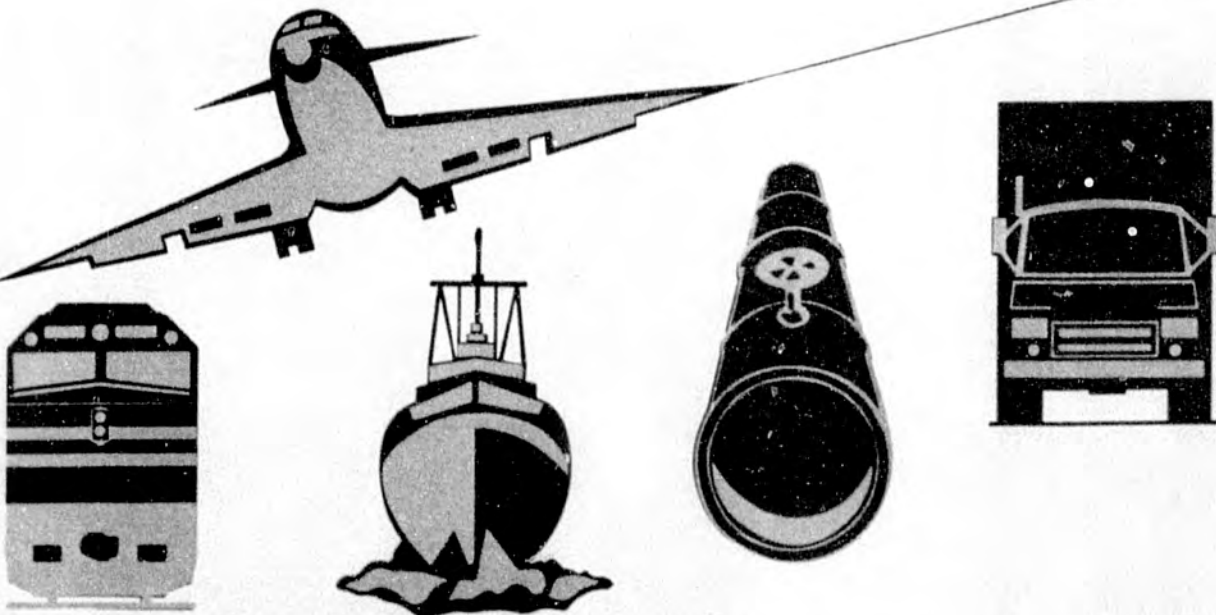
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NATIONAL TRANSPORTATION SAFETY BOARD

MARINE ACCIDENT REPORT

GROUNDING OF
THE U.S. TANKSHIP EXXON VALDEZ
ON BLIGH REEF, PRINCE WILLIAM SOUND
NEAR VALDEZ, ALASKA
MARCH 24, 1989



The National Transportation Safety Board is an independent Federal agency dedicated to promoting aviation, railroad, highway, marine, pipeline, and hazardous materials safety. Established in 1967, the agency is mandated by the Independent Safety Board Act of 1974 to investigate transportation accidents, determine the probable cause of accidents, issue safety recommendations, study transportation safety issues, and evaluate the safety effectiveness of government agencies involved in transportation.

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16. Abstract This report explains the grounding of the U.S. Tankship EXXON VALDEZ near Valdez, Alaska on March 24, 1989. The safety issues discussed in the report are the vessel's navigation watch, the role of human factors, manning standards, the company's drug/alcohol testing and rehabilitation program, drug/alcohol testing, vessel traffic service, and oil spill response. Safety Recommendations addressing these issues were made to the U.S. Coast Guard, the U.S. Environmental Protection Agency, the U.S. Geological Survey, the Exxon Shipping Company and other tankship companies carrying North Slope crude oil from Port Valdez, the State of Alaska, the Alyeska Pipeline Service Company, and the Alaska Regional Response Team.					
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EXECUTIVE SUMMARY

About 0009, on March 24, 1989, the U.S. tankship EXXON VALDEZ, loaded with about 1,263,000 barrels of crude oil, grounded on Bligh Reef in Prince William Sound, near Valdez, Alaska. At the time of the grounding, the vessel was under the navigational control of the third mate. There were no injuries, but about 258,000 barrels of cargo were spilled when eight cargo tanks ruptured, resulting in catastrophic damage to the environment. Damage to the vessel was estimated at \$25 million, the cost of the lost cargo was estimated at \$3.4 million, and the cost of the cleanup of the spilled oil during 1989 was about \$1.85 billion.

The safety issues discussed in the report are:

- (1) The adequacy of the navigation watch on the EXXON VALDEZ on the night of the grounding;
- (2) The role of human factors, including fatigue and alcohol abuse, in this accident;
- (3) Coast Guard and Exxon Shipping Company manning standards and Exxon's procedures for determining manning levels for tankships;
- (4) Exxon Shipping Company's drug/alcohol testing and rehabilitation program;
- (5) Coast Guard regulations and procedures for drug/alcohol testing aboard commercial vessels;
- (6) The role of the Coast Guard Vessel Traffic Service at Valdez; and
- (7) Oil spill contingency planning and initial response to this accident.

Recommendations concerning these issues were made to the U.S. Coast Guard, the U.S. Environmental Protection Agency, the U.S. Geological Survey, the Exxon Shipping Company and other tankship companies carrying North Slope crude oil from Port Valdez, the State of Alaska, the Alyaska Pipeline Service Company, and the Alaska Regional Response Team.

Probable Cause

The National Transportation Safety Board determines that the probable cause of the grounding of the EXXON VALDEZ was the failure of the third mate to properly maneuver the vessel because of fatigue and excessive workload; the failure of the master to provide a proper navigation watch because of impairment from alcohol; the failure of Exxon Shipping Company to provide a fit master and a rested and sufficient crew for the EXXON VALDEZ; the lack of an effective Vessel Traffic Service because of inadequate equipment and manning levels, inadequate personnel training, and deficient management oversight; and the lack of effective pilotage services.

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

MARINE ACCIDENT REPORT

GROUNDING OF
THE U.S. TANKSHIP EXXON VALDEZ
ON BLIGH REEF, PRINCE WILLIAM SOUND
NEAR VALDEZ, ALASKA
MARCH 24, 1989

INVESTIGATION

The Accident

At 2335¹ on March 22, 1989, the EXXON VALDEZ (see figure 1) arrived at berth 5, Alyeska Marine Terminal, to load a cargo of Alaska North Slope crude oil. At 2350, the connections between the vessel's piping system and terminal pipelines were completed, and at 0054 on March 23, transfer of the vessel's ballast water to the terminal was started. By 0415, all ballast water had been discharged from the vessel, and at 0505, loading of the cargo of crude oil began. About 1030, the master, accompanied by the chief engineer and radio electronics officer, departed the vessel to go ashore.

The cargo loading operations were completed about 1924, and the chief mate directed the third mate, who had been assisting him with the topping-off operations,² to go to the bridge and test the navigation equipment. About this time, the chief mate ordered the deck force, consisting of six able seamen (ABs), to begin securing the decks for sea, which involved stowing or securing all deck firefighting equipment and all loose gear.

The third mate completed testing the navigation equipment on the bridge at 1948. He tested the steering system, navigation lights, whistle, and engine order telegraph and ensured that the following equipment was operating: compasses, course recorder, radars, radios, fathometers, and speed logs. The oil containment boom³ was still in place encircling the vessel, making it unsafe to turn the propeller. All equipment tested was found to be operating properly. After testing the navigation equipment, the third mate stayed on the bridge to communicate with tugs, which were to assist in undocking when they arrived alongside.

¹All times are Alaska standard time based on the 24-hour clock. All miles are nautical miles, and all courses and bearings are true.

²The final loading of the cargo, usually at a reduced rate, to ensure that the desired amount of cargo is loaded in each tank.

³A flatable/inflatable unit placed in the water to serve as a barrier to the movement of oil on the surface of the water.



2

Figure 1.--EXXON VALDEZ.

At 2020, the same State pilot who had piloted the vessel into port, boarded the vessel. He stopped at the entrance to the master's office, but when there was no response to his knock, the pilot proceeded to the bridge. Once on the bridge, the pilot conducted his usual checks and found that the radios were on the correct frequencies, the radars were operating on the desired range scales, and the gyrocompass was operating and indicating the correct heading for the berth. About the time the pilot completed his checks, a representative from the agent's⁴ office, who was seeking some cargo information, arrived on the bridge to await the arrival of the master. About 2030, the third mate was informed that the master had returned, and he in turn notified the pilot and the agent that the master was back on board.

About 2040, after ensuring that all cargo valves were closed and that the pumproom was secured, the chief mate proceeded to the bridge and relieved the third mate as the navigation watch officer. A short time later, the master arrived on the bridge, and following a brief conversation with the agent, he departed the bridge with her to obtain the needed cargo information in his office. At 2045, the oil containment boom around the vessel was removed, permitting the engineers to test the main engine at low speed. At that time, the chief mate retested the steering system by moving the rudder between hard right and hard left, using both pumps. When the master returned to the bridge a few minutes later, he inquired whether all navigation gear was ready, and the chief mate informed him that it was. At 2054, the master placed the main engine on bridge control. About 2100, on orders from the master, the deck force, consisting of three ABs on the bow under the direction of the second mate and three ABs on the stern under the direction of the third mate, began taking in the vessel's mooring lines to begin undocking procedures.

The navigation watch on the bridge consisted of the pilot, the master, and the chief mate. One of the two ABs on the 2000-2400 watch was scheduled to take the helm, but he was still handling lines on the stern. When the mooring lines were singled up (reduced to the minimum number necessary to hold the vessel at the berth), the AB left the stern and proceeded to the bridge, took his position at the steering stand, and stood by to move the helm as ordered.

At 2112, the last mooring line was removed from the pier, and the pilot began moving the vessel away from the berth. At that time, two tugs, under the direction of the pilot, were being used to assist in maneuvering the vessel from its berth. By 2121, the vessel was clear of the berth, and the pilot began conning the vessel toward the harbor entrance, known as the Valdez Narrows, which was about 6 miles away. One of the tugs was shifted to a position astern of the vessel, where it would remain to escort the vessel through the Valdez Narrows. The other tug was released.

⁴A company representing the vessel's owner or operator in a port where the owner or operator does not have an office. The agent arranges for pilots and tugs for docking/undocking, ship's stores, fuel, repairs and other, similar support.

According to the chief mate, when the vessel was a few hundred feet from the pier, the third mate arrived on the bridge to relieve him. The chief mate went to his stateroom to sleep. According to the pilot, about 15 to 20 minutes after the vessel got under way, the master left the bridge. The pilot continued to issue orders to the helmsman, as necessary, to head the vessel toward the harbor entrance and to direct the third mate to make the necessary changes in engine speed. The third mate supervised the helmsman to ensure that all rudder orders from the pilot were correctly followed and also monitored the vessel's progress by logging the time abeam of prominent landmarks and navigation aids. As the vessel approached the Valdez Narrows, the pilot reduced the speed to 6 knots to conform with the established speed limit for loaded tank vessels in the Narrows and then maneuvered the vessel to position it on the optimum trackline.⁵ (See figure 2.)

After the vessel passed through Valdez Narrows, the pilot brought it to 219⁰, the course of the outbound traffic lane. When the vessel was within about 15 minutes of arrival at the pilot station off Rocky Point, the pilot requested the third mate to call the master back to the bridge. The master returned to the bridge and a short time later relieved the pilot of the navigational control of the vessel. The master directed the third mate to escort the pilot to the debarkation ladder, which was rigged on the port side of the main deck. The master also called the AB acting as lookout on the bow by hand-held radio and instructed him to proceed aft and assist the third mate to disembark the pilot and to secure the pilot ladder after the pilot had left.

At 2324, the pilot departed the vessel. At 2325, the master informed the Coast Guard Vessel Traffic Center (VTC) for Valdez that the pilot had departed and that he was increasing the vessel's speed to "sea speed,"⁶ about 16 knots. He also informed the VTC that the vessel's expected time of arrival adjacent to Naked Island, one of the locations in Prince William Sound where tankships report their position to the VTC, would be 0100. The VTC watchstander requested a report on ice conditions, and at 2325 the master responded:

⁵The optimum trackline is the track that tank vessels and other large ships are required to follow in transiting Valdez Narrows. The trackline was determined by the Coast Guard and the Southwest Alaska Pilots Association after monitoring the tracklines followed by tankships during the first several months after the opening of Port Valdez to tank vessel traffic. Valdez Narrows is restricted to one-way traffic between Tongue Point south of the Narrows and Entrance Island at the northern end of the Narrows. Beyond the Narrows, tankships travel in northbound (inbound) and southbound (outbound) traffic lanes designated as a Traffic Separation Scheme.

⁶Sea speed is the normal sustained speed at which a vessel is designed to operate at sea. By contrast, maneuvering speed is a lower speed used in confined waters, such as channels and ports.

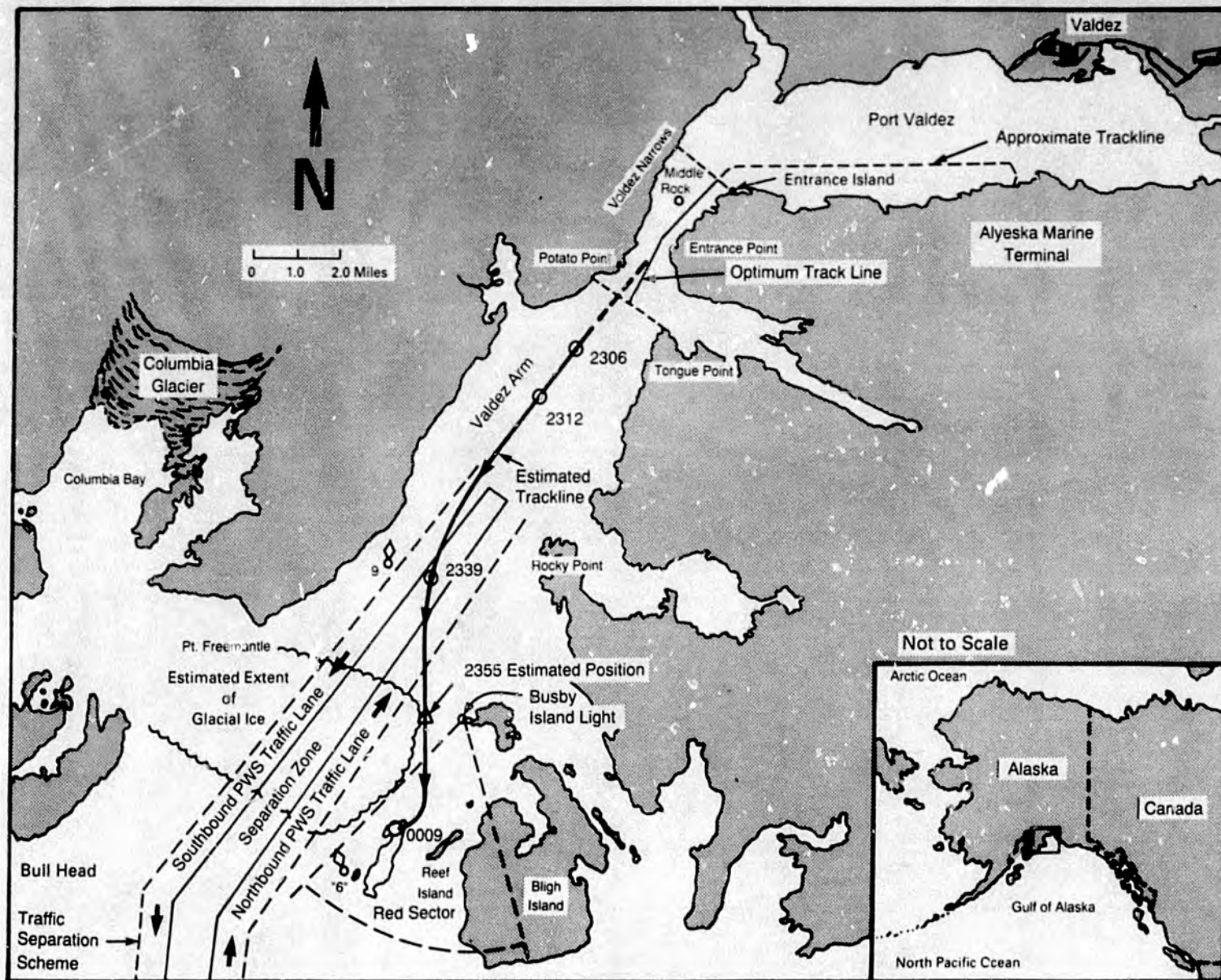


Figure 2.--Location of the accident.

Okay. I was just about to tell you that, ah, judging by our radar, I we'll probably divert from, ah, the TSS [Traffic Separation Scheme] and end up in the, ah, inbound lane if there's no conflicting traffic. Over.

The VTC watchstander indicated concurrence by stating that there was no reported traffic in the traffic lanes. The master again informed the VTC that the vessel might "end up" in the inbound lane, and he stated that he would notify the VTC when the vessel departed the traffic lanes. The master's transmission about 2326 is quoted below:

That will be fine. Yeah. We may end up over in the, ah, inbound lane, outbound transit. Ah, we'll notify you when we leave the, ah, TSS and, and, ah cross over the separation zone. Over.

About 2331, the master again called the VTC regarding the ice in the traffic lanes. The master's transmission is quoted below:

At the present time, I'm going to alter my course to two zero zero and reduce speed to about twelve knots to, ah, wind my way through the ice, and, ah, Naked Island ETA might be a little out of whack but, ah, once we're clear of the ice out of Columbia Gla ...Bay, we'll give you another shout. Over.

The helmsman on the 2000-2400 watch said that he had been steering 219⁰ and then changed the vessel's course to 200⁰ on orders from the master. The course recorder trace showed that the course change was made about 2331. The engineroom bell logger shows, however, that the vessel's speed was not decreased.

After the pilot ladder was secured, the AB assisting the third mate returned to his lookout station on the bow. The third mate then returned to the bridge, arriving there between 2334 and 2336. According to the third mate, the vessel was on course 200⁰ when he arrived on the bridge and he believed the engine was speeding up to 55 rpm (about 11 knots) to match the order for full-ahead maneuvering speed. The bell book indicates that the vessel was placed on "load program up"⁷ at 2352. The third mate stated that the master, before leaving the bridge, placed the vessel on load program up. (See figure 3.)

Shortly after the third mate returned to the bridge, the master informed the third mate that he (the master) would be bringing the vessel to 180⁰ to avoid ice, and the master directed the third mate to take a fix of the vessel's position. The course recorder trace showed that the course change was started about 2339. The third mate took a visual bearing of Busby Island

⁷The speed of the main engine was being increased slowly by a computer from maneuvering full ahead (55 rpm) to full-ahead sea speed (78.9 rpm), requiring about 43 minutes.

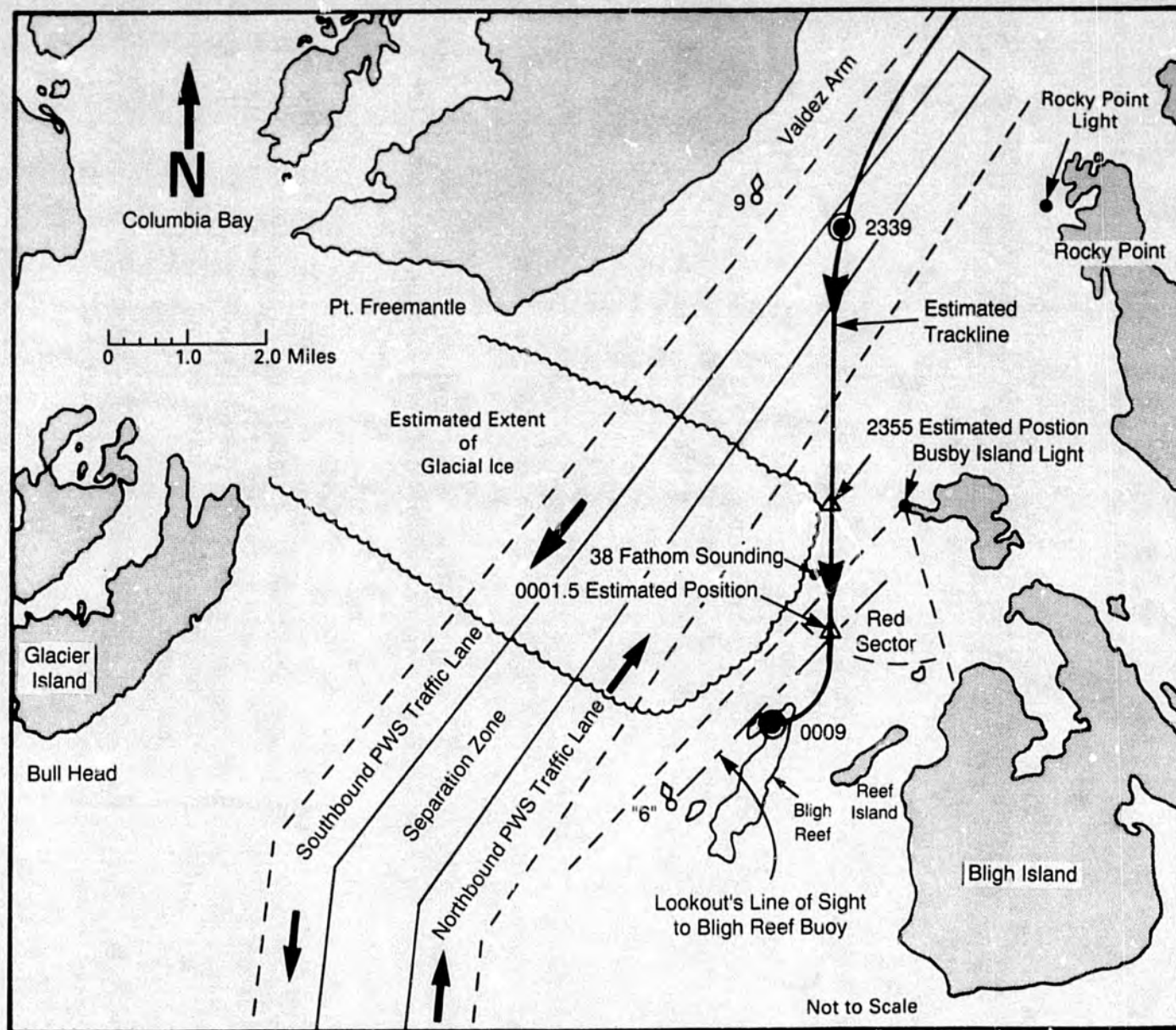


Figure 3.--Trackline of EXXON VALDEZ.

Light and Buoy No. 9 and a radar range to the land adjacent to Buoy No. 9. The third mate stated that the vessel was turning while he was taking the bearings. When plotted, his fix showed that the vessel's 2339 position was in the middle of the separation zone and approximately 2 miles west of Rocky Point Light. By about 2343, according to the course recorder, the vessel was steady on a course of 180°.

About this time, the master called the AB on lookout by hand-held radio and told him to go aft and tell the 0000-0400 AB, who would come on watch about 2350 as lookout, to report to the wing of the bridge instead of the bow to stand the lookout watch.

The 2000-2400 helmsman testified that shortly before he was relieved, the master had ordered him to bring the vessel to a course of 180° and to engage the automatic pilot. The helmsman testified that he changed the vessel's course to 180° and that when the vessel's heading was steady on 180°, he pushed the "gyro" button on the steering console to engage the automatic pilot.

At the change of the helm watch, about 2350, the helmsman being relieved reported to the third mate that he had been relieved of the helm, steering course 180° "on the gyro." According to the third mate, he learned that the vessel was on automatic pilot at this time. The third mate stated that he had not expected the vessel to be on automatic pilot because it was not in open water. He further stated that the vessel was not normally operated on automatic pilot when navigating the traffic lanes, but he stated that he did not discuss the reason that the vessel was on automatic pilot with the master. The third mate decided not to call his relief, the second mate, who was scheduled to come on watch at 2350, and to remain on watch until the vessel had cleared the ice flow.

According to the third mate, the master informed him that he would leave the bridge to send some messages that had to be sent before the vessel left Prince William Sound and that he wanted the third mate to start returning the vessel to the traffic lanes when Busby Island Light was abeam to port. The master said that he would be off the bridge a short time and that the third mate was to call him when he began returning the vessel to the traffic lanes if the master had not returned to the bridge by that time. The third mate said he and the master did not look at the chart together to review what the master expected him to do. The master asked the third mate whether he felt "comfortable" about what he was supposed to do, and the third mate replied that he did. The third mate testified that he had determined by radar that there was a distance of about 0.9 mile between Bligh Reef and the ice floe and that it would be possible to pass around the ice once Busby Island Light was abeam. The master left the bridge about 2352.

The third mate testified that he thought it would not be possible to turn sooner because of the ice. The third mate also testified that he never considered slowing the vessel because the decision had been made to avoid the ice rather than to proceed through it.

The third mate testified that according to the Exxon Shipping Company's Bridge Organization Manual, "Watch Condition C" was the watch condition required on the bridge at the time. The manual states that "Watch Condition C" is required during clear visibility when arriving or leaving port or operating in congested waters, and it also states that either the master or the chief mate is to be on the bridge in charge of the watch. The watch officer is responsible for fixing the vessel's position and assists as directed by the master or chief mate.

The third mate claimed that because he expected to change course in a few minutes, he went to the steering stand and pushed the hand steering button, removing the vessel from automatic pilot and placing it in hand steering. According to the third mate, the helmsman also attempted to push the hand steering button. He testified that he observed the indicator on the console illuminate, signifying that the steering system was in hand steering mode.

The third mate observed Busby Island on the radar and determined that the vessel would be about 0.9 mile from Busby Island Light when the light became abeam to port. The third mate then walked to the port wing of the bridge and took a visual bearing of Busby Island Light when it was abeam. At that time, while still on the wing of the bridge, he observed that the time on his watch was 2355. He then proceeded to the chart room, located in the after port side of the wheelhouse, to plot the fix. Although the third mate stated that the vessel was about 0.9 mile from Busby Island Light, he plotted the 2355 position 1.1 mile from the light.

The 0000-0400 AB scheduled to assume the lookout watch stated that she had arrived on the bridge about 2350. She looked briefly at the navigation chart to "get an idea of" the vessel's position and then looked at the radar, which, she stated, was her usual practice. She saw what she believed was ice, but she could not recall the distance to it. She noticed that the door to the port bridge wing was closed, so she proceeded to the starboard bridge wing, where the door was open, taking a position near the starboard side. Shortly after arriving on the starboard bridge wing, she observed Busby Island Light a few degrees forward of the port beam. A few minutes later she observed a red flashing light (Bligh Reef Buoy No. 6) on the starboard bow. She estimated that the light was broad on the starboard bow (45°) and that it was flashing once every 5 seconds. She walked into the wheelhouse, located the third mate at the chart table, and reported the light to him. She noticed that the third mate appeared to be plotting a fix. According to the lookout, the third mate acknowledged her report in a calm, routine manner. The third mate stated that he knew the lookout was reporting the light on Bligh Reef Buoy No. 6 and that he had already located the buoy on the radar. The lookout then returned to the starboard bridge wing.

The third mate claimed that shortly after he plotted the 2355 fix, he ordered the helmsman to put the rudder to right 10°. (See Test and Research section for time of turn and rudder used, as determined by computer simulation.) He estimated that he issued the order for right 10° rudder about a minute after taking the visual bearing on the port bridge wing. He did not recall watching the rudder angle indicator to ensure that the rudder

was actually applied. He also stated that he did not order the helmsman to come to any particular course because he intended to make a gradual, sweeping turn to the right. After ordering the right 10° rudder, the third mate telephoned the master to inform him that he had started to turn the vessel back toward the traffic lanes. While speaking with the master, the third mate had his back to the rudder angle indicator. He estimated that the telephone call lasted about 1 1/2 minutes. He informed the master that he believed the vessel would pass through the edge of the ice floe. He stated that the master inquired whether the second mate had arrived on the bridge, and the third mate informed the master that the second mate had not yet been called for the watch. After the telephone call was completed, the third mate went to the port radar. The third mate stated that he was taking radar ranges from Bligh Reef buoy and Reef Island to determine any vessel movement to the left or right. While observing the radar, he recognized that the vessel had not moved to the right of its original trackline, and then he noticed that the heading had not changed.

About this time, the lookout again entered the wheelhouse to report that the red light on the starboard bow was flashing every 4 seconds instead of 5 seconds. She found the third mate at the port radar, and he again acknowledged her report in a calm, routine manner. At this time, according to the third mate, he looked out, sighted the light, and identified it as Bligh Reef buoy. The lookout returned to the starboard wing of the bridge, and a short time later, she noticed that the vessel was beginning to swing slowly to the right.

The third mate claimed that after he noticed that the heading was not changing, he ordered the rudder increased to right 20°. He said he looked at the rudder angle indicator and saw the rudder approach and stop at 20° right rudder. However, he did not recall the position of the rudder when he issued the order for right 20° rudder. The third mate estimated that his order for the right 20° rudder was made "1 to 1 1/2, . . . perhaps 2 minutes" after his order for right 10° rudder. He stated that he stepped onto the port bridge wing, looked aft at Busby Island Light, then ahead to Bligh Reef buoy light, and returned to the radar. The third mate said that the white sector⁸ of Busby Island Light remained visible off the port quarter, indicating that the stern of the vessel was still in the white sector of the light.

According to the third mate, the radar indicated that the ship was still following a 180° track, although the vessel's heading was swinging right. The third mate then ordered hard right rudder. He estimated that Bligh Reef buoy was about 2 points (22 1/2°) on the port bow by this time that about 2 minutes had elapsed from the time of his order for right 20° rudder until he ordered hard right rudder.

⁸Busby Island Light comprised a white sector and a red sector. The red sector showed over an arc of 60° over the area of Bligh Reef to warn mariners of the location of the reef and surrounding shoals. The white sector was visible to vessels navigating the traffic lanes on Valdez Arm.

After several seconds at the radar, following the order for hard right rudder, the third mate telephoned the master and said, "I think we are in serious trouble." At the end of the telephone conversation, the third mate felt the vessel contact the bottom. He said that the contact seemed to occur forward on the vessel's starboard side and to cause the vessel to roll slightly. According to the third mate, about 40 to 50 seconds later the vessel sustained a series of sharp jolts for about 10 seconds. The third mate said the vessel seemed to be riding over something. He stated that when the vessel started to jolt, he ordered hard left rudder and that when the helmsman seemed to hesitate, he immediately went to the helm and spun the wheel to hard left in an attempt to slow or stop the vessel's right swing and thus prevent the stern from swinging aground. He said that there was a significant swing on the vessel as a result of the right 20° and hard right rudder and that the vessel continued to swing right during the grounding. The third mate stated that he believed the vessel was heading about 285° after it came to a full stop following the series of jolts. He said that he heard the "bullets" (pressure and vacuum relief valves) in the inert gas system⁹ lifting and smelled both inert gas and crude oil vapor.

The third mate estimated that the vessel grounded about 0005 on March 24; however, the course recorder printout showed that the vessel's heading reached 285° about 0009 and that the heading was still swinging right very rapidly at that time. After the vessel stopped, the third mate went to the wings of the bridge and turned on the search lights. He recalled that the master arrived on the bridge sometime after the grounding, but he could not estimate how long after the grounding. The master told the Coast Guard investigating officer that he felt the vessel ground when the third mate phoned him and that he then proceeded to the bridge. He said that the vessel was aground and stopped when he arrived on the bridge.

The helmsman recalled receiving orders for the right 10°, right 20°, and hard right rudder and then receiving an order for hard left rudder as the vessel grounded. The helmsman further recalled receiving helm orders from the vessel's master shortly after the grounding.

The helmsman provided two different versions of his activities regarding the steering of the vessel. When the helmsman was interviewed a few days after the grounding, he was unable to recall whether the vessel was on automatic pilot when he relieved the 2000-2400 helmsman. He stated later at the Safety Board public hearing, however, that when he arrived on the bridge he observed the 2000-2400 helmsman push the "gyro" button to place the vessel on automatic pilot. He also testified that later he was about to push the hand steering button to put the vessel in hand steering but that the third mate pushed the "button." The helmsman stated during the interview that the third mate was "panicky" when he gave the order for hard right rudder. The helmsman indicated that he did not expect the hard right rudder because the

⁹Inert gas produced by burning diesel oil in specially designed inert gas generators (or collected from the boiler flue gas on steam vessels) is piped to cargo tanks to provide an atmosphere that will not support combustion.

vessel was swinging well and he had already used some counter rudder to slow the vessel's swing as he was bringing the vessel to a course of either 235° or 245°, but he could not recall which course was correct. At the public hearing, the helmsman stated that he had received only helm orders and had not received an order to come to any particular course.

The lookout testified that the vessel was making a slow turn to the right at the time of the grounding and that as the vessel grounded, she saw an illumination in the water around the bow. She described the grounding as a series of jolts. When the vessel grounded, she heard what she believed were "bullets" lifting forward, and she smelled what she believed was inert gas. Shortly after the vessel stopped, she walked into the wheelhouse and noticed that the vessel's heading on the digital read-out located on the forward bulkhead was 289°. The course recorder printout showed that the vessel's heading was 289° shortly after 0009 and that the heading was still swinging right at that time.

The third mate could not recall the exact time that the master arrived on the bridge following the accident, but he recalled that the master gave a number of helm orders, including orders for hard left and hard right, and some orders for speed change following the grounding in an attempt to free the vessel. The third mate operated the engine controls during this period.

The chief engineer stated that he was in the engine room control room as the vessel was proceeding out of Port Valdez. Sometime between 5 and 10 minutes after midnight he heard a noise that he thought might be related to one of the turbochargers on the main engine. The turbochargers had sustained some bearing failures at the start of the voyage in San Francisco, California, and had required repairs. He quickly stepped into the engine room and walked over to the starboard side of the main engine to listen to the turbocharger. Hearing no unusual sounds from the turbocharger or the main engine, he returned to the control room about a minute later. Upon entering the control room, he noticed that the reading on the load indicator for the main engine was higher than normal, about 7.5 on a scale of zero to 8. The engine speed, according to the chief engineer, was 64 rpm, which he stated would normally produce a loading of about 5.5. Also, as he reentered the control room he immediately recognized that the vessel had acquired a starboard list, and an inspection of the inclinometer in the control room revealed that the list was 2° to starboard. Then he noticed that exhaust temperatures were slightly above normal. A few minutes later, he received a call from the third mate informing him that the bridge intended to stop the main engine. The chief engineer, who did not know that the vessel was aground, advised the third mate to reduce engine speed slowly. Shortly after that call, according to the chief engineer, the master called and informed him that the vessel was aground. The chief engineer immediately volunteered that the engine could be stopped quickly, and the engine was stopped soon afterward. The chief engineer said that the engine speed never rose above 64 rpm, although the engine was in "load program up" and according to him, the engine was stopped shortly after 0020.

The chief engineer testified that the master called again about 5 minutes after the engine was stopped and asked whether the main engine

could be used even though the vessel was aground. The chief engineer replied that the engine could be used. About 0027, the master notified the VTC that the EXXON VALDEZ was aground on Bligh Reef and leaking oil. At 0035, the master ordered the main engine restarted, which was done from the bridge, and resumed attempts to maneuver the vessel free of its strand, using various amounts of port and starboard rudder. The chief engineer stated that the highest engine speed thereafter was 55 rpm, that no particularly high loading was placed on the main engine after it was restarted, and that the main engine was never reversed during the more than 1 hour of resumed operation.

The chief mate was awakened by what he described as a "shuddering" of the vessel and by a "clanging" sound. He quickly dressed and went to the bridge. Upon arriving on the bridge, he was informed by the third mate that the vessel was aground and that the master was aware of the grounding. The chief mate then left the bridge and proceeded to the cargo control room, stopping briefly along the way to call the second mate. Once in the cargo control room, the chief mate observed that all center and starboard cargo tanks were rapidly discharging and that the starboard ballast tanks 2 and 4, which had been empty, were filling. Shortly before 0030, the chief mate called the master and informed him about the status of the cargo and ballast tanks and that about 115,000 barrels of cargo had been lost. The master, according to the chief mate, directed him to calculate the hull stresses and vessel stability. The chief mate began the stress and stability calculations, using the vessel's load master computer located in the cargo control room.

About 0030, the chief mate completed the calculations, which, he stated, revealed that the vessel's stability was adequate but that the stresses affecting the vessel's hull were in excess of acceptable limits. The chief mate took the computer printout of the calculations to the bridge to review the results with the master. En route to the bridge, the chief mate noticed strong cargo vapors in the passageways and upon arriving on the bridge he asked if the master wanted to sound the general alarm. The master stated that this might cause panic and that the crew was being informed about the grounding. The chief mate stated that he recommended to the master that the vessel not be moved. According to the chief mate, the master replied, "Yes, we are definitely not leaving this area." The chief mate returned to the control room and made further computer calculations, which he stated showed that the vessel's stability had become marginal and confirmed that the hull stresses were still beyond acceptable limits. Sometime before 0100, according to the chief mate, he informed the master that the computer calculations showed that the ship was "not stable to move," and he again recommended that the ship not be moved. The chief mate testified that he was unaware of any attempts to maneuver the vessel.

At 0107, the Coast Guard Captain of the Port (COTP) at Valdez called the EXXON VALDEZ and spoke with the master. During the conversation, the master stated, "We are working our way off the reef." The COTP cautioned the master to "take it slow and easy." The master further stated, "We are in pretty good shape right now stabilitywise...just trying to extract her off the shoal here." The COTP cautioned again against any "drastic attempt" to get under way. The master responded, "We are just kinda hung up in the

stern." According to the third mate, the master finally made a statement to the effect that "this isn't going to work, we better stop it now" and shortly afterward, ordered the main engine stopped. The engineroom bell logger showed that the main engine was stopped at 0141. The bell logger showed that the following engine orders were executed:

<u>Time</u>	<u>Command</u>	<u>RPM</u>
0035:57	Dead Slow Ahead	23
0040:24	Slow Ahead	31
0048:35	Half Ahead	41
0056:19	Full Ahead	50 to 56
0140:30	Slow Ahead	43
0140:43	Dead Slow Ahead	23
0140:53	Stop	

The course recorder showed that beginning about 0035, the vessel's heading, which had been nearly steady at 290° for about 6 minutes, started swinging to the left, reaching 280° about 0049. Thereafter, the vessel's heading swung back and forth about eight times between the headings of 291° and 276°, finally becoming steady at 280° about 0152.

The Executive Officer (XO) and the Senior Investigating Officer (SIO) of the Coast Guard's Valdez Marine Safety Office (MSO) boarded the vessel about 0335. The master told the XO that he wanted the third mate to start turning back toward the traffic lanes when Busby Island Light was abeam. However, the Coast Guard SIO stated that during separate interviews with the third mate and the master, both identified a position on the chart about 0.7 mile farther south at a 38-fathom sounding (bearing 235°, 1.2 miles from Busby Island Light) as the position where the third mate was to start turning back toward the traffic lanes.

The crew inspected the engineroom and pumproom and took soundings of fuel oil and water tanks adjacent to the engineroom. Later, the starboard anchor was lowered to steady the vessel, and then the crew commenced breaking out the lightering equipment, consisting of hoses and couplings, in preparation for transferring cargo off the vessel. During the evening of March 24, the EXXON BATON ROUGE moored with its port side to the port side of the EXXON VALDEZ, and cargo lightering began on the morning of March 25. During the following few days, preparations were made by Exxon to refloat the ship that required the installation of air compressors and blanking off the tank vents to pressurize the damage tanks.

Injuries

There were no personal injuries resulting directly from this accident.

Vessel Information

The EXXON VALDEZ was a typical modern tankship of all welded steel construction with a continuous main deck, raised foc'sle, straight raked stem, bulbous bow and transom-type stern. (See figure 4.) A split deckhouse was located aft on the main deck of the vessel above the engineroom. The forward section of the split deckhouse contained the navigation bridge (wheelhouse), radio room, recreation rooms, officer and crew dining facilities and accommodations, steward's stores, hospital, gymnasium, swimming pool, and the cargo control room. An overhead gantry-type crane for handling ship's stores was installed athwartship in the space between the forward and after sections of the split deckhouse. The after section of the deckhouse contained the emergency diesel generator room, inert gas system, halon cylinder storage room, and the emergency battery room. The machinery spaces below the split deckhouse contained the main propulsion engine, machinery control room, steering gear room, ships service electrical generators, and auxiliary machinery.

The EXXON VALDEZ, delivered to its owners on December 11, 1986, was the largest ship ever built on the U.S. West Coast. It was the first of two Alaska-class tankships designed and built for the Exxon Shipping Company (Exxon) by the National Steel and Shipbuilding Company in its San Diego shipyard from plans approved by the U.S. Coast Guard and the American Bureau of Shipping. The vessel was designed to meet the standards of the International Convention for the Prevention of Pollution from ships, 1973, as modified by the Protocol of 1978 (MARPOL '73/78). These standards provided for, among other items, protectively located segregated ballast tanks, maximum tank compartment length, and damage stability. The vessel was certificated by the Coast Guard for the carriage of crude oil products and flammable or combustible liquids Grade B or lower.

The EXXON VALDEZ measured 987 feet long overall, 166 feet wide, and 88 feet deep from the main deck (at the side) to the flat keel. The tankship had a maximum draft (loaded) of 64.5 feet with a corresponding deadweight tonnage of 214,861 and a displacement of 240,291 long tons. At maximum draft, the tankship could transport about 1.48 million barrels of crude oil per voyage.

Eighteen cargo, ballast, and slop tanks were located forward of the pumproom and were divided into five transverse tank sections. The sections were numbered from 1 to 5, beginning at the bow, with a port wing tank, a center tank, and a starboard wing tank in each section. The ballast tanks consisted of the forepeak, Nos. 2 and 4 port, and starboard wing tanks. The cargo oil tanks included Nos. 1 across (port wing, center, and starboard wing), center No. 2, Nos. 3 across, center No. 4, and Nos. 5 across. A permanently installed crude oil wash system was fitted in all the cargo tanks. Slop tanks were located aft of port and starboard wing cargo oil tanks Nos. 5. Void tanks (double bottoms) were located below the port and starboard slop tanks.

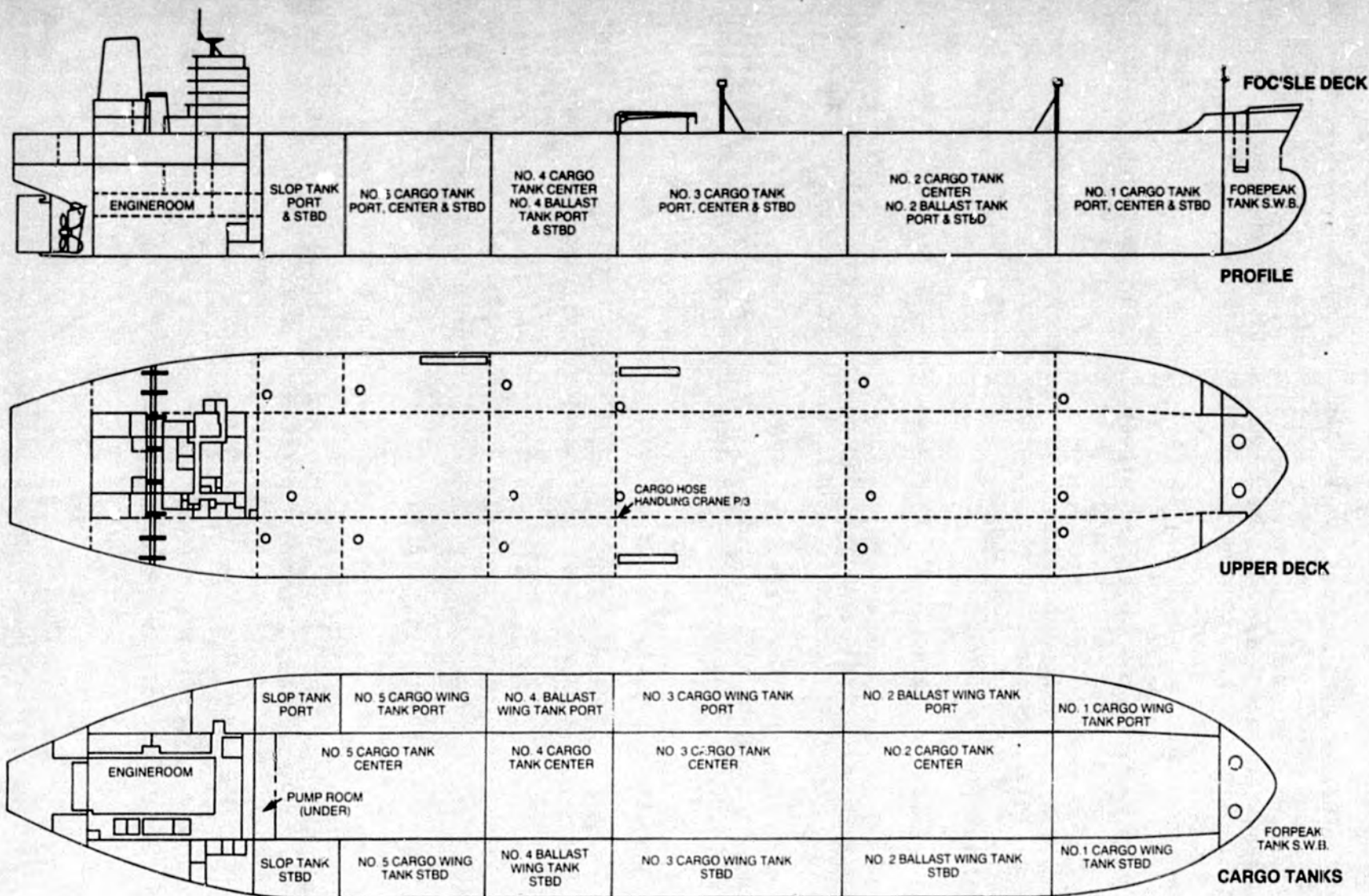


Figure 4.--Profile and plan views of EXXON VALDEZ.

The navigation bridge was located on E deck in the forward section of the split deckhouse. An island in the wheelhouse consisting of several consoles served as the main information and control center for the tankship. From these consoles the navigation watch received data concerning ship speed and direction, main engine speed and direction, selected engine operating parameters, fire detection and control data, alarms, the tankship's position, the position of other vessels and land masses relative to the tankship, and communications to locations about the ship.

From the port side to the starboard side of the wheelhouse, the island of control consoles consisted of:

1. a Raytheon 3-cm radar;
2. the general regulator console (see figure 5), containing a foghorn timer, general alarm switch, gauges for fire pump and firemain pressures, deck-watch annunciator call buttons, internal telephone communications, controls for the forward fire pump and associated remotely controlled fire main valves, and alarm indicators for the systems and equipment in the engineroom, steering gear room, and pump room;
3. the Sperry SRP-2000 (see figure 6) steering control console;
4. the main engine (see figure 7) control console, which contained the engine order telegraph (throttle), shaft rpm preselection control, gauges indicating main engine control air and starting air pressures, main engine RPM indicator, and a variety of engine indicating lights and alarms; and
5. a Raytheon Raycas V, 10-cm radar with a 16-inch-diameter screen, equipped with an Automatic Plotting Aid.

Installed on the overhead, between the bridge main control consoles and the front windows, was a rudder angle indicator. The rudder angle indicator could be seen from either the port or starboard side of the wheelhouse, from the helm position, and from the chartroom behind the bridge control console when the night curtain was not closed.

Located above the windows on the forward bulkhead of the wheelhouse from left to right were:

- o doppler speed log (connected to speed sensors located on the hull forward, midships, and aft),
- o a digital display gyrocompass repeater with an analog indicator showing illuminated headings,

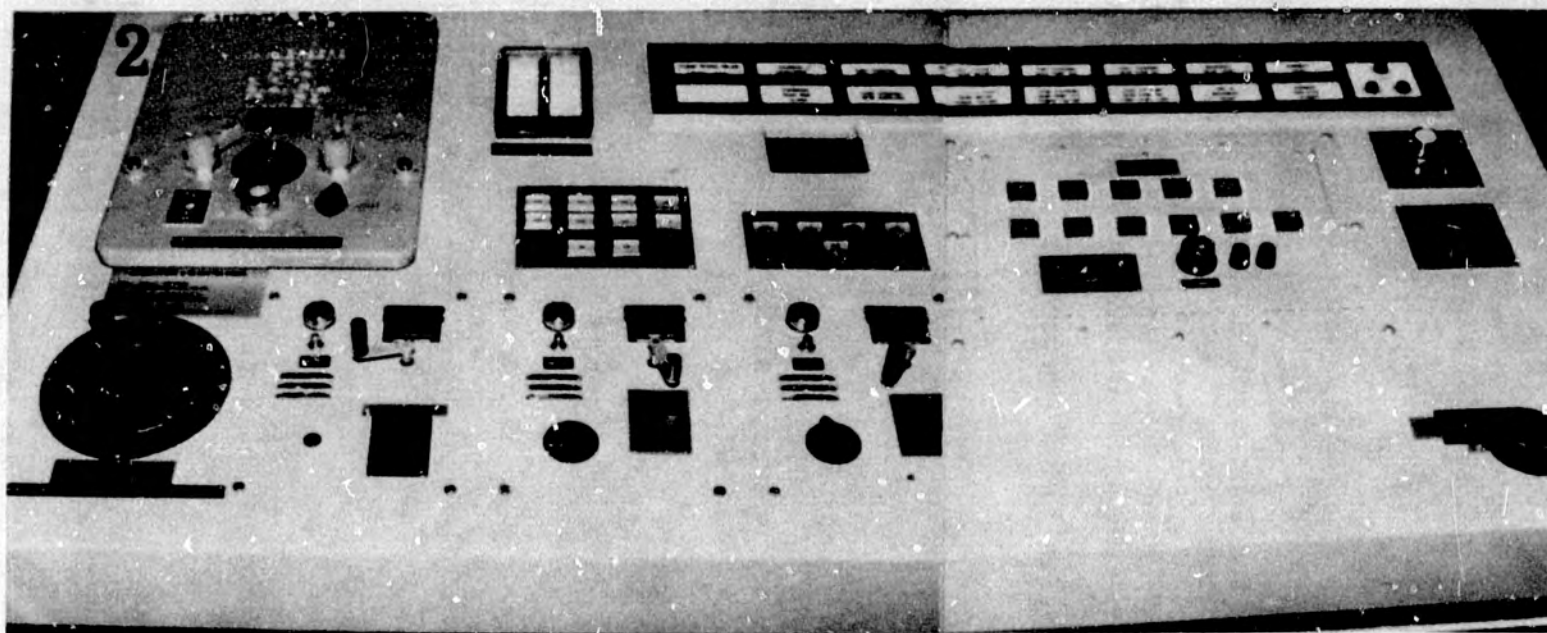


Figure 5.--Bridge control console.

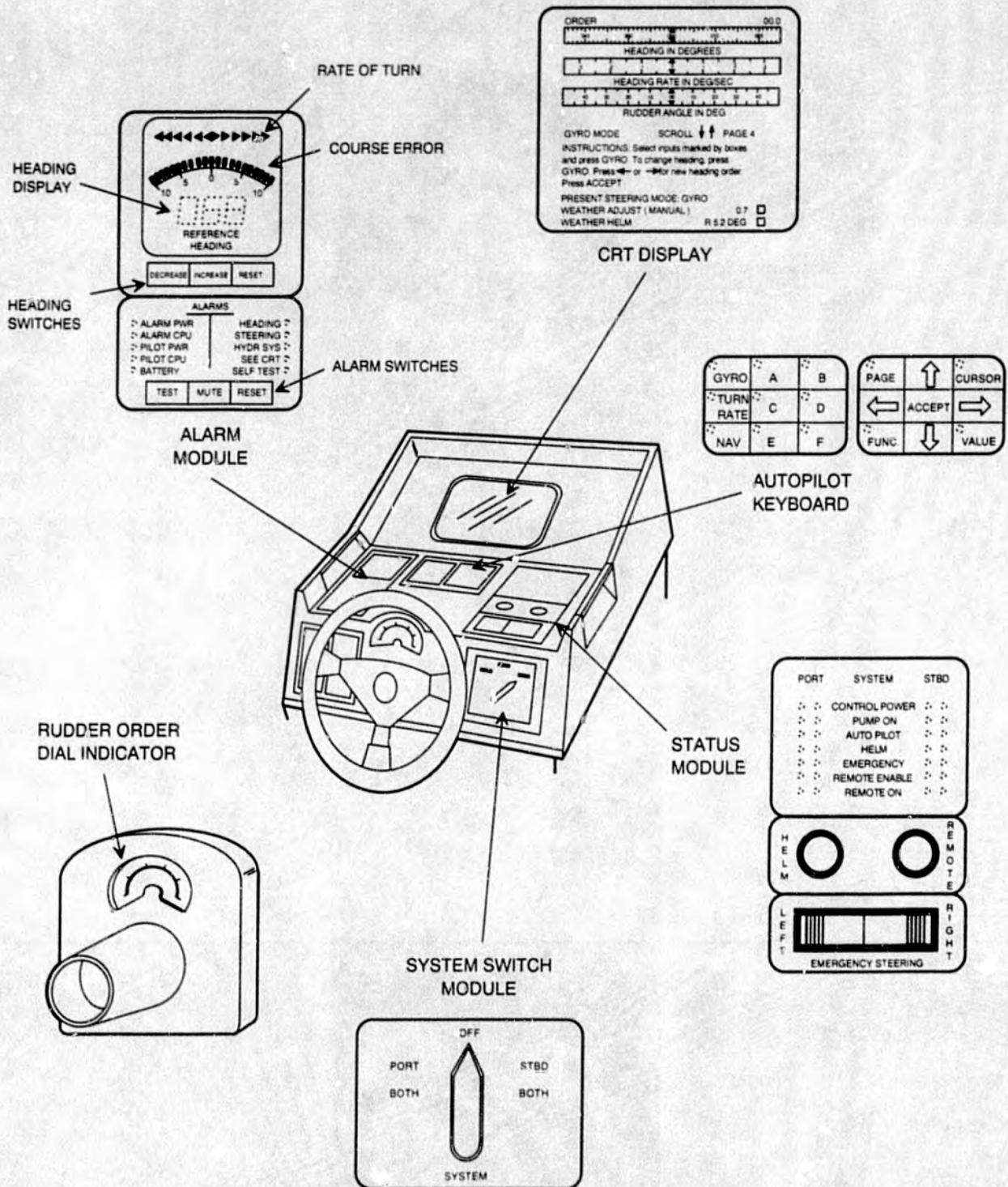


Figure 6.--SRP-2000 console.