STATE/FEDERAL NATURAL RESOURCE DAMAGE ASSESSMENT
DETAILED STUDY PLAN

Project Title:	Geographic Extent, Temporal Persistence and Mapping of Floating Oil from the T N EXXON VALDEZ Oil Spill
Study ID Number:	Air/Water Number 1
Lead Agency:	State of Alaska, Department of Environmental conservation, Administrative Services-Data Processing
Cooperating Agencies:	State:University of Alaska Fairbanks, Geophysical Institute Federal:NOAA
Principle Investigator:	Marshal Kendziorek, Analyst Programmer
Date Submitted:	October 6, 1989

	Signature	Date
Principle Investigator:	Marshal Kendziorek	10/6/89
Supervisor:	MT by Judy Bauder	10/6/89
OSIAR Senior Biometrician:		
OSIAR Program Manager:		
OSIAR Director:		

Study Title:
Geographic Extent, Temporal Persistence and Mapping of Floating and Beached Oil from the T/V EXXON VALDEZ Oil Spill

Introduction:

The general mission of this Natural Resource Damage Assessment floating oil mapping effort will be to document the extent, amount and persistence of oil resulting from the T/V EXXON VALDEZ oil spill. Maps have been produced on a regular basis showing the location of oil from aerial surveys from the first day of the spill on March 24, 1989. While the aerial overflight mapping effort has been reduced since mid May, to one flight a day from two or three, there are still regular aerial overflights being performed to monitor the location and extent of oil in the water. Another source of information that will yield answers on the extent of floating oil is satellite imagery. The data source used here consists of imagery obtained from a variety of polar-orbiting satellites. The function of the satellite imagery portion of this study is to &vise digital filtering techniques to remove noise and to perform digital enhancements to improve the identification of oil. In addition, the satellite imagery will be enhanced to provide oceanographic data useful in determining the oil's trajectory as well as its weathering, mixing with suspended sediments and related evolution. Finally, there is a possibility that some of the satellite imagery' will yield information that will document the extent of oiled beaches.

The aerial overflights produce three basic data types. The first type is a hard copy of a nautical chart with observers notes and markings indicating the location and extent of the oil as well as the flight track taken by this crew. The second data type is video tape showing the oil on the water. The third data type is a written report from the observers with any other observations they may have as well as weather information indicating the observing conditions. In many instances still photographs also exist from the flight. All of this information is combined to ensure the accuracy and reliability of the information.

The satellites produce image format data of the earth's surface in a variety of wavelength bands ranging from blue visible light to the thermal infrared Some of these bands are useful for the identification of oil while others are useful for identification of suspended sediment, the thermal regime, and possibly large concentrations of plankton. The oil signature in most cases is only slightly different from that of the ocean, requiring sophisticated digital image enhancement techniques to separate the two. It is possible that the oil signature will be found to change over time as a result of its weathering. Other techniques are used to display the identified oil relative to regions of suspended sediment where the oil may have become sufficiently heavy to have become submerged.

In the event that any samples of oil will need fingerprinting to confirm the connection to the T/V Exxon Valdez oil spill, NOAA has agreed to perform the chemical analysis.

Objectives:

A. Produce standard formatted maps of the location of floating oil for each day that information is available.

Relationship with Other Studies:

This study is coordinated between ADEC for the aerial overflight data and the University of Alaska, Fairbanks for the satellite imagery data, Please refer to the attached State of Alaska Winter Operations Plan for details of the aerial overflight data gathering. The electronic versions of these maps can be made available after the completion of this project for transfer to other graphic and GIS systems. The information on dismbution of oil will be available to support any of the other studies in the damage assessment process that require such information.

Methodology and Data Analysis:

Aerial overflights:
Through the use of existing computer mapping techniques, composites of the dismbution of the oil can be produced and have been from the beginning of the spill. A book of maps for each day and composites for each month showing the location, type and extent of oil will be produced. This book will also include documentation on the techniques and software used to produce these maps. All maps of the entire area effected by the spill will be produced in black and white 8x10 format for easy copying. Separate 8x10 blowups of Prince William Sound, the Kenai Peninsula, and Kodiak/Alaska Peninsula will be produced to give greater detail. Each map will also include a wind vector showing the direction and speed of the wind at the meteorological stations available. All maps will be produced to scale. Calculations of the area (in square kilometers) of each type of oil (i.e. rainbow sheen, mousse, black oil, etc) will be shown with each map. The monthly composite maps will also be produced in full color on 30 inch by 30 inch paper. The large format color maps, while not appropriate for copying, will be produced in numbers sufficient for dismbution to parties requiring them. The volume of maps required may be produced with the cooperation of the Alaska Dept. of Natural Resources and use of an electrostatic plotter. All maps will be available on diskette in both autocad DWG format as well as DXF format for use by other groups with computer based system.

In addition, a spatial database with attributes will be created that will allow one to perform a database search of a geographical area for presence of oil in the water. This database capability will allow damage assessment workers the ability to request a map of a specific site at any needed scale and time with oiling information present. This should greatly enhance the damage assessment workers ability to "see" what was going on in an area where they are doing research into the damage caused by the spill. By looking at the change over time of the amount and type of oil at any given area, damage assessment staff will better understand what happened during the critical days when the oil was impacting their study sites.

A computer based animation of the oil spill will be produced electronically from the maps and

transferred to video to show graphically a time series of the movement of oil from the beginning of the spill. This animation will be made directly from the maps produced and will thus maintain the first generation accuracy of the maps. The animation will also include the wind vectors to show the relation between wind conditions and the direction of the flow of oil.

Satellite Imagery:
This is not a statistical study utilizing a priori designed discrete samples but rather one involving mensuration using data sets which are randomly available. Thus, in many respects the methods described here will appear to be considerably different from the methods employed for most of the programs in the CERCLA damage assessment studies.

1. AVAILABLE DATA, At the time of the oil spill there were four satellite observational systems in operation which have subsequently been found to provide data which will help meet the objectives listed above. These are:

A. The Advanced Very High Resolution Radiometer (AVHRR). This system is carried aboard the NOAA series satellites. At the time of the spill, two of these systems were in orbit These systems provide wide area coverage in five wavelengths with rather coarse resolution (1km). Counting nighttime passes, up to six useful data-acquisitions are theoretically available daily. To date, the most useful data set to this study from this instrument has been the thermal infrared channel which provides useful images of sea surface temperature both day and night The next most useful data set is the broad-band visible light channel which provides suspended sediment information. The utility of the near infrared and mid infrared channels is still under investigation. These channels have been found to be useful for the identification of oil in the data from higher resolution systems. However, it is possible that their utility is diminished here because of the coarse resolution of this system. These data are cloud-limited but because of the high frequency of coverage, this system offers the greatest quantity of imagery. The Geophysical Institute acquires these images daily in 8-bit format However the greatest radiometric resolution is obtained from the 10-bit data which must be ordered retrospectively based on examination of the 8-bit imagery. (Discrimination must be employed because the 10-bit tapes cost nearly $100 each.)

B. The Landsat Thematic Mapper (Landsat TM). This system is carried on-board the (now) commercial Landsat Satellite. This system has a relatively high spatial resolution (20-30m), but scans a swath about one tenth the'useful portion of the AVHRR swath (approximately 180km). As a result. a given location in the oil spill study area can be imaged about three times every two weeks. Because of the size of the oil spill study area, on any given day there is about a 25% chance that some part of the study area will be in the area of coverage. These data are also cloud-limited. The Landsat TM images the earth in 7 wavelengths ranging from blue to the thermal infrared. As a result every aspect of the study can be

addressed by these **data.**

C. The SPOT HRV camera in multispectral mode (SPOT MS). Two High Resolution, Visible (HRV) sensor systems ride aboard the commercial French satellite, SPOT. In the MS mode they obtain data in three cloud-limited wavelength bands: blue-green to green, yellow to red and the near infrared. These **data** are obtained in 20m pixels which results in pixel areas less than half the area of Landsat TM pixels. However the signal-to-noise ratio at low light levels encountered in this work is poorer than the Landsat TM. As a result the utility gained by the higher spatial resolution is considerably diminished. These sensors can be "pointed to some extent, with the result that the ability to image a specific point on the earth's surface has a greater frequency than Landsat TM. However the rectification of off-nadir images to map projections is more difficult than for nadir-pointed sensors. As a result of this pointing capability, although the orbital characteristics of SPOT are similar to Landsat,, the frequency of coverage is potentially about three times as great.

D. The SPOT HRV camera in panchromatic mode (SPOT PAN). When the HRV cameras **(see** description in C above) are in panchromatic mode, spectral resolution is **traded** for spatial resolution resulting in a single black and white image per camera **with** 10m resolution.

2. DATA SELECTION. Because of the costs involved some care must be exercised when selecting the AVHRR imagery and considerable care must be taken selecting the Landsat and SPOT imagery. For this reason two distinct techniques are employed:

A. AVHRR selection, These **data** are received at Fairbanks and are available in hard copy format at the Federal Building for data seiection purposes. *8-bit* tapes of selected images may be borrowed from the Gilmore Creek receiving station for copying. Copying of these tapes costs the project approximately $20. Upon digital image display, selection of high quality images for analysis at high radiometric resolution is made and 10-bit **tapes** are ordered from the national archive at a cost of $75 each. Selection criteria for images include, absence of clouds, a useful solar elevation angle (good illumination but absence of sunglint) and absence of extreme distortion.

B. Landsat TM and SPOT selection, In order for the respective satellites to be activated, these two data sets must be ordered in advance and an acceptable degree of cloudiness must be specified. This gives the purchaser some cost protection Successful data takes cost approximately $3500. It is possible however that data will be acquired and archived which failed this selection criterion. These images may be re-examined retrospectively for useful data after the budgetary impact of' images acquired under the original criterion is known. For this project a cloudiness criterion of a maximum of 20% was chosen. Sun angle is not a problem with these data but the specific area of coverage must be determined because it is necessary to specify the image acquisition location rather generally if all possible data takes are to be considered

3. DATA AVAILABILITY. As explained above each satellite imaging system used in this study has different operating characteristics and different managing entities. As a result data availability varies considerably from one system to the next. As of September 15, 1989 data availability appears to be as follows.

A. AVHRR. These images have been acquired up to several times daily. Of these approximately 20 have been.analyzed in terms of one or more of the stated objectives. Others await analysis. These images contain a considerable range of cloudiness which can only be accurately assessed when the tapes are displayed digitally. Based on our selection of scenes for which we have acquired digital tapes, we estimate that some data related to the oil spill study objectives described above is to be found on AVHRR scenes for at least one third of the days between March 27 and the present, or about 50 scenes.

B. Landsat. Throughout the study period four scenes were acquired which met the selection criterion. Two scenes were acquired on both April 7 and September 3. We have the digital tapes for all four of these scenes. In addition we have acquired the tapes for a scene one year previous to the spill for-calibration purposes.

C. Spot. Spot management has decided to acquire imagery regardless of cloud cover. As a result there have been approximately 160 scenes acquired. We plan to select scenes for analysis on the basis of both cioud cover and date of acquisition. We estimate thac'we may eventually acquire between 20 and 30 of these images. To date we have acquired two.

DATA *ANALYSIS*

The imagery utilized in this study is in digital image format and is analyzed using digital image analysis hardware and software. The University of Alaska Fairbanks has two digital image analysis systems co-located at the Geophysical Institute. These systems allow for operator-interactive image enhancement as well as the application of standard computer-driven digital image analysis routines (digital filtering, clustering, principal component analysis, fourier analysis, etc.) In addition, the systems have the capability of image-to-image and image-to-map registration and geometric image rectification. Finally there is a capability to scan a hard copy product such as the Coast Guard's Side-Looking Airborne Radar data and convert it to digital image format. Output products are displayed on full color screens and recorded on 35mm or larger film format in 1024 by 1024 pixel arrays. In the paragraphs below the techniques and data sources to be used for addressing each objective are outlined

Method 1. All three satellite systems have been found useful for delineation of the oil extent at specific times. The oil is not readily identified in any spectral band so that contrast enhancement routines must be applied. Principal component techniques have been used to compress oil data from several wavelengths into one variate. It has also been found useful to create a digital mask for land surface areas so that the oil-water enhancement is not applied to those areas as well. To meet this objective all available satellite imagery should be examined for useful data and the oil extent extracted from each.

Method 2. As the morphological state of the oil changes its spectral signature will change correspondingly. This should allow us to identify the oil on the products generated for objective 1 in terms of morphological state using on-site observations from field observers for training sets.

Method 3. The paths taken by the spilled oil can be determined from the sequence of products generated for objective 1 and from detailed analysis of water mass movement as shown on AVHRR thermal IR images

Method 4. Suspended sediment is generally observed on spectral bands other than those particularly useful for detecting oil. It has therefore been found possible to display oil and suspended sediment as separate signatures on the same image. This allows the exposure of oil to suspended sediment to be documented and analyzed in terms of both duration and concentration.

Method 5. The thermal bands on both the Landsat TM and AVHRR systems are useful for mapping ocean surface temperatures and identifying the locations of upwellings. We have been supplying the ADEC Kodiak office ocean with relative ocean temperature data by facsimile for this purpose. Retrospective preparation of calibrated ocean surface temperature maps combined with reported on-site observations of the sudden appearance of oil in various forms will help validate the occasions when weathered oil was advected to the surface by upwellings.

Method 6. It appears possible that plankton blooms can be identified on Landsat TM and SPOT MS imagery that have been properly enhanced. Research is currently underway to determine the correlation between spectral response on the April 7 1989 TM image and simultaneous plankton density measurements made during the Aloha Helix cruise. If this proves possible we may be able to document the interaction between the spilled oil and plankton.

Schedule and Reports:

Date	Overflight data entry	Composite map production	Wind vector calculation	Spill area calculation	8x10 final printing	Large format color	Animation of spill map	Documentation of system	Spatial database
March 24									
April 1									
15									
29									
May 6									
20									
June 3									
17									
July 1									
15									
29									
August 5									
19									
Sept. 2									
16									
30									
Oct. 7									
21									
Nov. 4									
18									
Dec. 2									
16									
30									
Jan. 6, 1990									
20									
Feb. 3									
17									

Aerial overflight and beach survey work will continue throughout the winter. This study will produce a final report on February 15 but it will continue to be added to as long as information continues to be gathered.

Lead Agency: Alaska Department of Environmental Conservation

Cooperating Agencies: State: University of Alaska Fairbanks, Geophysical Institute
Federal: NOAA

Project Budget:[1]

Budget:Alaska Department of Environmental Conservation
Contact: Marshal Kendziorek
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P.O. Box O
Juneau, Ak. 99811-1800
(907) 465-2621

Salaries	regular and overtime for AP IV on spill duty		10.0
subtotal		$10.0	
Travel	Juneau-Valdez		4.5
	Juneau-Seattle (meet with NOAA)		.8
	Valdez-Rhode Island (coordination with ETech)		3.0
subtotal		$ 9.3	
Contracts	GIS customization and programming		19.7
	ETech services		20.0
	Printing		10.0
subtotal		$49.7	
Supplies	Plotter pens, paper and supplies		5.1
	Printer cartridges, paper and supplies		1.1
	Backup tapes, diskettes, cable		2.5
	Film and processing		.5
	Video tape		.2
	Plotter maintenance		2.1
	Equipment shipping		2.0
subtotal		$13.5	
Equip.	Graphics workstation		38.0
	Computer/Video subsystem		5.0
	Plotter		2.0
subtotal		$45.0	
TOTAL		$127.5	

[1]This budget will require an amendment to the existing RSA to ADEC to adjust line items within the total awarded amount of $127.5

Budget: University of Alaska Fairbanks, Geophysical Institute

Contact: W.J. Stringer
Geophysical Institute
U.A.F.
Fairbanks, Ak. 99775-0800
(907) 474-7455

Personal Services		
Associate Professor of Geophysics		$14.5
Remote Sensing Geologist		$15.0
Technician III		$8.0
Remote Sensing Analyst		$12.0
subtotal	$49.5	
Travel		
Fairbanks to Valdez and Kodiak		$2.5
Fairbanks to Juneau		$1.0
Fairbanks to Seattle		$1.0
subtotal	$4.5	
Contractual		
Photographic Services		$10.0
Computer Service Center charges		$17.0
subtotal	$27.0	
Supplies Satellite Imagery		$22.5
subtotal	$22.5	
Administrative overhead to U.A.F.	$20.7	
TOTAL	$124.2	