Development of a SCAT Data Management Manual

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Abstract

Documenting oiling conditions using the Shoreline Cleanup Assessment Technique (SCAT) method is now a standard practice in North America. The data generated by SCAT surveys have the potential to support every aspect of the process necessary to develop and apply shoreline treatment methods, including planning treatment strategies, selecting treatment methods, providing detailed instructions to operations personnel, and evaluating the response effort.

However, in order to be used effectively for decision support, SCAT data needs to be understood, validated, captured within computerized systems, processed, and transformed into support documents, including maps, tables and reports. These documents then need to be distributed to their intended users, in a timely manner. This entire process, from SCAT data capture to distribution of support documents, is referred to as “SCAT data management”.

Although SCAT data management has been used during a number of SCAT-intensive spills, the process has never been formally described. To redress this deficiency, Environment Canada undertook the development of a manual that would describe the practical aspects of the SCAT data management process, and provide various guidelines, directions, procedures and recommendations to ensure the effective use of SCAT data during a response. This manual was created by consulting available literature on the subject and from the experience of SCAT data managers and coordinators and covers the following topics: SCAT data capture methods, data management procedures, data processing methods, and decision support outputs. In addition, the manual describes SCAT data structures and provides guidelines for the selection of SCAT data management systems.

1 Introduction

Field surveys are essential for adequate planning of spill response operations. The Shoreline Cleanup Assessment Technique (SCAT)(Owens and Teal, 1990) is now the recognized method to report observations on the state of oiling in North America (Owens and Sergy, 2004; NOAA, 2000), and is used in other parts of the world such as Australia and New Zealand (Lamarche and Roberts, 2004a).

Although the fundamental principles of the method have remained unchanged (Owens and Teal, 1990; Owens and Sergy, 2003), the scope of the application has been increased to incorporate different types of data collection methods adapted to the evolving needs of the decision makers (unified command, planners, operations, logistics and finance personnel) in the course of a spill: aerial reconnaissance surveys provide a quick overview of the extent of oiling; first responder surveys provide an initial assessment of the oiling characteristics shortly after the spill; and full-scale ground surveys provide detailed, systematic information on segment character and oiling condition. The data collected by each of these methods, which is similar in nature but quite different in scope, amount, and precision, needs to be understood, documented, categorized, and processed so that they can be used to support a large array of decisions. The processes by which field survey data are stored, documented, evaluated, and transformed into decision support documents is referred to as "SCAT Data Management". The task of managing SCAT data has been recognized as an essential element of spill response during incidents that involved a large amount of shoreline survey activities (Lamarche and Tarpley, 1997). The work involved in SCAT data management and the methods developed to make the process more efficient have been partially described in a number of publications. These show how SCAT data assessment can be automated to support the development of response options, such as defining response priorities, selecting cleanup or treatment options, monitoring the progress of the response, locating the sites to be treated, estimating required equipment and personnel, etc.(Lamarche *et al*., 1995), or how the use of Geographical Information Systems can further support and enhance the development of decision support maps (Lamarche and Owens, 1997). Some of the aspects of the tasks involved in providing SCAT data management and how the data are integrated within an incident response organization have also been discussed (Lamarche and Tarpley, 1997; Lamarche et al, 1998). A number of articles also indicate how technological advances can support the SCAT process; such as electronic management response systems (Rubec *et al*., 1998), digital cameras (Lamarche and Roberts, 2004b), weatherized hand-held portable computers (Lamarche *et al*., 2004), or high resolutions georeferenced aerial pictures (Lamarche and Gundlach, 2004). However, the actual details of the type and amount of effort necessary to manage SCAT data within an incident response organization has not been fully and completely described. The areas that were particularly lacking included: detailed descriptions of the different tasks involved in providing SCAT data management support; determination of the exact nature of the responsibilities and abilities required to manage SCAT data; details on how to summarize SCAT data for segments covered with multiple surface and sub-surface oil zones; and methods to integrate SCAT derived information within incident action plans. In addition, there are no publications that provide details on the exact nature of the data generated by SCAT activities, nor on how to organize them into databases.

These gaps motivated the development of a document that would provide explanations, guidelines and details for the management of SCAT data. The manual provides an understanding of the need, an approach for the process, and procedures to ensure proper SCAT data management and effective use of SCAT data for decision support. The manual also provides direction and the tools required for both the SCAT data manager and the SCAT coordinator

2 Methodology

The manual was primarily developed from the analysis of the SCAT data management work done in a number of spills and drills. The principles of the Task Analysis were applied to create lists and procedures describing the various steps involved in the management of SCAT data. The analysis used both published material and the experience of the authors as SCAT coordinators and SCAT data managers in a number of spills and drills.

The “Arctic SCAT Manual” (Owens and Sergy, 2004) was used as a reference for all SCAT terminology and definitions.

Numerous practical examples were taken from published literature. In addition, data from SCAT surveys were simulated from a hypothetical oil spill impacting the coastline somewhere in the Atlantics regions. An experienced Environment Canada emergency officer of the Atlantics region verified that the simulated oil distribution represented a “possible and realistic” situation. This dataset of simulated oiling was used to illustrate the various data processing methods, processes, and decision support documents (maps and tables) that can be produced by the reduction of SCAT data.

The ShoreAssess SCAT data management system (developed by EPDS) was use to:

- Create a georeferenced database containing the results of the simulated SCAT surveys;
- Evaluate surface and sub-surface oiling characteristics, including oiling category, oil cover, remobilisation potential, persistence oil volume and substrate type;
- Develop oiling summaries for single segments, including length of segment oiled by oiling category, remobilisation potential and substrate type;
- Develop decision support documents, such as summary tables and maps.

A Spreadsheet program (Microsoft Excel) and a GIS (MapInfo) were also used to fine-tune the reports, tables and maps presented in the manual.

3 Results

The manual includes six chapters that can be grouped in three parts (Figure 1).

General Principles

Chapter 1	**Background to SCAT**
	Overview of SCAT
Chapter 2	**The Collection of SCAT Data**
	Description of the five SCAT survey methods

Managing SCAT Data

Chapter 3	**The SCAT Data Management Team**
	Summary of the SCAT data management work Responsibilities of SCAT data management teams Required abilities for SCAT data management teams
Chapter 4	**How To Manage SCAT Data**
	Setting-up a SCAT data management system Managing initial response survey data Managing full-scale SCAT ground survey data
Chapter 5	**How To Apply SCAT Data**
	Detailed SCAT data processing explanations Examples of SCAT derived reports and maps

Developing SCAT Databases

Chapter 6	**Developing SCAT Databases**
	SCAT Data Structure Description of each element of a SCAT database
Chapter 7	**SCAT Data Management Support Tools**
	List of basic SCAT Data management tools Guidelines for the development of management systems Recommendations for SCAT data management training

Figure 1 SCAT Data Management Manual Overview

3.1 General Principles

In order to provide SCAT data management support intelligently, personnel involved in the SCAT data management should have a good understanding of the nature and purpose of SCAT, and of the nature of the data that it produces. To this end, the first part of the manual includes two chapters that provide background information on SCAT and describes various aspects of SCAT data collection in the field.

Chapter 1 provides a brief overview of SCAT to introduce the concept for those not familiar with the process and provides a refresher for those who are. The chapter summarizes the entire SCAT process, describes where SCAT activities are located within and Incident Response organization (Figure 2) and how SCAT-derived information is used within a response (Figure 3). A short description of the nature and purpose of SCAT data management is also provided.

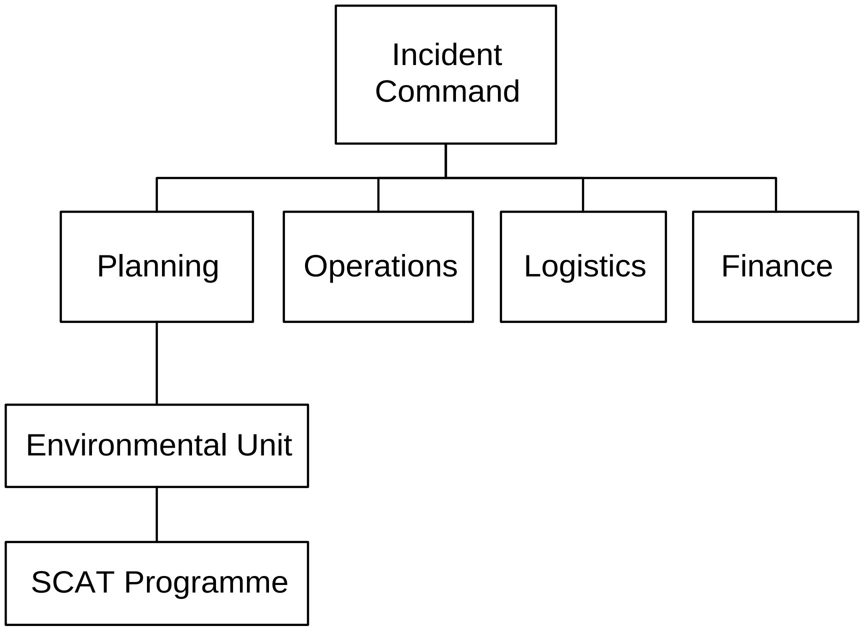

Figure 2   Position of the SCAT program within and Incident Response organization

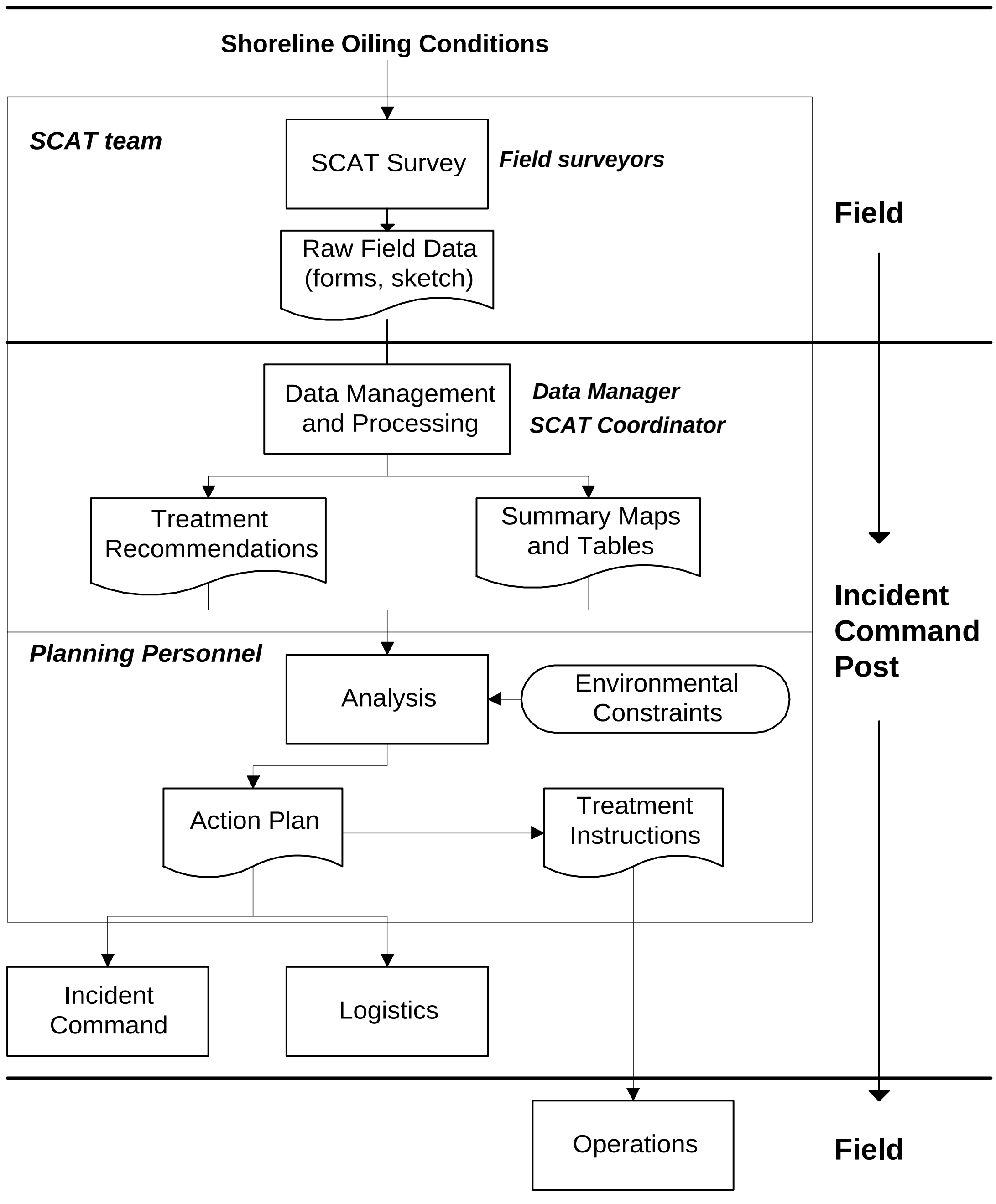

Figure 3 Processing and use of SCAT data during a response to an oil spill

Chapter 2 describes how SCAT data is collected in the field. For each of the five different types of SCAT surveys (Table 1), the manual presents the purpose and objectives of the survey, as well as details on the data collection methods and the nature of the data collected.

Table 1 List of the five different types of SCAT surveys

First Phase – Initial Response:
(1) **Aerial reconnaissance -** a quick overview of the extent of shoreline oiling (2) **Aerial video/mapping survey** – systematic data is generated on physical shoreline character and shoreline oiling (3) **First responder (ground) surveys** – an initial assessment of oiling characteristics shortly after a spill, before the implementation of a formal SCAT survey
Second Phase: Treatment
(4**) Full-scale SCAT team ground surveys** - detailed, systematic observations and information on segment character and oiling conditions
Third Phase: Inspection
(5) **Post-treatment ground surveys** – supports the inspection and “sign-off” process.

The manual presents examples of data, such as sketches or forms, as they are generated in the field. The following three data capture support tools are reviewed: GPS receivers, digital cameras and small weatherized hand-held field computers. The review describes the characteristics of each tool, and includes a short practical analysis of their advantages, drawbacks and limitations (Table 2).

Table 2 Summary of the main characteristics, limitations and uses of field data capture equipment

GPS Receivers
Characteristics
● Uses signals from satellites to calculate geographical coordinates ● Horizontal measurement accuracy between 1 to 20 m
Limitations
● Will not work in certain areas (clear view of the sky needed) ● Variable accuracy of the coordinate measurement
Uses to support SCAT
● Navigation to the start or end of a shoreline segment ● Record location of surface oil zones, pits, pictures or other affected resources
Digital Cameras
Characteristics
● Can record high resolution still images or short video clips
Limitations
● Digital documents can be modified easily ● Data is easily lost or destroyed ● Data transfer and image or video format are variable between brands of camera ● Very easy to operate – with the possibility to record too many images
Uses to support SCAT
● Very valuable complement to SCAT observations ● However, a strict data transfer procedure should be developed ● Each image file should be accurately documented
Field Computers
Characteristics
● Small weatherized hand-held or portable computers, used to capture data during field surveys.
Limitations
● Lack or size of keyboard PDAs makes text entry difficult during ground surveys ● Small display area for PDAs ● For optimal use, field computers need to be incorporated within an overall system that includes a central processing computer ● Use requires training
Uses to support SCAT
● Can provide navigational support ● Should improve data quality ● Faster data availability ● Eliminate data transcription error ● Shorten time necessary for data processing and provision of decision support documents

3.2 Managing SCAT Data

The second section includes three chapters that describe the processes and methods used to manage SCAT data and forms the core of the manual. These chapters include details on how to manage the data and how to use the information in different ways to support planning, decision-making and operational functions

Chapter 3 provides a summary of the work and responsibilities of the SCAT data management team. One of the purposes of this chapter is to provide guidance for spill managers that need to create a SCAT data management team, so that they understand the nature of the work required, and the abilities of personnel in charge of SCAT data management.

Chapter 4 describes the processes necessary to manage SCAT data. The chapter lists and explains each of the tasks that will lead to the establishment of a SCAT data management system, manage the initial response survey data, and manage the ground survey data. The information is presented as lists of steps to be performed (Figure 4) and includes visual examples of any output that is produced to support the management and survey effort. A practical example is also developed for one hypothetical shoreline segment.

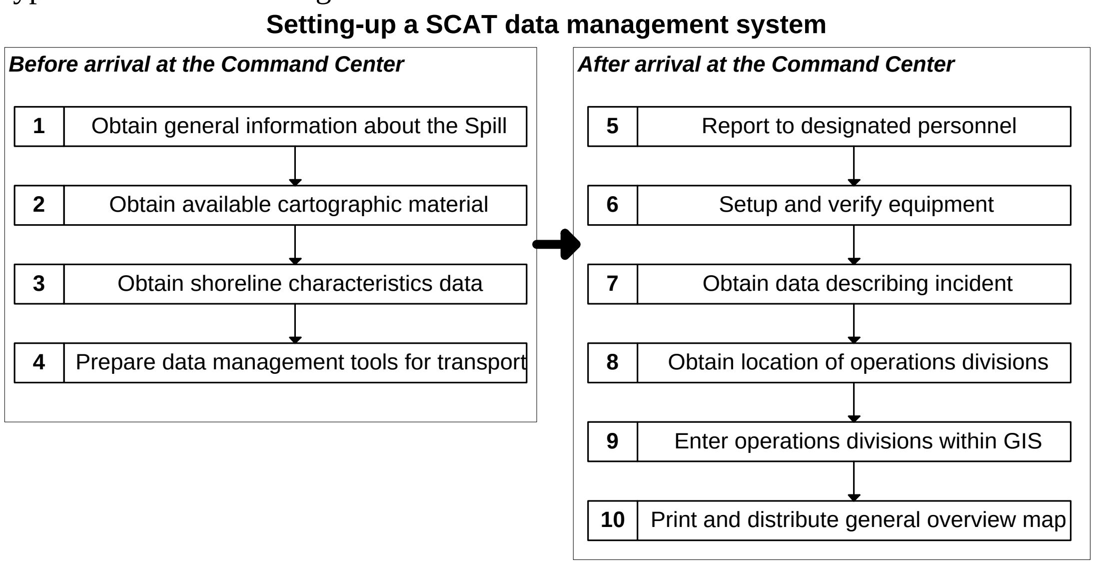

Figure 4 Tasks performed during the setup phase of the SCAT data management effort

Chapter 5 provides a detailed explanation on how to process SCAT data so that it can be used to support planning, decision-making, and operational functions. The chapter provides detailed explanations on how to calculate or evaluate more than eleven types of assessments, such as: total oiled area, surface oil distribution, surface oil category, subsurface oil thickness and category, etc.. Examples are provided to help understand the limitations of certain types of measurements, such as oil volume (Table 3).

Table 3 Results of oil volume calculation for simulated oiling data

			Distribution (%)				*Oil Thickness (cm)*				***Oil Volumes (m^3)***		
Oil Zone ID	*Width (m)*	*Length (m)*	*Category*	*Min.*	*Mid.*	*Max.*	*Cate-gory*	*Min.*	*Mid.*	*Max.*	***Min.***	***Mid.***	***Max.***
A	2	100	Continuous	91	95	100	PO	1	1.5	2	**1.82**	**2.85**	**4.00**
B	2	100	Patchy	11	30	50	CV	0.1	0.5	1	**0.02**	**0.30**	**1.00**
C	2	100	Broken	51	65	90	CV	0.1	0.5	1	**0.10**	**0.65**	**1.80**
D	2	100	Sporadic	1	5	10	CV	0.1	0.5	1	**0.00**	**0.05**	**0.20**

The SCAT data processing section also describes how to summarize SCAT data for individual segments, or entire impacted areas. Developing summaries for segments that might include multiple oil zones is a subject that are not clearly addressed in the literature. Detailed step-by-step explanations are provided for that purpose (Figure 5).

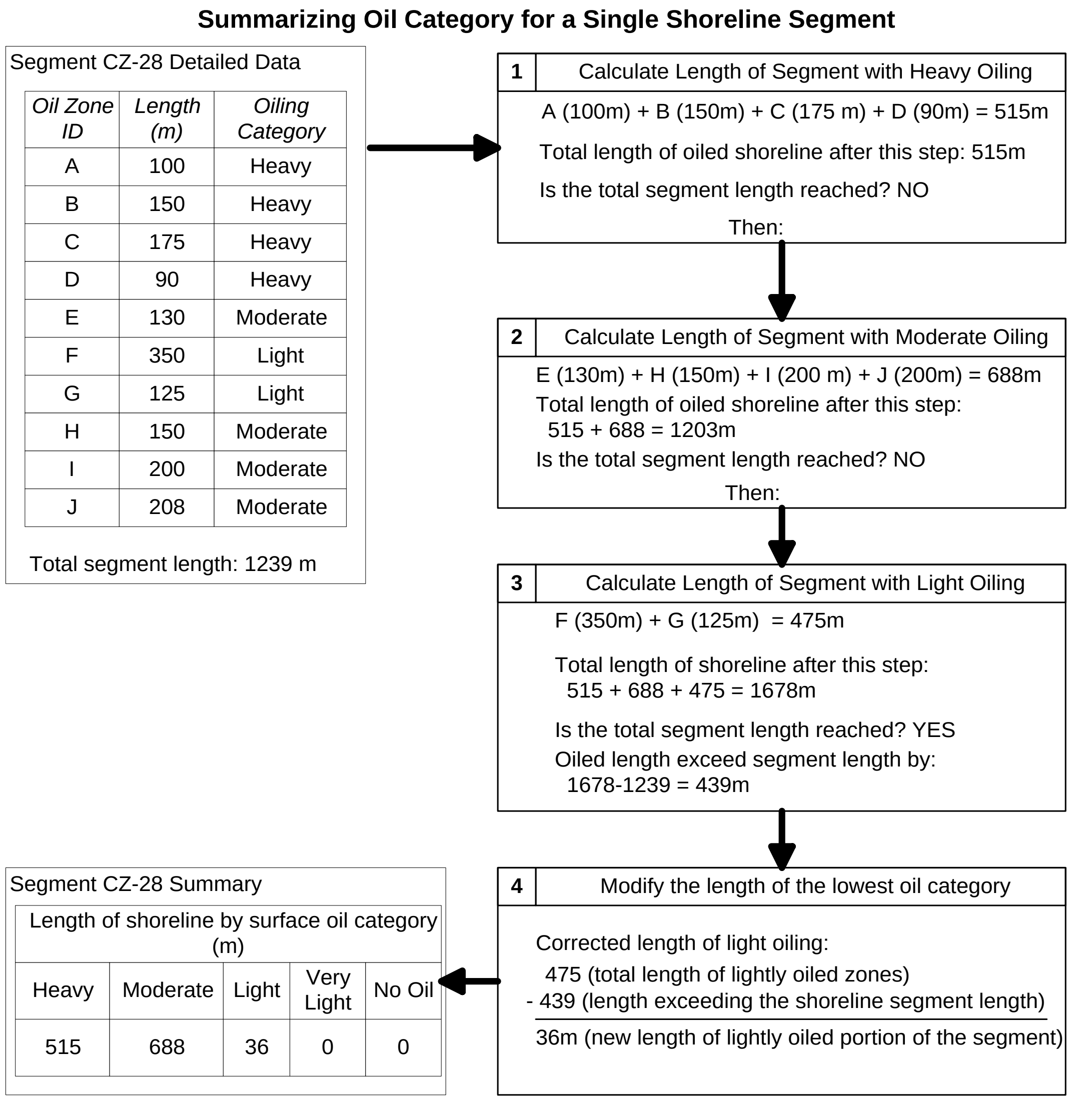

Figure 5 Step-by-step procedure used to summarize Surface Oil Category for a single shoreline segment

More that twenty types of maps and reports used for decision-making are presented, along with the data processing necessary for their production (Table 4). All of these examples, of which two are shown below (Figure 6, Table 6) were built from the simulated SCAT dataset. Guidelines were developed for the formatting and presentation of maps and reports, including map legends, and the content of headers and footers.

Table 4 List of decision support maps, reports and tables presented in the SCAT data management manual

Maps
Overview Map of oil category from Initial Response Surveys
Detailed oiling maps for a given Shoreline Segment
Overview map of Surface Oil Categories
Overview map of oil zone substrate types
Overview map of Remobilisation Potential
Overview map of Oil Persistence
Overview map of Subsurface Oil Category
Overview map of Subsurface Oil State
Summary map of Surface Oil Categories
Summary map of Oil Substrate Types
Summary maps of oil volume
Overview map of Work Status
Tables
Summary table of oil category from Initial Response surveys
Oiling summary for a single Shoreline Segment
Summary table of treatment recommendations
Summary table of SCAT Survey History
Summary tables of Surface Oil Category
Summary Table of Work Status
Reports and forms
SOS Forms Printouts
Sketch Maps
Treatment Recommendation Transmittal Form

Maps and reports have also been categorized into 1) raw (detailed) segment field data, 2) segment-based reports and summaries and 3) regional summaries. The intended target users is provided for the most common maps produced within each of these categories (Table 5)

Table 5 Intended users of the most commonly used reports and maps.

Category	*Output*	*Users*
Raw, detailed, segment field data	- SOS Forms (original and computerized) - Sketch maps	- SCAT coordinator - Operations Section - SCAT survey team members
Segment based summaries	- Treatment Recommendations Transmittal Form	- SCAT coordinator - Planning Section - Operations Section - Stakeholders
Regional Summaries	- Surface Oil Category Map (detailed or summary) - Oil Zone Substrate Types maps - Work Status maps - Length of oiled shoreline report*	- SCAT coordinator - Planning Section - Incident Command - Public groups
	- Survey Summary table	- SCAT coordinator - Planning Section

*Broken down by oil substrate type and Surface Oil Category

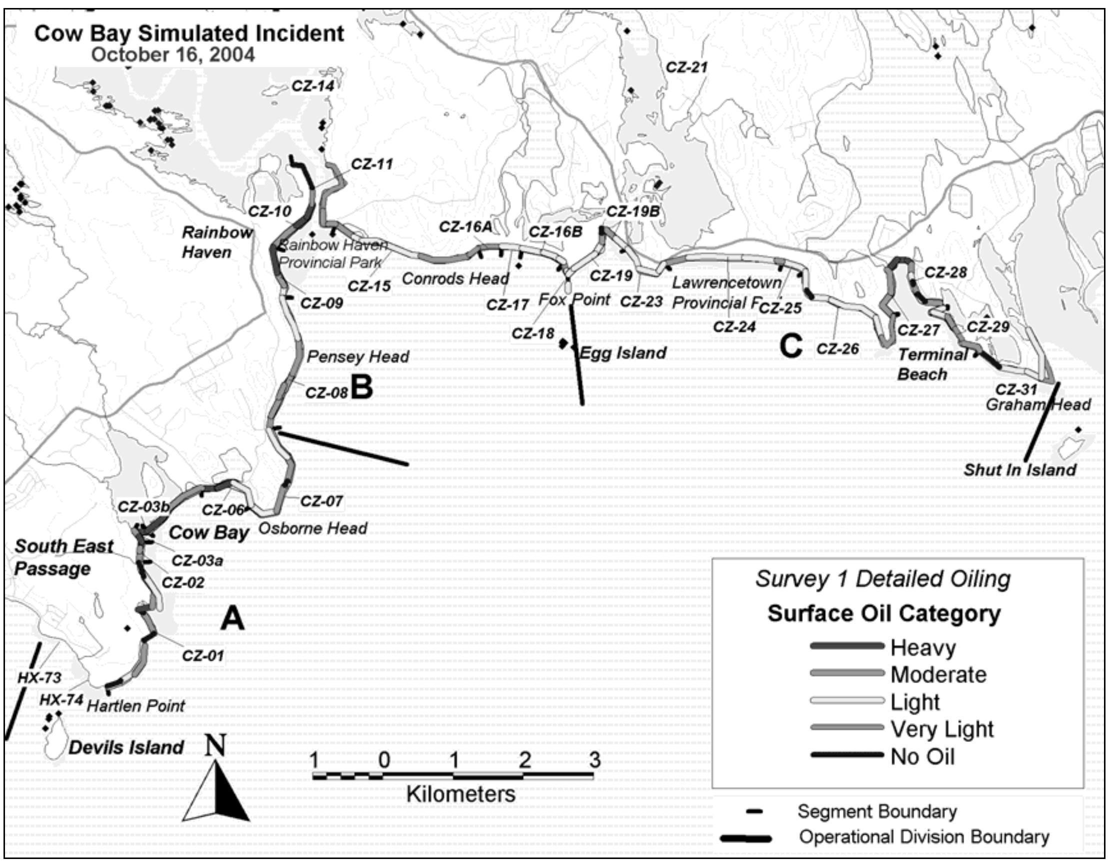

Figure 6 Overview map of Surface Oil Category for each oil zone observed during a given Survey

Table 6 Summary table of Surface Oil Categories broken down by substrate type

Substrate Type	*Length of shoreline by Surface Oil Category (km)*				
	Heavy	*Moderate*	*Light*	*Very Light*	*No Oil*
Bedrock	0.00	0.00	2.37	0.39	0.00
Boulder	0.00	1.62	0.12	0.00	0.00
Cobble-Pebble	1.44	3.13	4.86	1.62	0.00
Marsh	0.00	0.00	0.29	0.01	0.00
Rip-Rap	0.38	1.97	0.45	0.00	0.00
Sand	1.23	2.13	2.88	0.34	0.00
Sandy Gravel	0.64	2.09	0.78	0.01	0.02
Total	**3.69**	**10.94**	**11.74**	**2.36**	**0.02**

One key data management issue that has not been adequately addressed is the difficulty presented by the representation of multiple parallel surface oiled zones observed along shoreline segments. The manual provides guidance to help resolve this particular problem by presenting a number of map examples and a decision tree to help select the most appropriate format. (Figure 7)

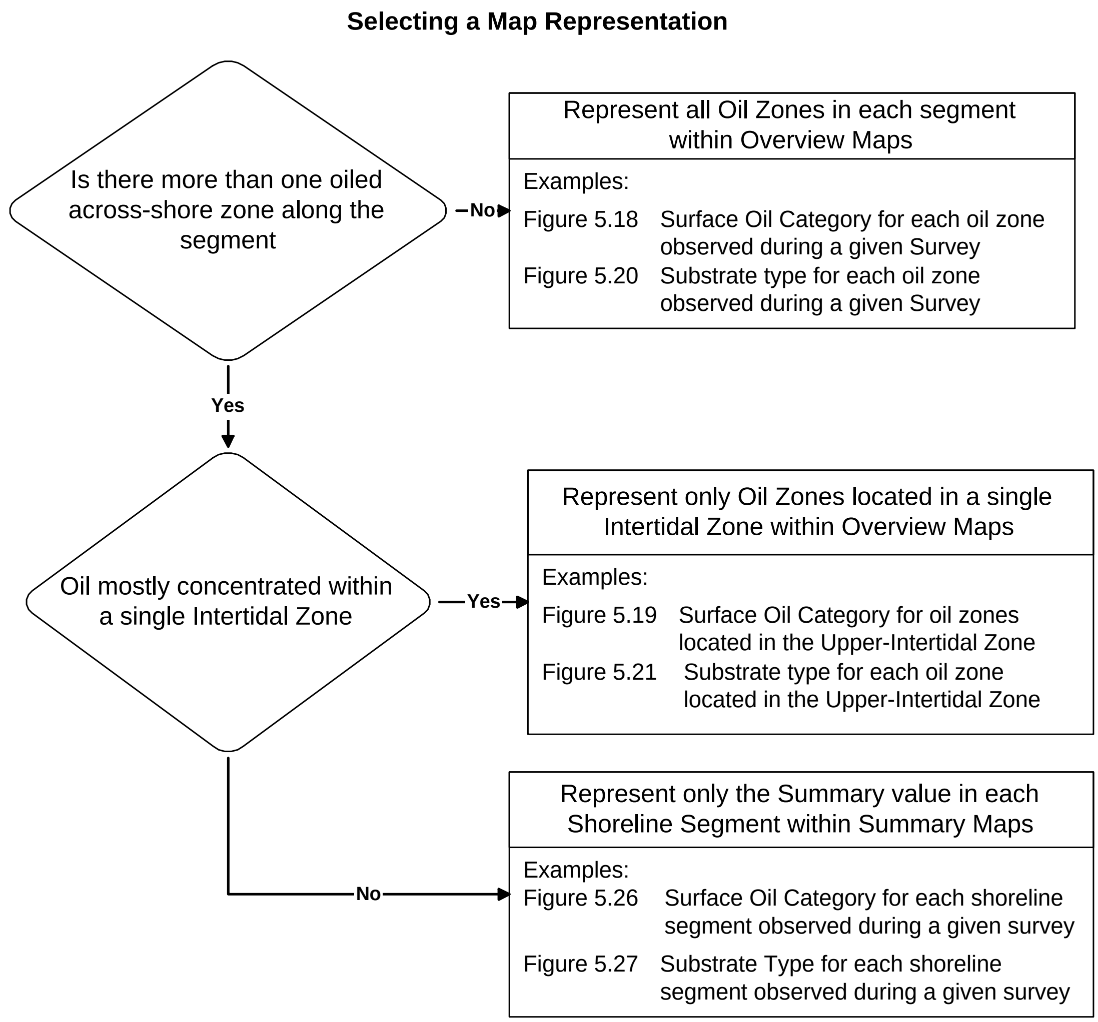

Figure 7 Decision Tree for the selection of map representations of oiling characteristics data.

3.3 Developing SCAT Databases

The third section of the manual covers the technical aspects of developing and maintaining a SCAT database and includes two chapters that provide a technical description of SCAT data structure and content and describe the basic tools that can be used to manage and process SCAT data.

Chapter 6 describes all of the data elements that are captured during SCAT surveys and how they can be organized in tables to create a SCAT database. Data elements that are essential for the SCAT data processing and decision-making are identified.

Chapter 7 provides guidance for the selection of SCAT data management tools and for their combined use within a SCAT data management system. The chapter provides a review of a number of basic tools (Table 7) and indicates how they can be used to support the various tasks that are part of a SCAT data management system (Figure 8).

Table 7 Basic Data Management and Processing Tools

Tool	*Optimal Use*
Pencil and Paper	Field data capture of SCAT observations on forms, sketch maps
Spreadsheet Programs	Reports, data processing
Databases Systems	Data management (data entry, reports)
Geographical Information Systems (GIS)	Data processing (production of overview and summary maps)
"Specialized programs"	Data processing (automation of certain types of processing)
Word Processors	Organize processed data (production of comprehensive reports, including tables and other types of outputs)
Web-based Applications	Distribution of processed data
Portable Applications	Field data acquisition

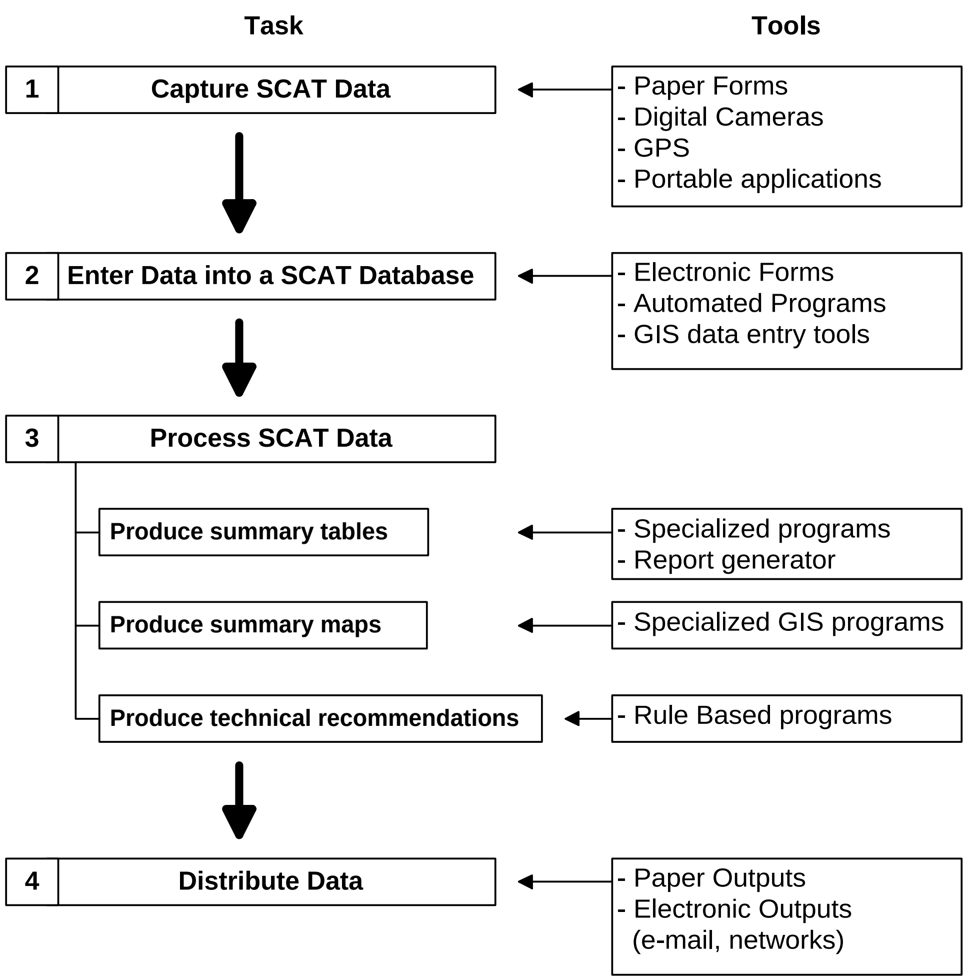

Figure 8 SCAT Data Management System Tasks and Support Tools.

In addition, the chapter provides guidelines for the development of SCAT data management training courses. These include preparing for some of the likely events that might face SCAT data management teams and possibly affect their efficiency: such as, equipment breakdowns, software corruption, and overwhelming volumes of data.

4 Discussion

During the development of the manual it became evident that many practical issues related to SCAT data management and data processing are not clearly addressed in the literature. It was thus necessary to develop formal descriptions of the role, responsibilities, and abilities of the SCAT data management team. The SCAT data management process had to be thoroughly analysed and categorized in order to provide detailed step-by-step procedural descriptions that could be used as "recipes" for the implementation of SCAT data management capabilities. The manual also had to address and provide solutions to a number of data processing issues. Many issues were related to the presence of multiple parallel bands of oil within a segment, a fundamental characteristic of the SCAT survey process. This issue had to be addressed to develop summary tables to report the length of oiled shoreline by oiling category, and also to present surface oiling characteristics in overview maps.

The manual is also intended to provide guidance both for the technical personnel in charge of providing SCAT data management support, and SCAT coordinators and spill response managers that use the results of SCAT data management effort. The manual thus provides information at various levels of detail and complexity, from general overviews of the SCAT process and SCAT data management, to the details of how to develop SCAT databases.

Guidance is provided for an "emergency procedure" that enables the generation of minimal but adequate SCAT data management services. However, the manual stresses that SCAT data management ideally requires training and computerized tools. The selection of data management tools is also addressed. Clearly, for small spills with limited shoreline impact, SCAT data can be entirely managed and presented by pen-and-paper. However, for larger incidents with significant shoreline activities, some degree of automation becomes quickly required to ensure that SCAT data can be used efficiently. What constitutes a "significant" incident, in terms of SCAT data management, is difficult to define in precise quantitative terms. Since a line had to be drawn, it was decided that any incident where more than 5 shoreline segments would be surveyed daily would generate a large enough amount of data to make the use of automated (i.e. computerized) systems profitable. It should be noted that, regardless of the size of a spill, SCAT data management always benefits from automation.

A number of tools are now commonly used to support field activities. These include GPS receivers, digital cameras and weatherized hand-held computers. It was thought important to describe not only the advantages, but also some of the drawbacks and limitations of each tool. GPS receivers, for example, provide geographic coordinates with a precision that can vary considerably depending on the quality of the reception. Guidelines were developed to indicate the number of significant digits that should be kept when recording latitudes and longitudes. Similarly, the manual provides guidelines for the storage and recording of information regarding digital pictures to ensure that their validity cannot be questioned.

Since even the most dependable computerized system can fail, it was thought that personnel involved in providing SCAT data management services should understand SCAT data processing well enough to detect anomalies in the computed results (i.e. unrealistic values) and also be able to process data and prepare summaries manually, following the principles of "graceful degradation". The manual also provides details on how the SCAT data is used for response planning, decision making and to support operations, so that SCAT data managers can provide their services intelligently: when they are needed, and in the most appropriate form. This essentially sums up the purpose of the manual.

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