Environmental
Studies
Research
Funds

097

Beaufort Sea Ice Scour Data Base (Scourbase) Update to 1986

Canada

March 1989

ENVIRONMENTAL STUDIES RESEARCH FUNDS

Report # 097

March 1989

BEAUFORT SEA

ICE SCOUR DATA BASE (SCOURBASE)

UPDATE TO 1986

Glen. R. Gilbert
Stephen J. DeLory
Karen A. Pedersen

Cdn. Seabed Research Ltd.
P.O. Box 2508 Stn M
Halifax, Nova Scotia
B3J 3N5

Scientific Advisor: Steve M. Blasco

The correct citation for this report is:

Gilbert, G.R., DeLory, S.J. and K.A. Pedersen. 1989. Beaufort Sea Ice Scour Data Base (SCOURBASE), Update To 1986. Environmental Studies Research Funds, Report No. 097. Ottawa, 95 p.

Published under the auspices of the Environmental Studies Research Funds

ISBN-0-920783-96-1

TABLE OF CONTENTS

LIST OF TABLES

LIST OF MAPS

LIST OF FIGURES

PROJECT PERSONNEL

Scientific Advisor

S.M. Blasco	Geological Survey of Canada Energy Mines and Resources

Cdn. Seabed Research Ltd. Personnel

G.R. Gilbert	Project Supervision/Interpretation
K.A. Pedersen	Data Interpretation
M. Brogan	Data Interpretation
S.J. DeLory	Programming/Data Analyses

Subcontracted Personnel

J. Shearer	New Scour Analyses (Shearer Consulting)

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the clear direction and enthusiasm provided by the scientific authority, Steve Blasco, of the Geological Survey of Canada (GSC). Project reviews and assistance were provided through David Milburn and Natalie Moir of the Environmental Studies Research Funds (ESRF). The authors would also like to thank Mike Lewis of the GSC for reviewing the manuscript. Bob Harmes and Randy Currie of the GSC are thanked for downloading numerous navigation data tapes from a mainframe computing environment to IBM PC compatible disks. Lauchie Meagher of Earth and Oceans Research Ltd. is acknowledged for providing a detailed bathymetry map of the Yukon Shelf Region. Thanks are also extended to Norma Poirier of CSR for her computer drafting capabilities and finally to all the project participants and friends for their interest and excellent support.

STATEMENT OF ACCESS

1) This report and copies of the data base listings and/or magnetic media are available, at duplication costs, from the Geological Survey of Canada, at the Bedford Institute of Oceanography in Dartmouth Nova Scotia. Interested parties should contact Mr. S. Blasco at (902) 426-3932.

2) SCOURBASE data processing and interpretation software is the property of Cdn. Seabed Research Ltd. (CSR) in Halifax. Copies of the digital maps presented in this report are available at different scales through CSR and interested parties should contact Mr. Glen Gilbert for further information at (902) 422-2840.

SUMMARY

The grounding of sea ice on high latitude continental shelves of the world represents a potential threat to the maintenance of subsea industrial installations. The ESRF Beaufort Sea SCOURBASE System was created to store the major scour parameters relevant to engineering design in a comprehensive data base format. This system represents a unique and powerful tool for studying the statistical and risk-related attributes of ice scour and environmental parameters in areas of potential seabed development. In response to the recent collection of high quality acoustic scour data sets, this SCOURBASE system was upgraded and improved by the present study. A total of 116,991 records are present in the system that were processed totally in a micro computer-based environment by new data processing, interpretive and graphical software utilities.

Scour depth data for the ECHOBASE system were digitized and formatted using the new ECHOPRO processing software. Results from this study indicate a high scour frequency of 8.2 scours/km (for echo sounder data) that results from the utilization of a more detailed measuring technique for scours less than 0.5m deep. The data displayed negative exponential characteristics in the low end of the distribution, (scours down to 0.25m) until resolution truncation reversed this trend. Distribution analyses of the depth parameter indicated that scour depth values should be binned using standard techniques, at a bin interval greater than the one decimal accuracy level of the data.

Error analysis of the scour depth parameter demonstrated a maximum error bound value of +/-0.21 metres. This study identified the seafloor smoothing/digitizing process as the major source of error for a scour depth determination. The results suggest that a more sophisticated digital acquisition and scour detection system is warranted for future studies. Such a system would remove interpretive biases, reduce error and facilitate data processing operations. This study also identified the potentially different effects arising from the use of narrow and wide beam sounder transducers, suggesting more research is needed in this direction. Error analyses and statistical operations also identified that scour depths should be measured to two decimal places in the future, in order to retain accuracy.

The SCOURBASE system has been improved and upgraded by this study, through a combination of data processing utilities linked to the NAVBASE system. Selected SCOURBASE results were used to graphically illustrate data-deficient regions within the data base. It was shown, that upon regionalization of the Beaufort shelf data, these gaps were accentuated, such that statistical objectives were considerably constrained.

The NAVBASE system used for storage of survey navigation data was newly developed for this project. Through the use of software utilities, this system provided exact line distances within user-defined regions that were used to normalize scour data for calculation of spatial frequency statistics. The results of one

comparison for Yukon shelf data were presented using bivariate contour and 3-dimensional perspective plots. The data indicated a considerably denser deep-water scour population when normalized, thus illustrating the importance of the NAVBASE system and this form of graphical display.

A second, new data base was created during this study, that stores new scour (age distinct) data, derived through side scan image comparison from repetitive mapping surveys. This data base stores important parameters used in deriving estimates of modern day impact rates and temporal scour frequencies for subsea engineering pipeline design. NEWBASE results indicated that more data are required for this system (especially when the data are partitioned) before meaningful conclusions can be drawn.

New scour distributions revealed a significant visual correlation with ECHOBASE distributions only when a new correction factor was applied to the new scour data. This correction introduces a novel approach to the analysis of scour depth data, which should be explored in more detail.

RÉSUMÉ

L'échouement de glaces de mer sur les plate-formes continentales du globe aux hautes latitudes peut constituer une menace pour les installations industrielles sous-marines. Le Système SCOURBASE du FEE en mer de Beaufort a été créé pour le stockage des principaux paramètres de l'affouillement par les glaces pertinents pour les études techniques suivant un format extensif de base de données. Ce système constitue un outil puissant pour l'étude des caractéristiques statistiques et associées au risque des paramètres environnementaux et de l'affouillement par les glaces dans les secteurs d'aménagement possible du fond marin. En réponse à la collecte récente d'ensembles de données acoustiques de grande qualité sur l'affouillement, ce système SCOURBASE a été perfectionné et amélioré dans le cadre de la présente étude. Au total, le système comprend 116 991 enregistrements qui ont été entièrement traités sur micro-ordinateur grâce à de nouveaux logiciels utilitaires de traitement, d'interprétation et de représentation graphique.

Les données sur la profondeur des cicatrices d'affouillement pour le système ECHOBASE ont été numérisées et mises en forme à l'aide du nouveau logiciel de traitement ECHOPRO. Les résultats de cette étude indiquent une fréquence élevée de 8,2 cicatrices/km (pour les données obtenues à l'échosondeur) résultant de l'utilisation d'une méthode plus détaillée de mesure des cicatrices d'une profondeur inférieure à 0,5 m. Les données présentaient des caractéristiques d'exponentielles décroissantes à l'extrémité inférieure de la distribution (profondeurs jusqu'à 0,25 m) jusqu'à ce qu'une troncature de la résolution inverse cette tendance. Des analyses de la distribution des profondeurs ont indiqué que les valeurs de profondeur des cicatrices devraient être stockées au moyen des méthodes ordinaires, à un intervalle de stockage plus grand que l'intervalle de précision des données qui sont recueillies à une décimale près.

L'analyse d'erreur pour le paramètre profondeur des cicatrices a fourni une valeur de +/-0,21 mètres comme borne maximale de l'erreur. Cette étude a identifié le processus de lissage/numérisation du fond marin comme principale source d'erreurs lors de la détermination de la profondeur des cicatrices. Les résultats suggèrent qu'un système plus évolué de saisie numérique et de détection des cicatrices serait justifié pour les études futures. Un tel système éliminerait les erreurs sysématiques d'interprétation, réduirait le nombre d'erreurs et faciliterait les opérations de traitement des données. Cette étude a également identifié les différents effets potentiels de l'utilisation de transducteurs de sondeurs à faisceaux étroits ou larges et suggère que d'autres recherches concernant cet aspect sont nécessaires. Les analyses d'erreur et les opérations statistiques ont également indiqué que les cicatrices devraient être mesurées à deux décimales près à l'avenir pour permettre de conserver la précision.

Le système SCOURBASE a été amélioré et perfectionné dans le cadre de la présente étude par une combinaison de programmes utilitaires de traitement de données reliés au système NAVBASE. Des résultats choisis du SCOURBASE ont été utilisés pour illustrer graphiquement des régions pour lesquelles les données sont insuffisantes à l'intérieur de la base de données. Il a été démontré qu'une régionalisation des données pour la plate-forme de Beaufort accentuait ces lacunes au point de limiter considérablement les objectifs statistiques.

Le système NAVBASE utilisé pour le stockage de données de navigation pour les levés a été récemment mis au point pour ce projet. Par l'utilisation de programmes utilitaires, ce système a fourni des distances linéaires précises à l'intérieur de régions définies par les utilisateurs qui ont été utilisées pour normaliser les données sur les cicatrices en vue de calculs statistiques sur la fréquence spatiale. Les résultats d'une comparaison avec des données pour la plate-forme du Yukon ont été présentés au moyen de tracés en courbes en deux dimensions et de tracés en perspective en trois dimensions. Les données indiquaient une population considérablement plus dense de cicatrices en eau profonde après normalisation, ce qui illustre l'importance du système NAVBASE et de cette forme de représentation graphique.

Une deuxième base de données, composée de données nouvelles, a été créée dans le cadre de cette étude pour le stockage des données sur les nouvelles cicatrices (se distinguant par leur âge) obtenues par comparaison d'images relevées par balayage latéral lors de levés de cartographie répétitifs. Cette base de données sert au stockage de paramètres importants utilisés pour l'obtention d'estimations des taux contemporains d'impact et des fréquences temporelles d'affouillement destinées aux études techniques de pipelines sous-marins. Les résultats obtenus avec le NEWBASE indiquent que des quantités plus importantes de données sont nécessaires pour ce système (surtout lorsque les données sont segmentées) avant que puissent être tirées des conclusions sensées.

Les distributions de cicatrices nouvelles ont présenté une corrélation visuelle significative avec les distributions de l'ECHOBASE seulement après application d'un nouveau facteur de correction aux données sur les cicatrices nouvelles. Cette correction introduit, pour l'analyse des données sur la profondeur des cicatrices, une approche originale qui devrait être explorée de manière plus approfondie.

1.0 INTRODUCTION AND OVERVIEW

1.1 Introduction

The seafloor of the Canadian Beaufort Sea retains a unique historical record of ice/sediment interaction that is expressed morphologically in the form of complex linear gouges found on the seabottom (See Fig. 1). These features, identified on side scan sonar records and termed "ice scours" by their discoverers (Shearer,1971; Pelletier,1971), may extend linearly for tens of kilometres, with widths of 400 metres or more, and incisions of 5 metres or more, into the seabed. The processes of ice scouring implied by such phenomena, have been recognized as potential threats to safe petroleum operations in the Beaufort Sea. Analysis of the ice scour record, however, is problematic as the observed seafloor distributions represent a cumulative history of scouring over geologic time and may not truly reflect the record of modern processes which is needed for accurate prediction of future ice scour effects. The overall scour record possibly includes effects related to events of sea level changes, geologic processes of scour degradation and temporal/spatial variations in sea ice conditions. A great deal of research has been carried out over the years to help interpret, as fully as possible, these important geological seafloor features.

The recent focus of much of this work has utilized the ESRF Beaufort Sea SCOURBASE System; a data base created to store the major scour parameters relevant to engineering design for subsea industrial installations. In response to the recent collection of high quality data sets, a requirement was identified to include this data and to generally improve the formats and operating efficiency of the SCOURBASE system.

Study Objectives

The specific objectives of this study were:

- to incorporate approximately 1600km of high quality data from the ESRF84, TULLY85 and TULLY86 data sets.

- although not specified by the agreement, it was a CSR objective to perform the processing and interpretation operations totally in a micro computer-based environment.

- to calculate estimates of error for ECHOBASE scour depth values, and

- to create two new data bases; one for the storage of new scour parameters (NEWBASE) and one for the storage of survey line navigation data (NAVBASE) used to derive spatial scour frequency estimates.

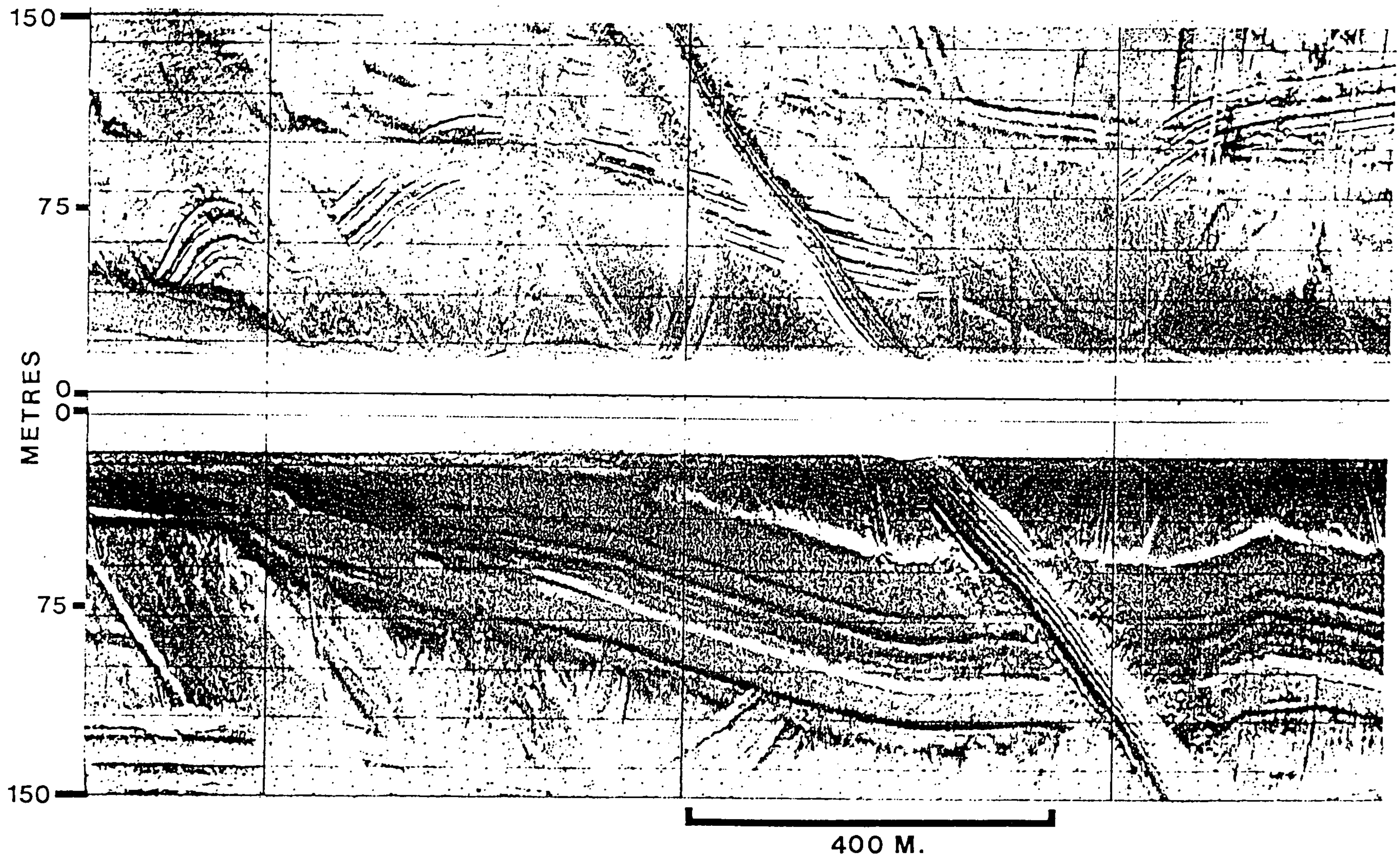


FIG 1 BEAUFORT SEA SCOURED SEABED

1.2 Background

Ice scour research has been quite varied since the 1970's, owing to changing data collection and processing methods and also a natural expansion of the knowledge base of the marine geological community concerning these features. Early work, such as that by Pelletier and Shearer (1972) and the Arctic Petroleum Operators Association (APOA) projects (19,32 and 69 initiated in 1973) contributed a great deal of observational, as well as, statistical data concerning scour parameters including; preferred scour depth distributions and basic length and width numerical data. Perhaps one of the most important accomplishments achieved by these studies was an understanding that the assessment of risk to seafloor emplacements by modern ice scouring was complicated by relict (very old and deep) scours occurring in the observed seafloor scour populations. This early realization in the 1970's continues to be a source of concern today in the late 1980's.

Researchers such as Lewis (1977), Hnatiuk and Brown (1977), Wahlgren (1979) and Shearer and Blasco (1975) extended ice scour knowledge further, by comparing scour relationships in different water depths on the shelf, calculating yearly scouring rates from repetitively-mapped corridors and providing basic parameter values and important observational information.

Further work was undertaken in the 1980's by J. Shearer, establishing new scour data from geographic corridors, producing mosaics for site specific studies and further refining the important scour parameters of orientation, depth and frequency. Shearer et al. (1986), under contract to Geoterrex Ltd., undertook the ESRF 1984 repetitive mapping program in the Beaufort Sea, that resulted in the acquisition of new scour statistics.

A new computerized data base, to store ice scour information from Gulf Canada Resource's 1982 regional line data, was established by Gilbert et al. (1983), while employed by Geoterrex Ltd. The flexibility and utility of this data base was quickly recognized, which led to a major data compilation (Gilbert and Pedersen, 1986) funded by the ESRF. During this project, which lasted 1 1/2 years, approximately 5000kms of side scan sonar, subbottom profiler, and echo sounder data, from a number of different survey years were interpreted and processed. Although each year's data was in different formats due to equipment changes, a listing of over 45,000 scour records was successfully created for parameters such as location, depth, width, orientation, length, form, morphology, smoothness, relative age, area, infilling, bathymetry, sub-scour deformation, data quality and various interpreted geological relationships (Gilbert et al., 1985).

Since the establishment of the Beaufort Sea SCOURBASE system, Shearer and Pedersen (in prep) have updated this data base with an additional 7,433 scour records from the Yukon Shelf region. Comprehensive statistical modelling and extremal analyses studies were undertaken using the SCOURBASE system by Nessim et al. (1988), which successfully established the utility of the ESRF scour data base. The results from many of the preceding studies are summarized by Goodwin et al. (1985) and Lewis et al. (1986) in ESRF ice scour reports.

Recent ice scour studies completed by Cdn. Seabed Research Ltd. include the documentation of unique seafloor features for the Marine Science Atlas of the Beaufort Sea (Pelletier et al., in prep). CSR has recently completed a detailed SCOURBASE parameter analysis for the Geological Survey of Canada that included statistical analyses of the orientation, depth and width parameters in different physiographic and bathymetric regions of the shelf. This project (Gilbert and d'Apollonia (a), in prep) was extended to focus on bivariate relationships in deep water regions of the Beaufort Shelf. Presently, CSR is undertaking a project relating to digital scour mapping and Geographic Information Systems (GIS) for the Geological Survey of Canada (Gilbert and d'Apollonia (b), in prep) and a project to digitize and process echo sounder data automatically in the field, such that ice scours are detected and their depths measured and downloaded to the ECHOBASE environment.

In summary, it is evident that Canada has maintained an active role in cold ocean ice scour research. Further advancements can be achieved through the continued update and analysis of the ESRF Beaufort Sea SCOURBASE System, which represents a powerful tool for spatial scour density and risk-related subsea analyses.

1.3 SCOURBASE Overview

The term "SCOURBASE" has been adopted as the formal name for the five data bases in the Beaufort Sea Ice Scour Data Base System. Some degree of duality exists, as this term is also used to define the main scour data base, derived from the interpretation of side scan sonar data. However, since the SCOURBASE data set is by far the largest and most important of the five data bases, this term was chosen to represent the system as a whole. The names and functions of the present components of the Beaufort Sea SCOURBASE system are summarized in Table 1. The data base names presented in this table are also those that formally identify each data file on digital storage media.

TABLE 1 COMPONENTS OF THE BEAUFORT SEA SCOURBASE SYSTEM

Prepared by Cdn. Seabed Research Ltd.

NAME	ORIGIN	# FIELDS	#RECORDS	SIZE(meg)	FUNCTION
SCOURBASE	Side Scan	27	66,549	8.9	Stores major scour parameters.
ECHOBASE	Echo Sounder	11	24,801	2.5	Stores scour depth and bathymetry.
NAVBASE	Navigation	12	22,669	1.5	Stores exact navigation.
NEWBASE	Side Scan Echo Sounder	27	882	0.1	Stores new scour parameters.
NNAVBASE	Navigation	11	2,090	0.1	Stores new scour navigation.
RELEVANT	TOTALS		116,991	13.1	

Throughout this ESRF study, the Beaufort Sea SCOURBASE System has successfully been created, archived and interpreted, by CSR, totally in a micro computer-based environment. An integrated sequence of in-house software processing utilities were written either in FORTRAN or the FOXBASE programming language, that processed the various data sets into their respective data base formats. For interpretation purposes, the Ice Scour Interpretation System (ISIS) was developed. This system includes a number of data processing , binning and statistical and graphical utilities. Example outputs of the ISIS system include unique bivariate contour plots and their 3-dimensional, perspective-view equivalents, presented in this report. A final software mapping system, GEOCAD, was written to digitally map track lines and scour parameters for interpretive and quality control operations. This system takes full advantage of the multiparameter SCOURBASE format by spatially plotting and overlaying different scour parameters onto a referenced, digital map base. Outputs from GEOCAD are found in the map pocket on the back report cover.

1.4 Report Overview

This report is the result of a study funded by ESRF and awarded to Cdn. Seabed Research Ltd. of Halifax, Nova Scotia. The main focus of the work was to update the Beaufort Sea SCOURBASE system (previously established by ESRF), with additional high quality 1984-1986 data sets. An additional task, partially funded by the Geological Survey of Canada, was to create the NAVBASE system and to upgrade and improve the original ESRF Ice Scour Data Base. A number of interesting interpretive and data processing operations were also undertaken that are briefly outlined in this section on a chapter by chapter basis.

Chapter 2 introduces the ECHOBASE system and the various details of the ECHOPRO data processing system responsible for building and controlling the quality of the various data sets. Graphical displays from the ECHOBASE system are used to outline scour depth distributions and to assist in the statistical analysis of important scour depth parameters. These capabilities are extended further by the estimation of error for scour depth measurement, and by a discussion on how these errors may be reduced for future ECHOBASE updates.

Chapter 3 deals specifically with the main SCOURBASE system; the parameters it stores, how they are measured and processed, and some of the results from different statistical analyses. This section presents interpretive graphical results, that illustrate data deficiencies that should be upgraded in the future.

The NAVBASE system is presented in Chapter 4. This digital navigation storage system represents a great advantage in data processing and normalizing operations. Besides documenting the various parameters and NAVPRO data processing operations,this section presents a striking example of normalized versus un-normalized scour orientation frequency data, that is graphically illustrated in bivariate contour and 3 dimensional perspective plots.

Chapter 5 presents a new data base (NEWBASE) for the storage of scours, that are known to be recent and thus bear an associated indication of age. This section introduces a novel concept in scour depth measurement, that is illustrated by comparing scour depth distributions for the total new scour population and a large subset of the total ECHOBASE population.

The final chapter summarizes the major findings of this work and presents recommendations for future ice scour research projects.

2.0 ECHOBASE (ECHO SOUNDER DATA BASE)

2.1 Introduction

High resolution echo sounding yields precise profiles of the Beaufort Sea's ice scoured seafloor morphology. (Refer to Gilbert and Pedersen, (1986) for a review of echo sounding principles and the factors affecting data quality). The important scour parameter, depth, can be accurately measured from this data and correlated to exact bathymetric values and UTM geographic positions, for further statistical analysis within the ECHOBASE environment. The reader is referred to Appendix 1 for a complete description of ECHOBASE parameters and the format of the ECHOBASE system.

Direct correlation between the SCOURBASE and ECHOBASE data sets is presently not possible due to the variable cable length, hence layback, of the side scan sonar fish in contrast to the hull-mounted sounding fathometer. (Refer to Gilbert and Pedersen, 1986 for additional details). At the present time, independent analyses of these data bases are yielding useful statistical analyses (Gilbert and d'Apollonia (a), in prep). Recent data acquisition techniques, however, are attempting to improve correlations through the successful utilization of a fish-mounted echo sounding device.

2.2 ECHOPRO Data Processing System

2.2.1 Data Preparation

Through repeated processing and interpretation of ice scour data, it has been demonstrated that data quality is one of the most important factors in achieving high quality statistical outputs. As discussed in Gilbert and Pedersen (1986), data quality is not degraded solely by imperfect weather conditions alone. Operator selections of scale, paper speed, and subsequent processing methods, are also factors relevant in maintaining high quality results.

In recognition of the importance of data quality, the selection of high quality lines for this project was undertaken in unison by Gilbert, Pedersen, and Shearer in Ottawa. Echo sounder and side scan sonar data were preprocessed at that time, following the steps outlined in the data preparation flow diagram shown in Fig. 2.

Records were catalogued and filed by company name, survey year, and regional line number into separate boxes. Each of the data sets were described on data quality sheets in terms of record annotation including; survey date, line number, correct fix increment, physiographic location, scale ranges, draft settings, fix part information, type of survey system and corrections applied to the data. Unusual features such as artificial islands, dredge holes, pingos, evidence of sand and unusual scours were also noted on the data sheets at this time, as an interpretation aid and for future reference purposes. Special attention was given to data breaks and the documentation of exact fix numbers for each section (Part) of usable

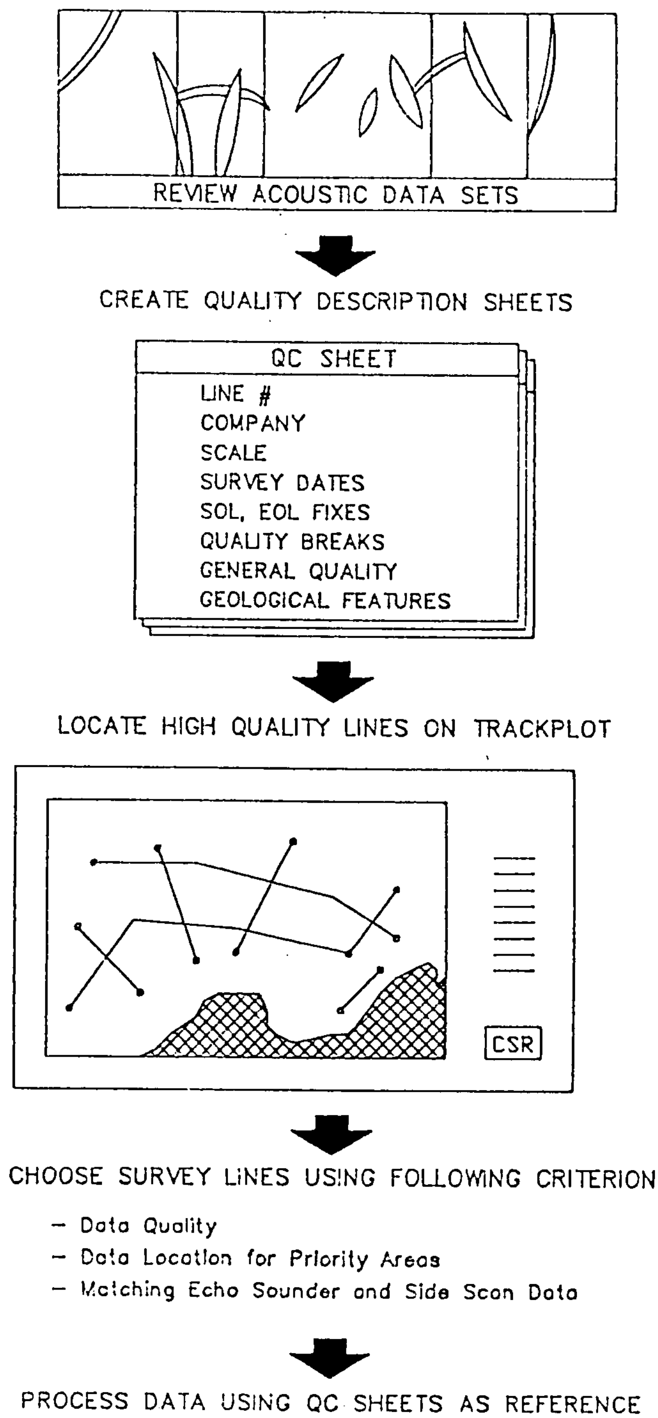


FIG 2 FLOW DIAGRAM OF DATA PREPARATION

CSR

data. This fix information is used to create the navigation data base, NAVBASE, from which scour frequency statistics (# of scours/km) can be derived.

Final line selections were then made using the following criteria:

- Data quality

- Data location in areas of priority or scarcity

- Matching echo sounder and side scan data sets

- Total kilometre distance objectives for the survey

Over 1600 line kilometres of high quality data were chosen for further analysis, however, it should be noted that data quality was generally quite high for the 1984-1986 data sets, such that all the high quality data could not be analyzed. It is recommended that this data be incorporated into the SCOURBASE System during subsequent updates.

2.2.2 Digitizing

ECHOPRO represents a number of data processing sequences developed by Cdn. Seabed Research Ltd. to create the ECHOBASE system. These routines are summarized by the flow diagram in Fig. 3. The data are first digitized using a specialized software system called MAC1, that measures and stores scour parameters, in a pre-formatted data base environment. The program is initiated by the following relevant input parameters: Company, year, line, part, data quality, reference depth, scale factor, and global or scour specific comments. The digitization took place on a Graf/Pen sonic digitizing table, yielding an accuracy of +/- 0.1% of the distance to the sensors from any digitized point. This translates into a resolution of 0.1mm, which is more than adequate for ECHOBASE data processing operations.

Data are taped to the table, covered by mylar and a "best estimate" smoothed seafloor is drawn along the profile, thus establishing a reference datum. Please refer to Fig. 4. for processing details. The digitizing process is initiated by inputting the start fix # and the numeric fix increment (the increment is 1 in Fig. 4). The measurement of a scour depth is accomplished by digitizing two points at the deepest location of the scour depth; first, the seafloor filter position (A) and second, the position of maximum scour depth on the original sounder profile at (B). This action initiates the following 4 operations:

- an accurate fix is interpolated for that coordinate location

- a scour depth (rounded to 1 decimal point) is generated using the scaling factor in metres.

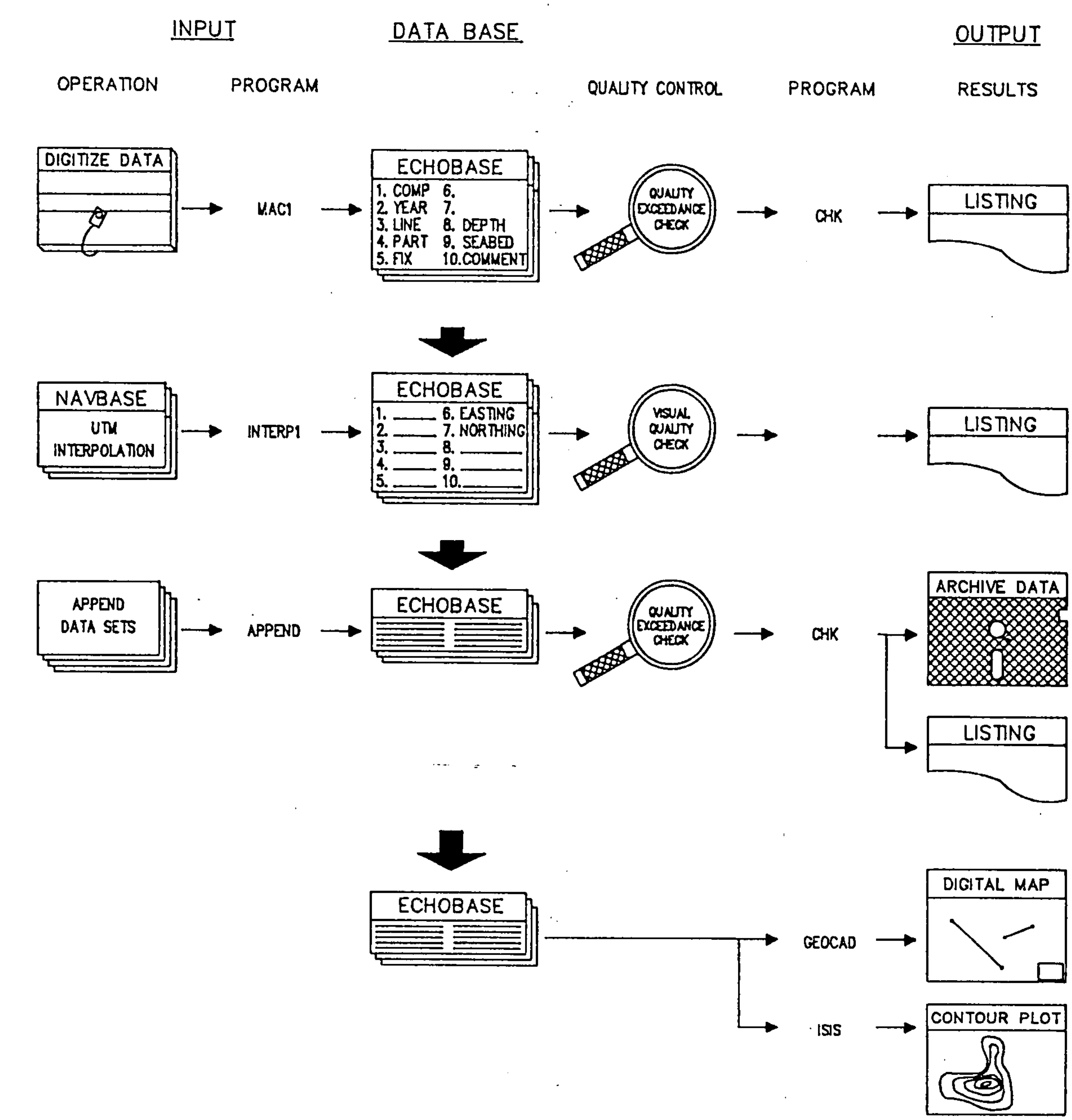


FIG 3 FLOW DIAGRAM FOR ECHOPRO SYSTEM

CSR

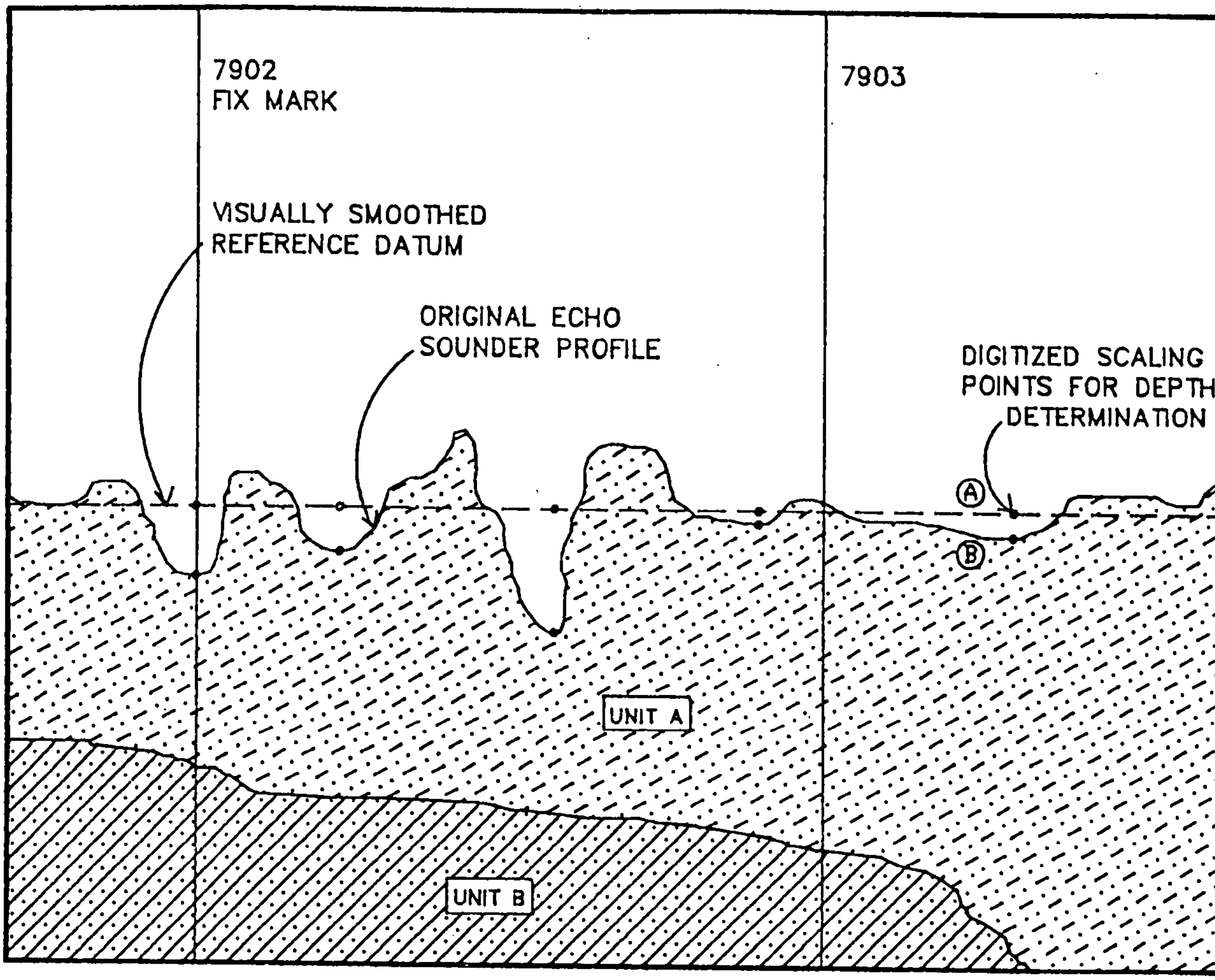


FIG 4 ECHOPRO DIGITIZING OPERATION

- a bathymetric depth (to the smoothed seafloor) is derived at that coordinate position and rounded to one decimal point.

- the preceding information plus the original annotation data is passed to a structured ECHOBASE file as one unique record.

Program execution is sufficiently fast that the operator can proceed immediately with the next scour measurement. It is also important to note that scour depths, less than 0.5m, were measured during this study, such that the low end of the distribution (previously truncated in the 1986 study) can be statistically modelled. A low-end cutoff value of 0.2-0.3 metres was generally realized, depending on data quality.

2.2.3 Processing

Upon completion of a line of data, known errors are edited as shown by Fig. 3 and a listing produced for visual examination. Subsequent to this, an automatic quality check program, CHK.PRG is run to isolate failure values that exceed allowable inputs or thresholds for both character and numeric fields. At this stage, the data are assumed correct, thus initiating the final stages of ECHOPRO processing.

The remaining processing sequence uses NAVBASE information and the program INTERP1.PRG to generate UTM values for the ECHOBASE data. Each scour fix position from ECHOBASE is passed to the NAVBASE system and an exact UTM Northing and Easting coordinate is interpolated for that fix and returned to ECHOBASE in its correct data base format. The results are then visually checked against the original navigation data files on a line by line basis. It is noted that this program, as well as most in the ECHOPRO system, worked quite well and few errors were encountered.

Following these quality checks all data files were merged, yielding one final file. A last quality exceedance check (identifies spurious values) was run on the single file before final archiving at CSR and production of listings as shown in Fig. 3.

2.2.4 ECHOPRO Evaluation

The ECHOPRO system established by Cdn. Seabed Research Ltd. was found to be accurate, and relatively time efficient, given the nature of the data sets. Nonetheless, digitizing can be a somewhat repetitive, time consuming and subjective process from one interpreter to another.

CSR has now developed an automated, digital acquisition system called the Seafloor Quantification System (SQS), whereby echo sounder data are digitally stored in the field, and seafloor features, such as ice scours are identified, measured and geographically referenced in a data base environment.

2.3 ECHOBASE Results

2.3.1 ECHOBASE Overview

A sample output of ECHOBASE is shown below in Fig. 5.

FIG 5 EXAMPLE OF ECHOBASE SYSTEM.

COMPANY	YEAR	LINE	PART	FIX	EASTING	NORTHING	DEPTH	SEABED	QUALITY	COMMENTS
ESRF	84	2B	3	66.7	457184	7745402	0.4	16.1	G	ES
ESRF	84	2B	3	66.9	457209	7745371	0.3	16.0	G	ES
ESRF	84	2B	3	67.7	457311	7745250	0.9	15.0	G	ES
ESRF	84	2B	3	67.8	457323	7745235	0.5	15.0	G	ES
ESRF	84	2B	3	67.9	457336	7745220	0.3	14.9	G	ES
ESRF	84	2B	3	68.2	457378	7745177	1.5	15.1	G	ES
ESRF	84	2B	3	68.6	457436	7745120	0.3	15.3	G	ES
ESRF	84	2B	3	68.7	457451	7745106	0.2	15.6	G	ES
ESRF	84	2B	3	69.4	457544	7744999	0.8	16.2	G	ES
ESRF	84	2B	3	69.7	457582	7744950	1.1	16.2	G	ES
ESRF	84	2B	3	69.9	457607	7744918	0.7	16.0	G	ES
ESRF	84	2B	3	70.1	457631	7744886	0.4	16.0	G	ES
ESRF	84	2B	3	70.3	457654	7744854	0.5	16.0	G	ES
ESRF	84	2B	3	70.9	457724	7744757	0.4	15.9	G	ES
ESRF	84	2B	3	71.2	457762	7744711	0.2	15.9	G	ES
ESRF	84	2B	3	71.5	457801	7744666	0.6	16.1	G	ES
ESRF	84	2B	3	71.6	457814	7744651	0.2	16.2	G	ES
ESRF	84	2B	3	72.0	457866	7744591	0.4	15.9	G	ES
ESRF	84	2B	3	72.1	457879	7744576	0.4	15.9	G	ES

The ECHOBASE system now contains a total of 24,801 scour records, reflecting the combination of the present update data and the previous ESRF study information. A breakdown of the number of records for each unique data set is presented in Table 2. Note that the increased number of records generated by the present study is due to the following reasons. First, the shallow water nature of this data contributed to high scour densities, hence unexpectedly high numbers of scour events. Secondly, the ECHOBASE data in this study was not truncated at the 0.5m depth value, as was the previous survey data. It should also be noted that echo sounder data was not independently processed for the Yukon Shelf data set and is therefore absent from this Table. It was measured as third channel data from the side scan system and much of the depth information thus resides in SCOURBASE. Individual track lines resident in ECHOBASE are shown in a trackplot in the map pocket.

TABLE 2 COMPILATION OF ECHOBASE DATA SETS

STUDY GROUP	SURVEY NAME	COMPANY	YEAR	# RECORDS	SUBTOTAL
Cdn. Seabed Research Ltd	ESRF Update	ESRF	84	8,576	
		TULLY	85	1,284	
		TULLY	86	3,477	13,337
Geoterrex	ESRF 86	DOME	80	3,341	
		DOME	81	1,140	
		DOME	82	1,019	
		ESSO	83	58	
		GULF	81	2,887	
		GULF	82	2,013	
		GULF	83	1,006	11,464

TOTAL ECHOBASE RECORDS = 24,801

TOTAL FOXBASE SPACE REQ'D = 2.5 meg.

Even though ECHOBASE contains almost 25,000 scour records, recent data analyses (Gilbert and d'Apollonia (a), in prep) have revealed that significant data gaps exist in ECHOBASE that may constrain statistical interpretations of subdivided data sets. This aspect is discussed in more detail in the SCOURBASE section.

2.3.2 Scour Depth Distributions

Scour depth distributions, (with bin intervals of 0.1m) for both the present update study and the original ESRF study, are compared in Fig. 6a and 6b. These figures portray only those scours less than 2.0m deep, in order to document a problem concerning the low end of the scour depth distribution. This problem was initiated during the data processing stages of the original ESRF compilation project.

The problem is centered around the low end truncation of the echo sounder data at the 0.5m value. At the time of the original ESRF survey, it was felt that scours less than 0.5m could not be confidently distinguished from wave noise on the analogue data sets, especially as data quality degraded. The ECHOBASE data was thus truncated for values less than 0.5m, as shown by the ES_GTX line in Fig.6b. However, this truncation was done before the actual scour depth was measured and rounded off to one decimal place. Consequently, the 0.5m depth value only represents the values contained within 0.5-.54m bin and not the value .45-.54, as it should. It is evident, from its depressed frequency, that the first data point in the ES_GTX distribution (see point on Fig.6b) is under-represented by at least 1/2 of its potential magnitude.

FIG 6a

SCOUR DEPTH DISTRIBUTION (ECHOBASE)
COMPARISON BETWEEN 2 MAJOR DATA SETS
SCOURS < 2.0m ONLY

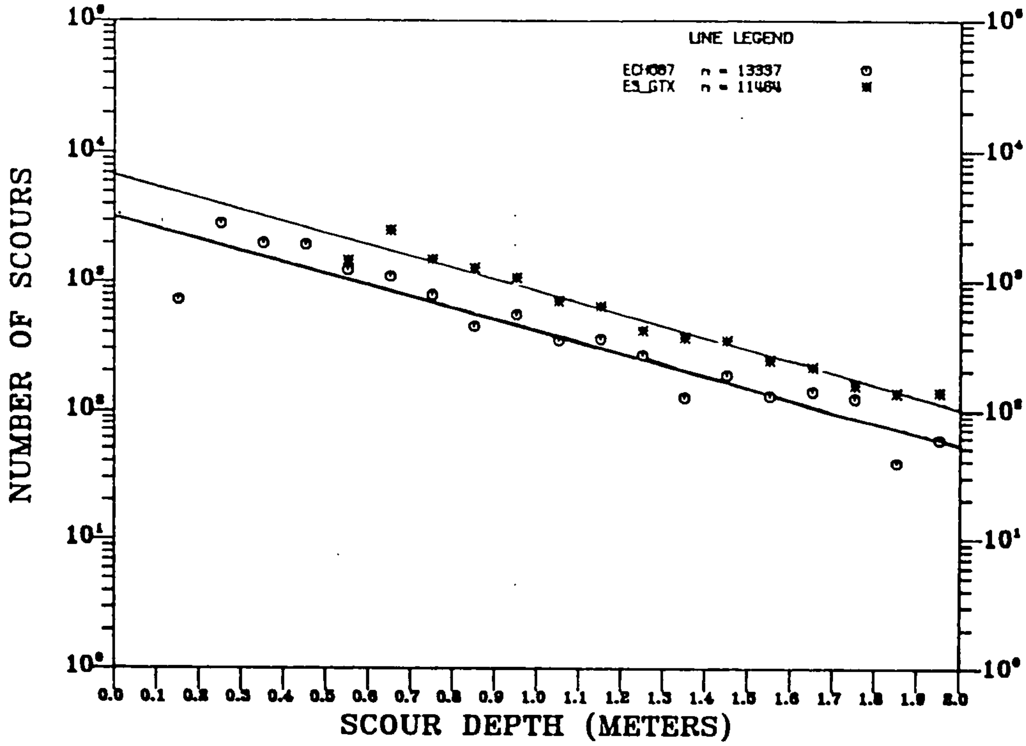
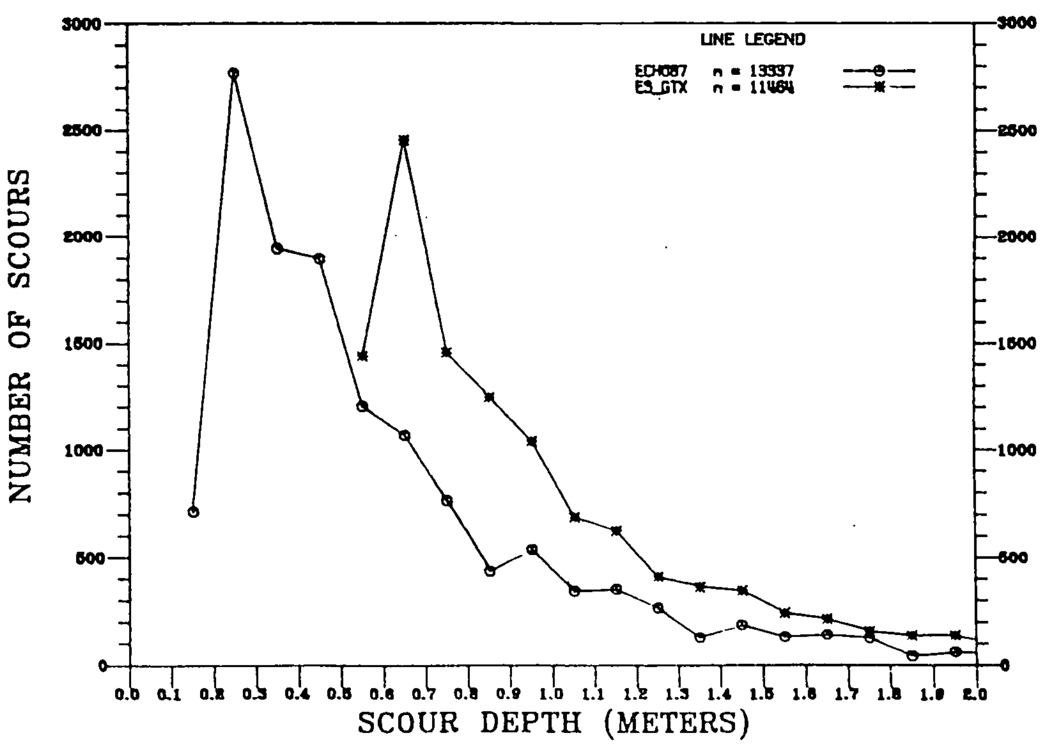


FIG 6b

SCOUR DEPTH DISTRIBUTION (ECHOBASE)
COMPARISON BETWEEN 2 MAJOR DATA SETS
SCOURS < 2.0m ONLY



The identification of this problem is important to the user in deriving the best probability distribution to represent the scour depth data. In fact, there had been some controversy, based on the original data set, whether the distribution might approach zero below the 0.5m depth value, as opposed to rising exponentially. Intuitively, it was felt by the authors, that there was no physical reason for the exponential rise to change at 0.5m, in the scour depth distribution. This prompted CSR to measure shallow scour depths for the present update study, in detail, so the low end of the distribution could be defined and the problem resolved. A total of 8516 scours <=.5m were measured for this study. It is interesting to note that these shallow scours represented almost 65% of the total ESRF Update data set.

The results of this study, shown in Fig.6a, confirm that the data are negative exponential in nature, well below the 0.5m value. However, referring to Fig.6b, it is clear that the distribution does decline sharply below the .2m scour depth interval. The authors believe this truncation also is not indicative of the present scouring process, but rather results from resolution limitations of the equipment and the interpreters inability to consistently measure very small features. The author's propose the term "resolution truncation" for this low-end distributional phenomena and suggest that the point at which resolution truncation is reached in a distribution is dependant on the following:

-the type of survey equipment used (Frequency, resolution etc.)

-the horizontal and vertical scale settings of the instruments

-the data processing system (computer versus manual)

-and the difficulty in positioning the original seafloor as defined by the interpreter.

For example, if the seafloor position was consistently placed too high, the shallow scours would be artificially removed from the population. On the other hand, if the seafloor was placed too low, they again would be missed as they would occur above the measurement datum. It is evident that the identification and measurement of shallow scours is highly sensitive to the selection of a measurement datum.

This process can be further constrained by the selection of the acoustic profiling equipment and the scale settings utilized in the field. For example, it is noted that resolution truncation is very pronounced in scour depth distributions that are derived from equipment such as, subbottom profilers, which have wide beam angles and reduced resolution capabilities. Such conditions, both constrain the recognition of smaller features and minimize the depths of those scours that are profiled.

One last point should be documented for the potential ECHOBASE user. This concerns the practice of binning scour depth data for the purposes of graphical display with a histogram, for example. Standard statistical routines generally utilize bin widths that are larger than the potential data error value; in this case 0.1m (Data are derived to one decimal place only). Standard techniques also begin the first bin interval with 0 and end at say, .9999, for a bin from 0-1m. This allows 0.5m to be the centre point of that bin. In binning the ECHOBASE data we have adopted that standard. A problem arises if one wishes to bin the data at an interval as fine as the actual accuracy of the data (0.1m). If one begins the bin intervals at 0.5m, a bin representing D= 0.5-0.6m is created, with the centre point of the bin at 0.55m and the bin data, including the 0.5m data point, but not the 0.6m data point. Herein lies the problem. The ECHOBASE data is measured to an accuracy of one decimal place only, (ie. D=0.5, 0.6....) such that the bin in question is represented solely by the value for 0.5m scours. Each actual depth measurement, however, was rounded off from a more precise value. This implies that the value of D=0.6m in the data file actually means $0.55 \le D < 0.65$. Thus a 0.05m shift in the scour depth data is built into the ECHOBASE data set.

The authors feel that these points are important to raise, such that the user may utilize the data from an informed position. As a note of caution, however, we also feel it important to place the data in its' true context. For example,

- can we really recognize scours less than 0.5m with confidence?

- is it statistically valid to bin data at such fine intervals?

- can we in future add a second decimal place to scour depth data, if we feel we can not measure the data that accurately?

Additional information regarding these questions are addressed in the Error Estimates section of the report.

2.4 Scour Depth Error Estimates

2.4.1 Introduction

Accurate, reliable, scour parameter data is a crucial component of risk estimate models, for petroleum-related subsea installations. The scour depth parameter is perhaps the most important one in these models, such that information relating to the degree of measurement accuracy of this parameter is highly desirable. To date, estimates of error for this parameter have not been studied in detail. The purpose of this section, is to present an analysis of the error of the scour depth measurement technique, for ice scours in the ECHOBASE system.

Three main error components are recognized that include; echo sounder equipment error, environmental error, and methodology error as introduced by the ECHOPRO data processing system. The reader is referred to Section 2.2 for a detailed explanation of this system, however, a summarized version is presented as follows. The echo sounder is used to record the seafloor profile on a paper echogram. This profile is placed on a digitizing table, and the seabottom is interpreted and manually smoothed by drawing a line on the profile. The smoothed seabottom and the deepest point of the identified scour are digitized, and the subtracted value is computed as a scaled scour depth. That depth is rounded to the nearest 0.1m and stored in ECHOBASE.

The analysis of error in marine acoustical equipment is a complicated process. We have not attempted to consider all potential errors, but rather have processed the major factors to derive a maximum error bound. The approach in this study generally follows standard techniques (eg. Bragg, 1974) which are summarized by the flow chart in Fig. 7. This diagram indicates that the errors in the system are identified, and the major sources of error are quantified. The method of combining these errors is described, and an accuracy for the scour depth is presented. Recommendations for improvement of data accuracy are presented in Section 6.2.

2.4.2 Error Sources

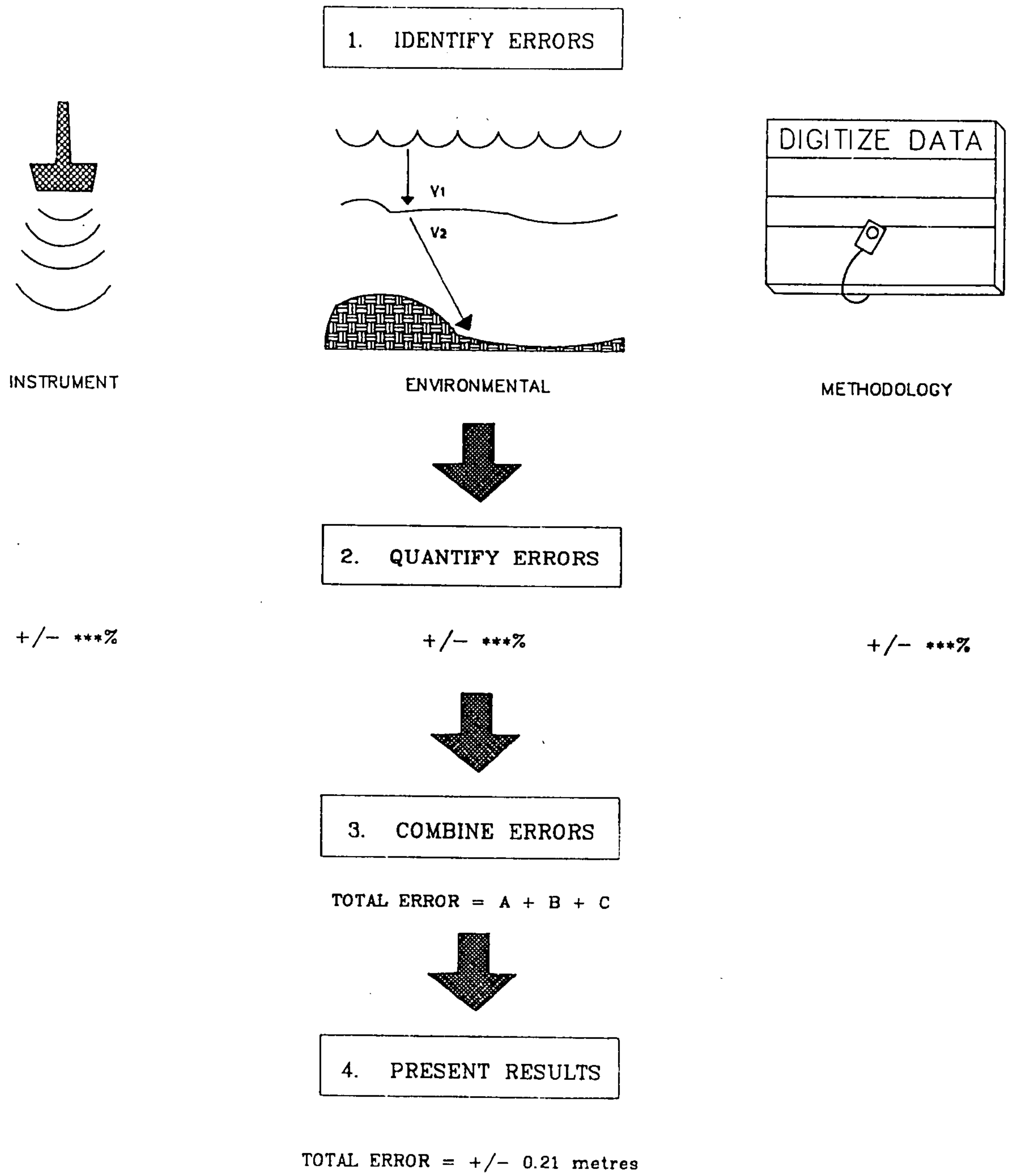
The three main sources of error include; equipment error, environmental error, and methodology error. These errors are considered separately in this section.

Equipment Error

The detection capability of an echo sounder, as described by Ingham (1974), is related to a number of factors which include; the pulse duration, the angle of incidence of the wave front, the sensitivity of the recorder, the nature of the target and the beam angle of the transducer. The error work undertaken for this project is based on an industry standard sounder, Raytheon DE-719, operating at a frequency of 200kHz. Given the fact that the resolution capabilities of this system are quite high, one of the most important parameters noted by Ingham (1974) that may affect our estimates of error, is that of beam width. The typical transducer used with the DE-719 system has an 8 degree beam width at -3dB (Raytheon,1979).

Since the transducer receives the earliest return from a target within the wavefront of the beam, this return may not necessarily represent the true depth below the transducer, especially if a wider beam transducer is utilized in areas of rough or steeply dipping topography. This effect, when applied to the geometry of an ice scour, would tend to horizontally compress the feature, increase the slope of the scour walls, and minimize the actual scour depth position. This is well illustrated by MacPhee (1976), who presents example echograms of narrow versus wide beam soundings. The implications of this to a scour depth distribution may be considerable. For wide beam sounding, scours are likely deeper than they appear on the echogram and futhermore,

Fig. 7 ERROR ANALYSIS FLOW DIAGRAM



CSR

shallow scours, that are outside the resolution range of the system, may drop out of the distribution totally, thereby constraining statistical scour depth analyses. Raytheon also offers a narrow beam transducer designed for precision survey work required for accurate delineation of seafloor features. The specifications indicate a beam width of 2.75 degrees at -3dB and a greater directivity index due to the larger radiating area (Raytheon, 1979). Although, the results using this system deteriorate as sea-states increase, a field calibration test is felt warranted to resolve this beam width problem. Beam width error is not quantified for this study, but its implications are presented in order that further research can be undertaken.

There may also be some systematic error in the sounding process, (ie. consistently low or consistently high), due to an incorrect ship's draft setting. However, this would not significantly affect the depth of a scour, since it is determined by measuring the deepest part of the scour with respect to an averaged seafloor.

The overall signal processing error of the Raytheon DE-719C is quoted to an accuracy of +/- 0.5 % of measured depth, +/- 1" (Raytheon, 1979). This error is a composite of errors in signal timing, temperature effects on electronic components, the acoustic properties of the target, detection threshold of target, and thus is assumed to bound many of the errors described above (with the exception of beam width). This is the major equipment error value that is passed on and will be dealt with in the Error Combination section.

Environmental Error

Environmental sources of error given by Eaton (1968) include the variables; sound velocity, substrate hardness, ship heave and tidal effects. These effects are significant in the measurement of water depth, however, since our application involves depth differences; the measurement from the smoothed seafloor to the bottom of a scour, these effects would be very small and therefore are not considered further. One interesting aspect of substrate hardness and the beam width problem was noted by L. King (pers comm). He felt that in soft sediments, reflection events from the outer perimeter of the beam pattern may not be strong enough to be measured within the dynamic range of the sounder receiver. Such conditions would tend to lessen the beam width error.

Methodology Error

The seafloor smoothing/digitization process is the main stage in the ECHOPRO system where data interpretation takes place, and as a result, it is a potential source of significant error. The process involves visually estimating the scour bottoms and berm tops, to derive an estimated smoothed seafloor reference, from which scour depths are measured. Echo Sounder scale setting used for this study was approximately (1cm=2metres). Coarser scale settings have been shown in the past to produce spurious data (Gilbert and Pedersen, 1986).

In order to determine the error induced by the seafloor smoothing and digitization process, a section of echogram (representative of a moderately scoured area) was repeatedly interpreted (10 times) by smoothing the seafloor and digitally measuring scour depth values. Additional sections were also interpreted in moderately deep and deep water areas. In total, a sample of 742 scour depths were obtained. For each scour measured from the echogram, the sample of scour depths were averaged, thereby generating a mean scour depth and standard deviation. A plot of the standard deviations of the sampled scours versus the mean scour depth was plotted (Fig. 8). The plot indicates that there is no correlation between scour depth and deviation of interpreted depth from the mean, which shows that error resulting from the smoothing process is independent of scour depth.

The dispersion of the scour depths about the mean (measured scour depth - mean scour depth) was calculated, and these figures were binned at 0.02m intervals, in order to quantify the seafloor smoothing and digitization error. The results are plotted in a histogram as shown in Fig. 9. Although the distribution was not defined, it can be noted that over 90% of the deviations are between +/- 0.16m of the mean scour depth. This value is felt to typify a reasonable maximum error that will be used to represent the digitization/smoothing process.

The accuracy of the digitizer can be found from specifications given by the manufacturer, which are +/- 0.1 % of the distance from the digitized point to the sensor, which corresponds to an accuracy of +/- 0.09m Note that the digitization/smoothing incorporates the digitization process, and so includes this error. Proportionally this error would be quite small.

The final error in the production of a scour depth value, occurs as the digitized data are entered into ECHOBASE. Since the field DEPTH is rounded to 1 decimal place (tenths of metres), depths entering the data base are rounded either up or down. The largest possible error in this rounding process can be shown by the following example: a scour depth of 2.04999 is rounded to 2.0m when inserted into ECHOBASE, and a scour depth of 2.0500 is rounded up to 2.1m. Thus, the largest possible error is 2.1-2.0500 = 0.05m. This error will be carried on to the Error Combination section.

2.4.3 Error Combination

The potential scour depth errors associated with the measurement process are summarized in Table 3. Although the errors are bounded, their distributions are unknown, resulting in an unknown distribution of the total error. However, these errors can now be combined in order to put a reasonable maximum bound of accuracy on the measurement process (Dr. Dahel, pers comm). The error found in the smoothing/digitization process was predictably the largest at +/-0.16m.

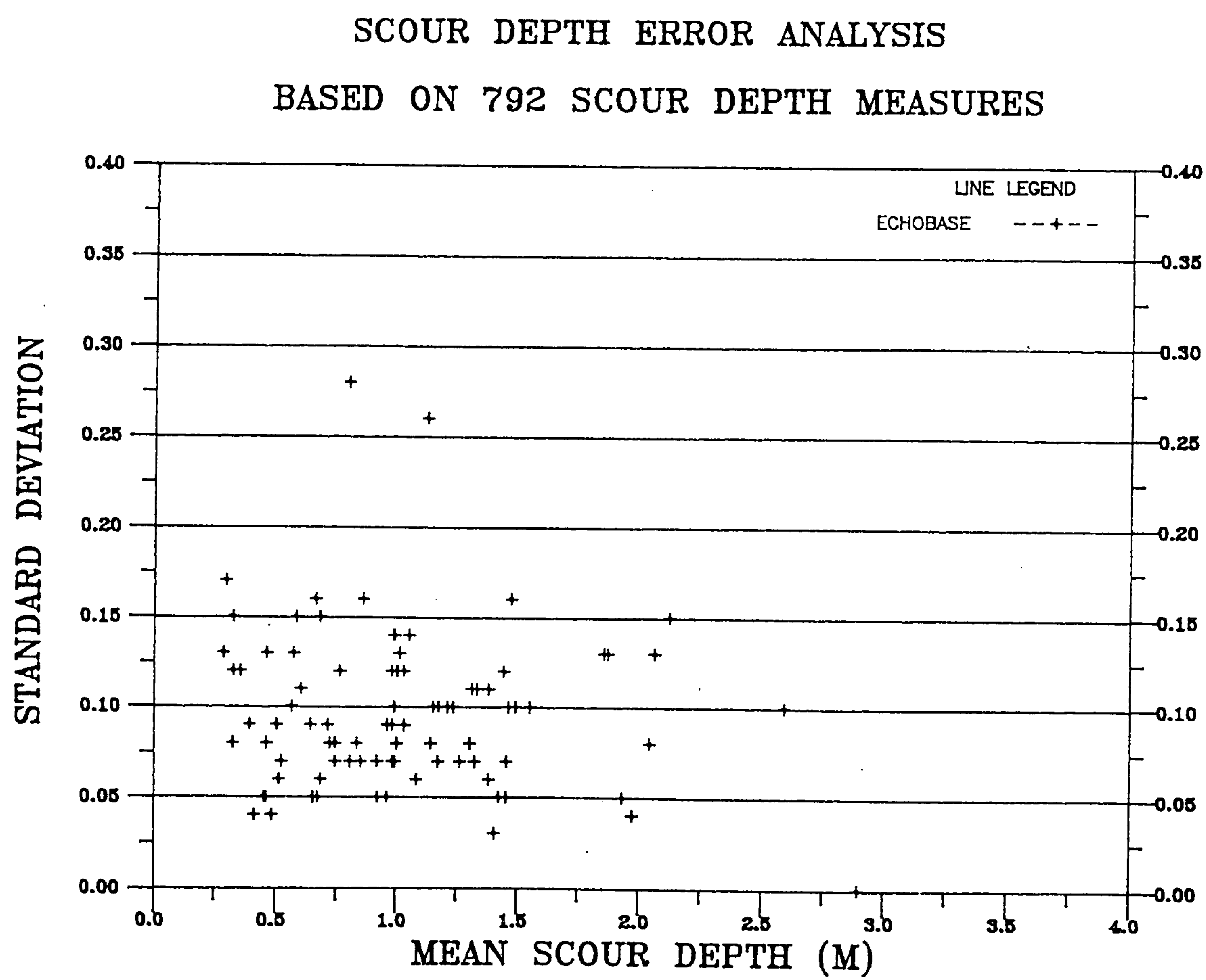

SCOUR DEPTH ERROR ANALYSIS
BASED ON 792 SCOUR DEPTH MEASURES
STANDARD DEVIATION
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
MEAN SCOUR DEPTH (M)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
LINE LEGEND
ECHOBASE

FIG 8

FIG 9

SCOUR DEPTH ERROR ANALYSIS
ERROR DISPERSION ABOUT MEAN
(SAMPLE SIZE n = 792)

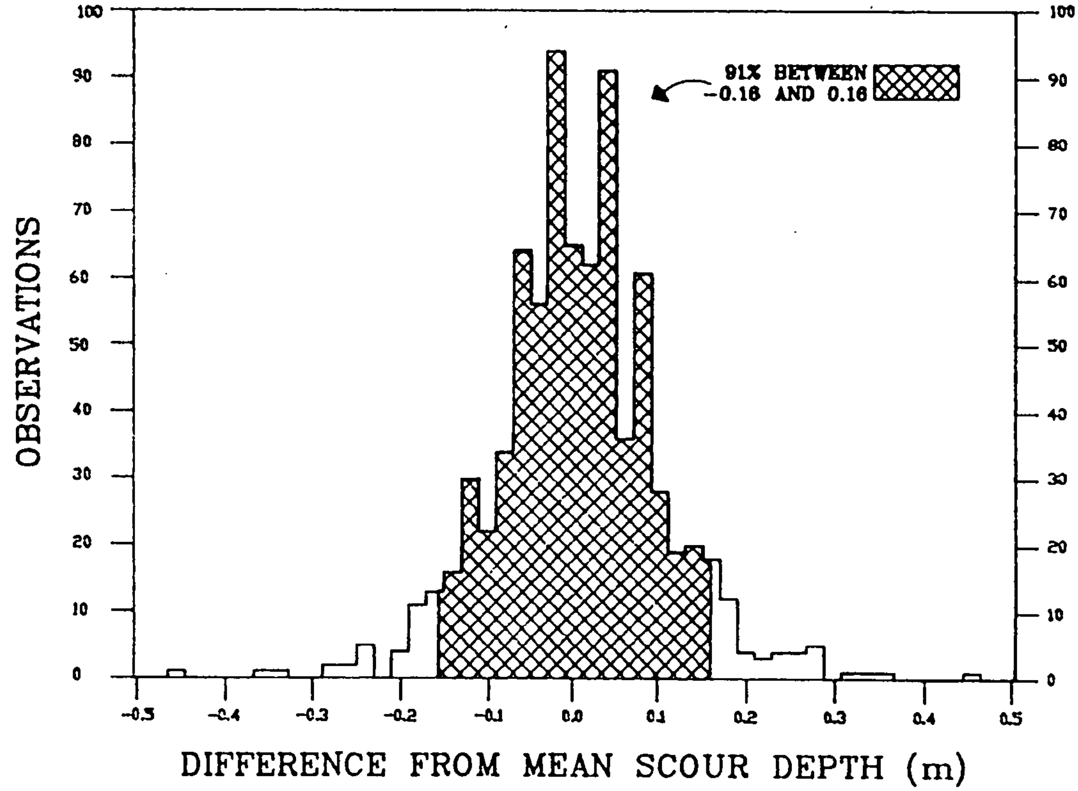


TABLE 3 ERROR COMPILATION

ERROR SOURCE	TYPE	MAXIMUM VALUE	WEIGHT
ECHO SOUNDER -Instrument error	Instrument	.5%+/-1"	No Influence
SOUNDING PROCESS -Sound velocity -Ship heave -Tidal effects	Environmental	n/a	Minor Influence
SEAFLOOR SMOOTHING	Methodology	+/-.16m	Major Influence
ROUND OFF ERROR	Methodology	+/-.05m	Influence

On considering the effects of equipment error, it was determined that most of this error would be averaged out by the seafloor smoothing operation. (This assumes a high resolution sounding device, that incorporates a transducer of reasonable beam width). For example, if the echo sounder has a systematic error (eg. all depths are low), there will be no effect on the measured scour depths, since both the maximum scour depth, as well as the seafloor, will have been shifted an equal amount. If the echo sounder has a random error, the seafloor smoothing technique would average out this error. As well, in the selection of a maximum scour depth, the interpreter averages many echoes to find the true bottom. Thus, echo sounder error is minimal and will not be considered in the error combination process.

The rounding error, however, does bear significant influence and therefore must be incorporated in the analysis of total error. The maximum error incurred by rounding is +/- 0.05m and this error must be added to the smoothing/digitization error previously given, in order to reliably bound the total scour depth error.

Error combination thus yields a total maximum error bound of +/- 0.21 metres, for any scour depth value residing in ECHOBASE, that was processed during the present update study. This bound is calculated using the best available data, but unestimated error sources, previously discussed (especially beam angle) may play an important role, and serve to significantly increase this figure.

3.0 SCOURBASE (SIDE SCAN SONAR DATA BASE)

3.1 Introduction

Imaging the seafloor by side scan sonar yields an oblique plan view of the seabed's detailed morphology, as a function of acoustic reflectivity. The reader is referred to Gilbert and Pedersen (1986) for a review of basic sonar principles and the factors that affect data quality. Through detailed examination of Beaufort Sea images, many useful ice scour parameters have been identified and documented in a data base environment, called SCOURBASE. Important scour and environmental parameters such as; orientation, form, morphology, smoothness, length, width, depth, sediment fill, sediment type, and associated bathymetry and relevant survey parameters are documented in this system. The reader is referred to Appendix 2 for a complete description of the SCOURBASE parameters, how they are derived and the format of the SCOURBASE system.

The present ESRF86 update study is preceded by both the original ESRF study (Gilbert and Pedersen,1986) and by the Yukon shelf study processed by Shearer and Pedersen,(in prep). It is natural that slightly different data acquisition and processing styles have been utilized for these studies, and it is important to document these variations in this report. The geophysical equipment specifications utilized for the present update data as well as the Yukon shelf data, are tabulated in the Equipment Specifications Table (Table 4).

Techniques for interpreting and processing scour data have been kept as consistent as possible since the inception of the SCOURBASE program in 1983. Data processing techniques and the resulting parameter values have undergone a minor degree of re-interpretation since the original work and those variations are noted here.

TABLE 4 EQUIPMENT SPECIFICATIONS TABLE

DATA PACKAGE AND SURVEY YEAR

PARAMETER	YUKON BANKSLAND84	ESRF84	TULLY85	TULLY86
SIDE SCAN SONAR				
Recorder	Klein53IT	Klein53IT	Klein53IT	Klein53IT
Frequency	100kHz	100kHz	100kHz	100kHz
Scale	150m	150m	150m	150m
Fixes	Numeric	Numeric	Time	Time
Nav. Info.	Track Plot	Tape	Tape	Tape
Quality	Good	Good	Good	Good
THIRD CHANNEL				
Source	Altimeter	SBP	Altimeter	Altimeter
Frequency	100kHz	3.5kHz	100 kHz	100kHz
Vertical Scale	50m	50m	50m	25m
Quality	Good	Good	Good	Good
ECHO SOUNDER				
Source	N/A	Raytheon DE 719	Raytheon DSF6000	Raytheon DSF6000
Frequency	N/A	200kHz	24/100kHz	24/100kHz
Heave Comp.	N/A	No	No	No
Quality	N/A	Good	Good	Good

Note: The Yukon Shelf data set, compiled by Shearer and Pedersen, (in prep) is composed of Banksland 84 and a portion of Tully 85 data. The Yukon Shelf, Tully 85 data is labelled EMR 85 in the data base.

Original ESRF Study

Interpretation of SCOURBASE data for the original ESRF study was achieved through a complex processing sequence, whereby the detailed outline of each scour feature was digitized and stored on a mainframe computer. Scour parameters such as orientation, length, width and area were automatically derived from the digital data through a sophisticated, but labour intensive processing sequence. Scour positions (referenced to a "pivot point" at the leftmost portion of each feature) were derived through interpolation from digital survey navigation tapes. Bathymetry data were originally referenced at 5.0m intervals in an alphanumeric code system, however, it is noted here that this data has been upgraded by the present study to reflect numeric values at 1.0m increments.

YUKON Shelf Study

Scour measurements for this study, were made manually from the data sets and recorded on coding sheets for keypunching to a mainframe computer. The "Smoothness" parameter underwent a re-interpretation for this study and a 6 code system was utilized, over the more general 3 code system employed by the earlier study. Refer to Shearer and Pedersen (in prep) for details. Two further distinctions were that scour positions were taken where the scour cut the ship's path (or the closest point) and the bathymetry data was inserted as a numeric rather than alphanumeric value. Navigation information was derived for this study by measuring coordinates by hand, from a paper track plot and keypunching the data into the SCOURBASE system.

Present ESRF Update Study

The technique developed by Cdn. Seabed Research Ltd., to process scour data is an extension of the manual measurement technique; the main difference being that, the SCOURBASE system is built and interpreted totally in a microcomputer-based environment. Scour processing software SCOURPRO, developed at CSR, includes routines to keypunch and check data, interpolate values for the fields Easting, Northing, and Bathymetry from a separate NAVBASE system and to digitally map the resultant files using the in-house GEOCAD digital mapping facility.

The "Smoothness" parameter again underwent re-interpretation and a 4 code system was developed to reflect a new scour type, illustrating unique acoustic morphology, thought to represent recent scouring activity. Examples of the 4 smoothness values are shown in Fig. 10 and described further in Appendix 2. Note that the original ESRF and Yukon study have been upgraded to reflect this new smoothness coding system.

3.2 SCOURPRO Data Processing System

3.2.1 Data Preparation

Side scan sonar data from the ESRF84, Tully85 and Tully86 surveys were catalogued on data quality description sheets, in a similar way as described for echo sounder data in the ECHOPRO section. The reader is referred to that section of the report for compilation details. The final selection of over 1600km of regional line data was made using the data description sheets, to determine data quality and line priorities in areas of deficient data coverage. The selected and processed lines are plotted on a 1:250,000 scale trackmap found in the report cover map jacket.

The SCOURPRO software system was developed by Cdn. Seabed Research, to process ice scour data recorded from side scan sonar images in a format suitable for entry into the SCOURBASE system. A summary block diagram of this system is presented in Fig. 11 for illustrative purposes.

3.2.2 Keypunch

The first SCOURPRO operation involves keyboard entry of interpreted data. Scour parameters recorded on data coding sheets during an interpretation session for a line of sonar data are keypunched to a formatted SCOURBASE file, using the program DATAENTE (See Fig.11). This keypunching program is structured with 3 priority levels for data entry. The first level allows for one entry of global data values (eg. COMP, YEAR, LINE etc.), that will appear on every record. This screen is input only once or until a new line is ready for processing. The second level entry screen allows for input of those parameters that generally remain constant throughout the line (eg. SED. TYPE, QUALITY etc.), but may change especially for longer lines. The third entry level in the DATAENTE program contains those parameters that are unique to each record (eg. ORIENTATION, FIX, LENGTH, WIDTH etc.). The program loops within this routine for each new scour entry, until the data input session is terminated. This program is advantageous as it minimizes input of repetitive information and it stores the data in the correct SCOURBASE format, for the remaining processing utilities of the SCOURPRO system.

3.2.3 Quality Control

Once all the scour parameters for a particular survey line are keypunched into SCOURBASE format, a series of quality control operations are undertaken. A flow chart is presented in Fig.12 for illustrative purposes. The first routine, called QC, checks the various parameters of each scour against allowable character strings or exceedance numeric limits. For example, the parameters, company, year, and line do not change from one record to the next and thus can be easily checked for incorrect record entries by the QC program.

The program is also designed to check that each fix is greater than the preceding one, and that all fixes are within the start and end bounding limits pre-determined for that line. In this way spurious fix entries can be flagged and corrected. Disallowable data values for scour parameters are also identified by the QC routine. For example, heading values were checked to ensure that they are less than 360 degrees. Orientation values are checked to ensure that they are less than 180 degrees. The given limits of form, morphology, and smoothness are 0 to 3, 4 to 6, and 7 to 10 respectively. Relative age can be one of 4 allowable characters: ".", "+", " ", and "-". Dimensional parameters are checked for null value entries as well as threshold exceedance values. For example, scours depths greater than 5.5m are considered suspect and checked against the original coding sheets. Sediment codes can be either a "C", "S", or "CS" while quality codes are either a "G", "F", or "P". If any of these conditions are violated, program QC prints the erroneous data and the questionable entries are then checked and edited.

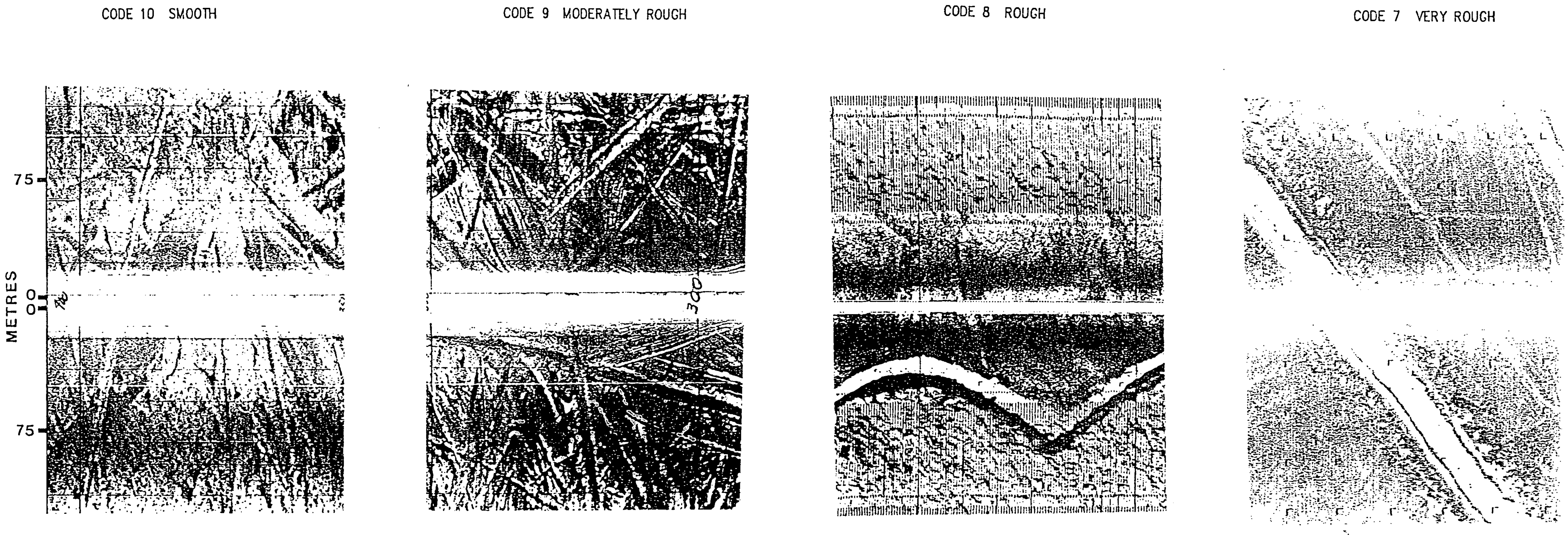


FIG 10 SCOUR SMOOTHNESS EXAMPLES

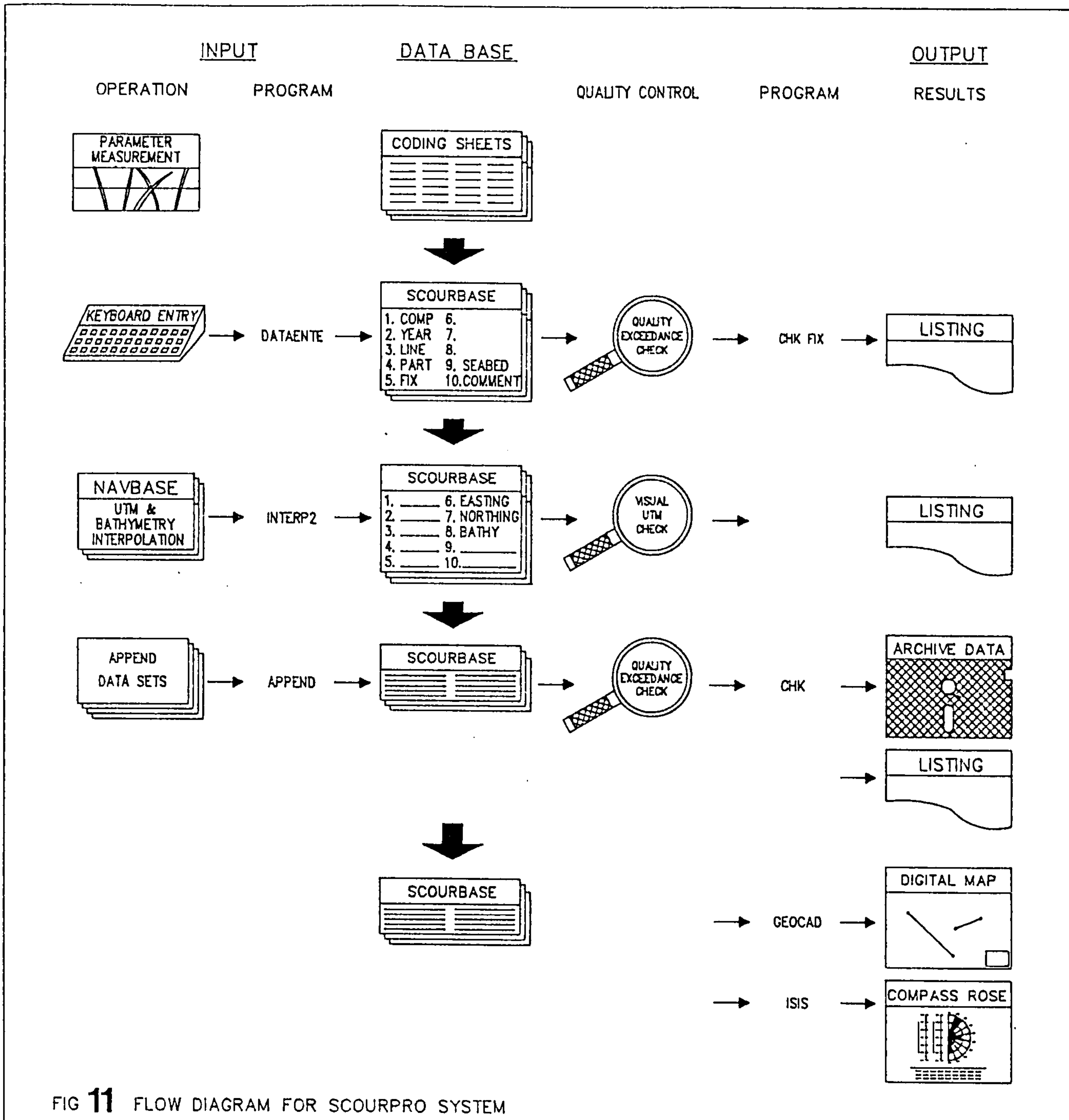


FIG 11 FLOW DIAGRAM FOR SCOURPRO SYSTEM

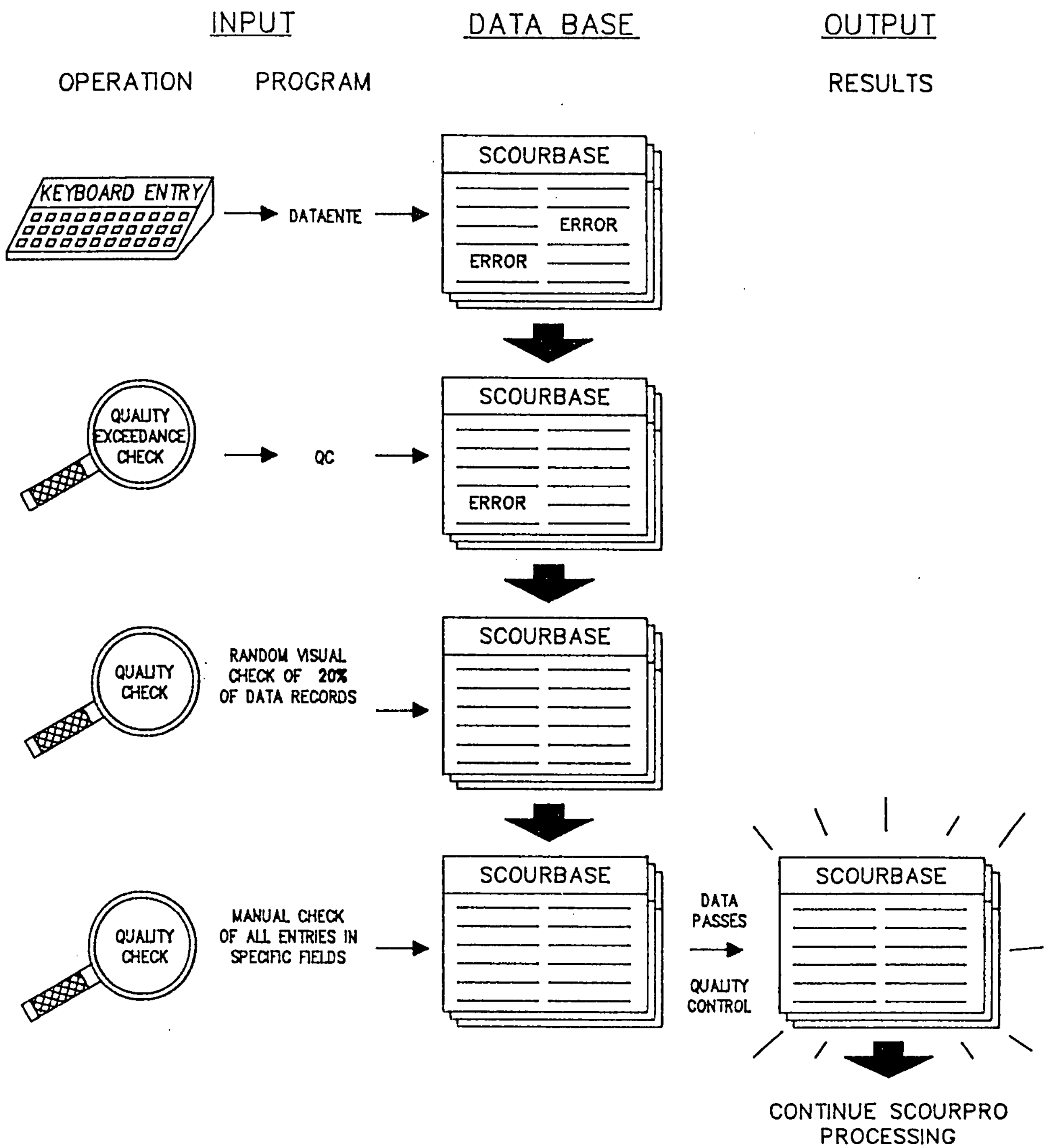


FIG 12 FLOWCHART OF SCOURPRO QUALITY CONTROL OPERATIONS

CSR

After all lines are keypunched and run through the QC utility, a second phase of quality control is initiated. This involves a random visual recheck of 20% of the record entries for the total data base, against the original coding sheet information. The results of this check revealed that most of the errors occurred in specific fields, notably fix, orientation, length, and width. This prompted a specific recheck of all records for these fields for the entire data base.

Considering the size of the SCOURBASE data base (>23,000 records) relatively few errors were found at this stage of quality control. The errors that may remain within the data base could reside in the following 3 fields: form, morphology, and smoothness. This is possible since the QC program has determined that the present SCOURBASE values are within tolerance limits for that field, although it is still possible they may infrequently represent an incorrect value resulting from the keypunching operations. At this stage, the data passes quality control, thus initiating the final stages of SCOURPRO data processing.

3.2.4 Navigation Merge

The remaining processing sequence uses NAVBASE information and the program INTERP2 to generate UTM and bathymetry values for the SCOURBASE data. Each scour position fix is passed to the NAVBASE system and an exact Easting, Northing and Bathymetry value (in Metres) is interpolated for that fix and returned to SCOURBASE in its correct format. The resulting values are then visually checked against the original navigation files, on a line by line basis. It is noted that this program worked quite well and no errors were detected.

Following these quality checks, all data files were merged yielding one final data file. A last quality exceedance check was run on the single file before final archiving of the data at CSR.

SCOURBASE data at this point is available for interpretation and the production of listings as shown by Fig. 11.

3.3 SCOURBASE Results

3.3.1 SCOURBASE Overview

An example section of data with parameter names from the SCOURBASE system is shown in Fig. 13.

The SCOURBASE system now contains a total of 66,549 records reflecting the combination of the present update study, the Yukon shelf study and the original ESRF study. A breakdown of the number of records for each unique data set is presented in Table 5. Refer to the Trackmap in the map pocket on the back cover, for a location reference of the lines processed for this survey.

FIG 13 EXAMPLE OF SCOURBASE SYSTEM

COMPANY	YEAR	LINE	PART	FIX	HEADING	EASTING	NORTHING	NUMBER	ORIENT	STD DEV	FORM	MORPH	SMOOTH	RANGE		LENGTH	WIDTH	AREA	DEPTH	FIX	SCOUR FILL	SS DEF	SED THK	SED TYPE	BATHY	QUALITY	COMMENT
ESRF	84	1A	1	7230	6	410802	7717093	0	15	0	1	5	1	0		2840	50	142000	1.5	0	0.0	0.0	10.0	C	43	G	
ESRF	84	1A	1	7230	6	410802	7717093	0	20	0	1	6	1	0		385	5	1925	0.0	0	0.0	0.0	10.0	C	43	G	
ESRF	84	1A	1	7232	6	410934	7717465	0	55	0	1	5	1	0		500	26	13000	1.5	0	0.0	0.0	10.0	C	43	G	
ESRF	84	1A	1	7238	6	410998	7718671	0	97	0	2	4	1	0		300	90	27000	1.0	0	0.0	0.0	10.0	C	43	G	
ESRF	84	1A	1	7241	6	411068	7719275	0	72	0	1	4	1	0		300	7	2100	0.0	0	0.0	0.0	10.0	C	43	G	
ESRF	84	1A	1	7241	6	411068	7719275	0	144	0	2	4	1	0		425	35	14875	0.0	0	0.0	0.0	10.0	C	43	G	
ESRF	84	1A	1	7242	6	411087	7719475	0	60	0	2	4	1	0		325	50	16250	0.0	0	0.0	0.0	10.0	C	43	G	
ESRF	84	1A	1	7243	6	411118	7719678	0	164	0	1	4	1	0		160	18	2880	0.0	0	0.0	0.0	10.0	C	43	G	
ESRF	84	1A	1	7243	6	411118	7719678	0	6	0	1	5		9		700	6	4200	0.0	0	0.0	0.0	10.0	C	43	G	
ESRF	84	1A	1	7243	6	411118	7719678	0	150	0	1	5	1	0		400	20	8000	0.0	0	0.0	0.0	10.0	C	43	G	
ESRF	84	1A	1	7244	6	411124	7719876	0	72	0	1	4	1	0		275	18	4950	0.5	0	0.0	0.0	10.0	C	43	G	
ESRF	84	1A	1	7244	6	411124	7719876	0	178	0	1	4	1	0		375	20	7500	0.0	0	0.0	0.0	10.0	C	43	G	
ESRF	84	1A	1	7245	6	411134	7720078	0	135	0	1	5	1	0		300	5	1500	0.0	0	0.0	0.0	10.0	C	43	G	
ESRF	84	1A	1	7245	6	411134	7720078	0	140	0	1	4	1	0		325	15	4875	0.0	0	0.0	0.0	10.0	C	43	G	
ESRF	84	1A	1	7245	6	411134	7720078	0	43	0	2	4	1	0	+	450	200	90000	0.0	0	0.0	0.0	10.0	C	43	G	
ESRF	84	1A	1	7246	6	411164	7720280	0	6	0	1	5	1	0		1000	18	18000	0.0	0	0.0	0.0	10.0	C	43	G	
ESRF	84	1A	1	7248	6	411201	7720684	0	60	0	1	4	1	0		175	15	2625	0.0	0	0.0	0.0	10.0	C	43	G	
ESRF	84	1A	1	7248	6	411201	7720684	0	128	0	2	4	1	0		325	40	13000	2.5	0	0.0	0.0	10.0	C	43	G	
ESRF	84	1A	1	7248	6	411201	7720684	0	152	0	2	4	1	0		475	25	11875	1.0	0	0.0	0.0	10.0	C	43	G	
ESRF	84	1A	1	7251	6	411255	7721294	0	5	0	1	5	1	0		800	5	4000	0.0	0	0.0	0.0	10.0	C	44	G	
ESRF	84	1A	1	7252	6	411268	7721496	0	133	0	1	4	1	0	+	300	40	12000	0.0	0	0.0	0.0	[illegible]	[illegible]	44	G	
ESRF	84	1A	1	7254	6	411335	7721688	0	144	0	1	5	1	0		350	15	5250	0.0	0	0.0	0.0	10.0	C	44	G	
ESRF	84	1A	1	7256	6	411381	7722286	0	82	0	1	4	1	0		175	20	3500	0.7	0	0.0	0.0	10.0	C	44	G	
ESRF	84	1A	1	7256	6	411381	7722286	0	62	0	1	4	1	0		350	50	17500	3.0	0	0.0	0.0	10.0	C	44	G	
ESRF	84	1A	1	7256	6	411381	7722286	0	30	0	1	4	1	0		700	10	7000	0.0	0	0.0	0.0	10.0	C	44	G	- PALEOSCOURS
ESRF	84	1A	1	7259	6	411420	7722665	0	6	0	1	5	1	0		1000	25	25000	0.0	0	0.0	0.0	10.0	C	44	G	
ESRF	84	1A	1	7261	6	411484	7723284	0	135	0	1	5	1	0		200	22	4400	0.0	0	0.0	0.0	10.0	C	44	G	
ESRF	84	1A	1	7262	6	411500	7723484	0	6	0	1	6	1	0	+	525	35	18375	1.2	0	0.0	0.0	10.0	C	44	G	
ESRF	84	1A	1	7262	6	411500	7723484	0	175	0	1	5	1	0		600	7	4200	0.0	0	0.0	0.0	10.0	C	44	G	
ESRF	84	1A	1	7264	6	411523	7723886	0	145	0	1	5	1	0		225	15	3375	0.0	0	0.0	0.0	10.0	C	44	G	
ESRF	84	1A	1	7266	6	411585	7724285	0	147	0	2	4	1	0		475	325	154375	2.0	0	0.0	0.0	10.0	C	44	G	
ESRF	84	1A	1	7266	6	411585	7724285	0	65	0	1	4	1	0		325	5	1625	0.0	0	0.0	0.0	10.0	C	44	G	
ESRF	84	1A	1	7267	6	411615	7724485	0	15	0	1	4	1	0	+	500	32	16000	0.0	0	0.0	0.0	10.0	C	44	G	
ESRF	84	1A	1	7268	6	411643	7724685	0	125	0	1	4	1	0	+	200	25	5000	0.5	0	0.0	0.0	10.0	C	44	G	
ESRF	84	1A	1	7269	6	411650	7724888	0	52	0	2	4	1	0		400	135	54000	1.5	0	0.0	0.0	10.0	C	44	G	
ESRF	84	1A	1	7269	6	411650	7724888	0	153	0	1	5	1	0		475	15	7125	1.0	0	0.0	0.0	10.0	C	44	G	
ESRF	84	1A	1	7271	6	411676	7725291	0	146	0	1	4	1	0		450	10	4500	0.0	0	0.0	0.0	10.0	C	45	G	
ESRF	84	1A	1	7272	6	411700	7725491	0	60	0	1	4	1	0		275	10	2750	0.0	0	0.0	0.0	10.0	C	45	G	
ESRF	84	1A	1	7272	6	411700	7725491	0	165	0	1	6	1	0		375	15	5625	0.0	0	0.0	0.0	10.0	C	45	G	
ESRF	84	1A	1	7272	6	411700	7725491	0	143	0	2	4	1	0		380	35	13300	0.5	0	0.0	0.0	10.0	C	45	G	
ESRF	84	1A	1	7274	6	411747	7725892	0	130	0	2	4	1	0		350	60	21000	1.5	0	0.0	0.0	10.0	C	45	G	
ESRF	84	1A	1	7276	6	411852	7726278	0	112	0	2	4	1	0		300	60	18000	2.0	0	0.0	0.0	10.0	C	45	G	
ESRF	84	1A	1	7277	6	411855	7726475	0	166	0	1	5	1	0		200	7	1400	0.0	0	0.0	0.0	10.0	C	45	G	
ESRF	84	1A	1	7278	6	411854	7726675	0	143	0	1	4	1	0		425	20	8500	1.0	0	0.0	0.0	10.0	C	45	G	
ESRF	84	1A	1	7281	6	411941	7727273	0	135	0	1	4	1	0	+	250	16	4000	0.5	0	0.0	0.0	10.0	C	45	G	
ESRF	84	1A	1	7282	6	411953	7727468	0	138	0	1	4	1	0		375	15	5625	0.0	0	0.0	0.0	10.0	C	46	G	
ESRF	84	1A	1	7283	6	411956	7727670	0	170	0	1	5	1	0		1800	17	30600	0.5	0	0.0	0.0	10.0	C	45	G	
ESRF	84	1A	1	7284	6	411956	7727873	0	144	0	2	4	1	0		200	20	4000	0.5	0	0.0	0.0	10.0	C	45	G	

TABLE 5 COMPILATION OF SCOURBASE DATA SETS

STUDY GROUP	SURVEY NAME	COMPANY	YEAR	# RECORDS	SUBTOTAL
Cdn. Seabed Research Ltd.	ESRF Update	ESRF	84	15,562	
		TULLY	85	2,385	
		TULLY	86	5,521	23,468
Shearer	YUKON SHELF	EMR	84	1,769	
		EMR	85	5,664	7,433
Geoterrex	ESRF 86	BEAU	76	3,858	
		DOME	80	9,670	
		DOME	81	2,137	
		DOME	82	1,669	
		ESSO	83	1,556	
		GULF	81	10,977	
		GULF	82	2,482	
		GULF	83	2,088	
		HUDN	70	1,211	35,648

TOTAL # OF SCOUR RECORDS = 66,549

TOTAL FOXBASE SPACE REQ'D = 8.9 meg.

Note that the increased number of records generated by the present update study is due to an unexpectedly high scour density, in the shallow water regions where most of this data originated. It is noted that even though a great number of records now exist within the SCOURBASE system, recent data analyses by CSR (Gilbert and d'Apollonia (a), in prep) have identified serious data deficiencies in certain areas of the total SCOURBASE system. These are illustrated in the section to follow.

3.3.2 ISIS Outputs and Data Deficiencies

Cdn. Seabed Research Ltd. has developed an integrated ice scour interpretation software system (ISIS), that can perform statistical analyses on selected scour parameters (or groups of parameters) and display the resultant data in a variety of graphical representations. The in-house ISIS software package has been used by CSR to illustrate bivariate and multivariate relationships between scour and environmental parameters, for selected subsets of the SCOURBASE and ECHOBASE systems. In this study, (funded by the Geological Survey of Canada) the data bases were subdivided and statistically processed for different physiographic and bathymetric regions on the Beaufort Shelf.

This was undertaken in the hope that region specific data sets would illustrate unique statistical relationships and therefore offer some degree of insight into the scouring process on the Beaufort Shelf.

Upon subdivision and statistical analysis of the SCOURBASE data sets, it was revealed that a number of physiographic or bathymetric regions were decidedly data-poor.....to the extent that the resulting statistical data representations were considered suspect. As a result, the data had to be pooled into larger subsets. This process always produces "better looking, less spurious" distributions but unfortunately it also compromises the original statistical objectives. After producing hundreds of rose histograms, distributions and bivariate plots, it was evident that large data gaps exist such that additional SCOURBASE data are required, especially in specific locations.

Results from this study, derived from both data-rich and data-poor regions, are presented in this section for illustrative purposes. These images are not intended to be compared, but rather are used to show selected examples of distributions from data-rich and data-poor populations. They also demonstrate the various graphical capabilities of the FORTRAN-based ISIS graphics system.

ROSE DIAGRAMS

The rose diagram plots presented in Fig. 14a,b present axial, (no direction inferred) scour orientation statistics derived from a data-rich Western Beaufort shelf location (Fig. 14a) and a data-poor Yukon shelf partition (Fig. 14b). The data-rich scour distribution, based on 2,135 observations, displays a highly preferred unimodal orientation direction. The data-poor distribution reveals a much more spurious distribution, evidently lacking a preferred directional mode, based on 638 scour records.

WIDTH WEIGHTED ORIENTATION DISTRIBUTION

The plot, shown in (Fig. 15a,b), compares the unweighted and width weighted orientation parameter for the total SCOURBASE data set (Fig. 15a) and a data limited subset (Fig. 15b) found in the shallow water region on the Yukon Shelf. This comparative graphic reveals a number of interesting relationships. The total SCOURBASE data set, represented by Fig. 15a, portrays a very smooth distributional form that identifies a primary directional mode of 115 degrees for Beaufort and Yukon Shelf scouring events. The figure also reveals that the average scour width increases within the preferred scour direction and that the mode of the preferred trend is accentuated in the width-weighted distribution, as compared to the unweighted distribution. The data-poor graphic (Fig. 15b) displays a very spurious, erratic orientation distribution, which yields inconclusive statistical information, even despite a sample size of 638 observations.

BEAUFORT SEA : ICE – SCOUR ORIENTATION
REGION: WEST ZONE: 50–60m

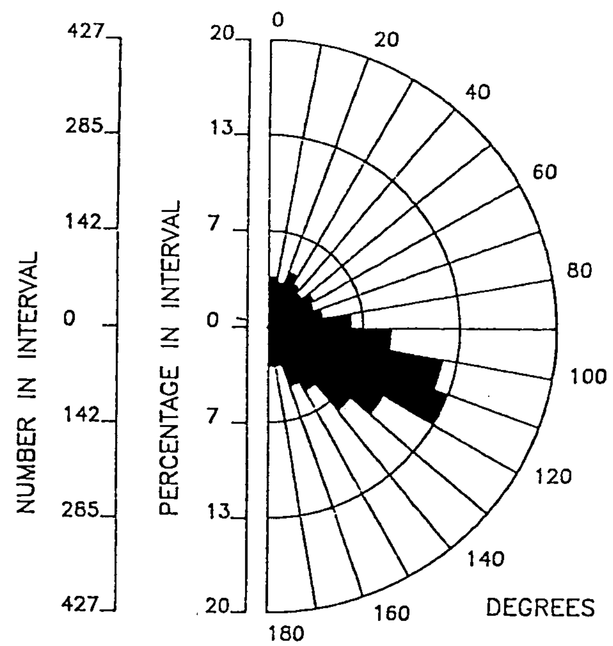


TABLE 1: DISTRIBUTION OF SCOUR ORIENTATIONS

INTERVAL	00–09	10–19	20–29	30–39	40–49	50–59	60–69	70–79	80–89
# SCOURS	75	68	87	72	64	78	72	81	124
PER CENT	3.51	3.19	4.07	3.37	3.00	3.65	3.37	3.79	5.81

INTERVAL	90–99	100–109	110–119	120–129	130–139	140–149	150–159	160–169	170–179
# SCOURS	183	264	285	199	161	109	94	60	59
PER CENT	8.57	12.37	13.35	9.32	7.54	5.11	4.40	2.81	2.76

TABLE 2: DISTRIBUTIONAL PARAMETER VALUES

MINIMUM	MAXIMUM	MEAN	STD DEV	SKEWNESS	KURTOSIS	MODE	TOTAL #
0.00	179.00	97.64	43.01	–0.506	2.554	115.00	2135

Cdn. Seabed Research

A

BEAUFORT SEA : ICE – SCOUR ORIENTATION
REGION: YUKON ZONE: 10–20m

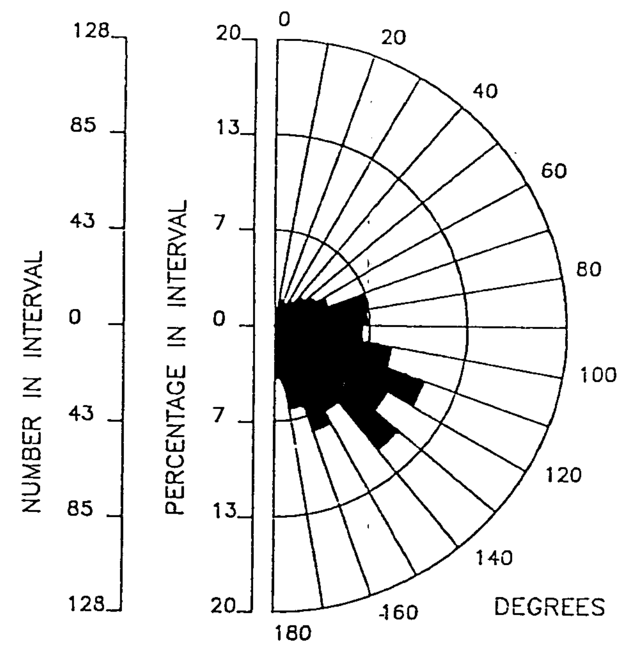


TABLE 1: DISTRIBUTION OF SCOUR ORIENTATIONS

INTERVAL	00–09	10–19	20–29	30–39	40–49	50–59	60–69	70–79	80–89
# SCOURS	8	12	11	13	17	20	25	42	41
PER CENT	1.25	1.88	1.72	2.04	2.66	3.13	3.92	6.58	6.43

INTERVAL	90–99	100–109	110–119	120–129	130–139	140–149	150–159	160–169	170–179
# SCOURS	39	53	71	58	72	44	50	38	24
PER CENT	6.11	8.31	11.13	9.09	11.29	6.90	7.84	5.96	3.76

TABLE 2: DISTRIBUTIONAL PARAMETER VALUES

MINIMUM	MAXIMUM	MEAN	STD DEV	SKEWNESS	KURTOSIS	MODE	TOTAL #
1.00	179.00	107.55	40.41	–0.516	2.656	135.00	638

Cdn. Seabed Research

B

FIG 14 SCOUR ORIENTATION ROSE DIAGRAMS

FIG 15a

WIDTH WEIGHTED SCOUR ORIENTATION

REGION : ALL BATHY ZONE : ALL

NUMBER OF SCOURS = 66549

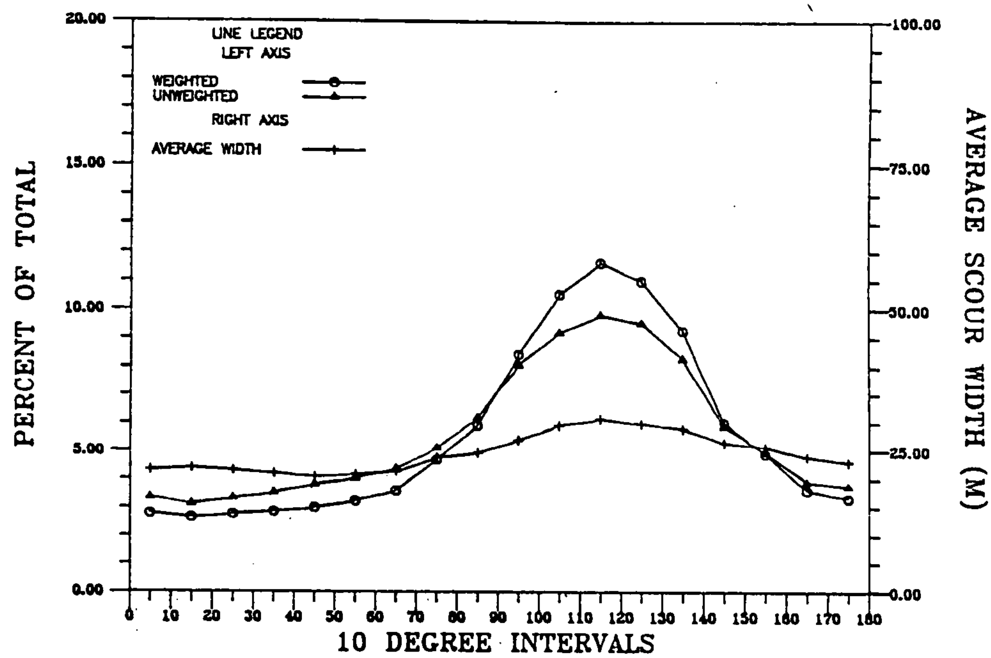
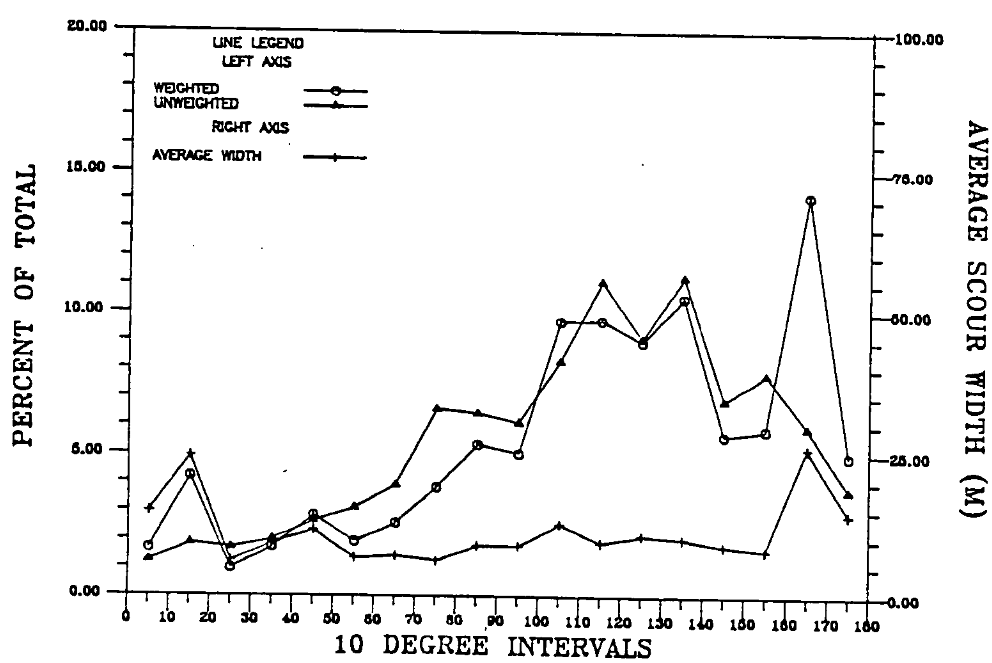


FIG 15b

WIDTH WEIGHTED SCOUR ORIENTATION

REGION : YUKON BATHY ZONE : 0-20m

NUMBER OF SCOURS = 638



BIVARIATE CONTOUR AND PERSPECTIVE PLOTS

The bivariate contour plot presented in Fig. 16a, represents a useful method to portray the spatial distribution of scour orientation by water depth. The contoured values reflect the number of scours observed in each 10 degree orientation and 10 metre bathymetric partition. Fig. 16b portrays the contoured surface of the same data in perspective such that processes within the data can be viewed from different angles and thus be readily interpreted. (Note that the viewing angle For Fig. 16b is from deep to shallow water.) Both figures reveal what might be interpreted as distinctly different scouring processes from shallow to deep water on the shelf. However, this apparent separation at the 20-25 metre bathymetric interval, simply results from a paucity of survey coverage in that area and not from any real scour process information. It is evident from this example, as well as the previous ones, that before spatial statistics can be applied to certain data limited sections of the Beaufort Continental Shelf, the bivariate response should be normalized, and in places, additional survey coverage for the SCOURBASE system is required.

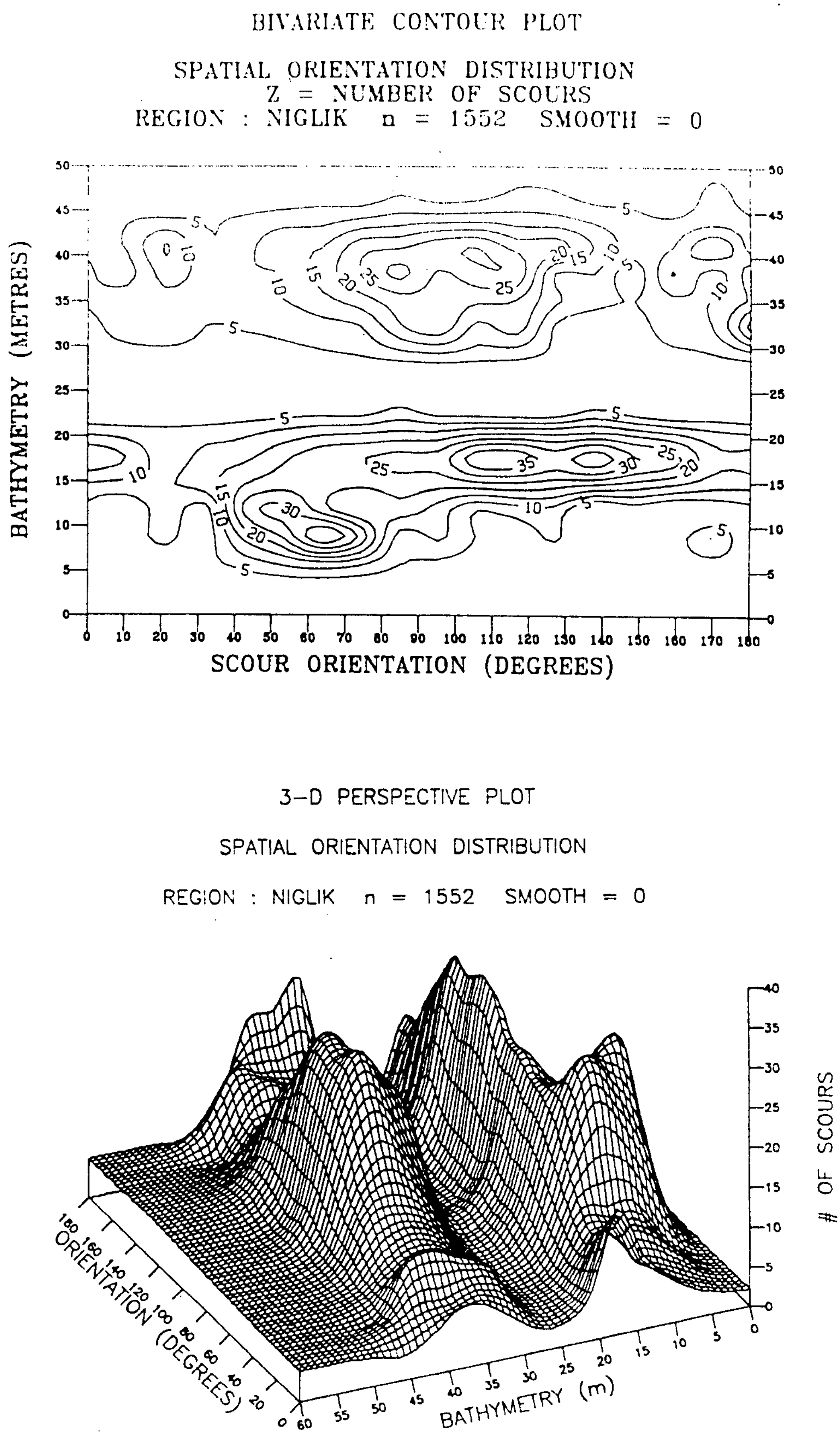


FIG 16 BIVARIATE CONTOUR AND PERSPECTIVE PLOTS

4.0 NAVBASE (NAVIGATION DATA BASE)

4.1 Introduction

NAVBASE is a new data base, created by CSR, to store survey line navigation, bathymetry and other related data sets in a format readily usable by the ECHOBASE and SCOURBASE systems. This data base emerged as a result of a number of important requirements that are explained as follows.

A desirable statistic in the study of ice scour processes in the Beaufort Sea, is a figure for the survey line length in a particular physiographic region or water depth interval. Linear scour frequency (number of scours/km) can then be accurately established, such that spatial distributions of different scour parameters can be normalized and therefore successfully compared from one region to the next. Previous measurements of line length utilized the first and last scour position data from SCOURBASE. This method is acceptable only in densely scoured areas where the scours are close to start and end-of-line positions.

In addition, a requirement to resurvey lines during future repetitive mapping surveys, dictated the need for an organized storage system for navigation information from each line. This data base provides accurate line UTM positions from former surveys, without extensive searches through navigation tapes or inaccurate manual measurements from paper track plots.

A natural byproduct of creating NAVBASE allows for the interpolation of UTM coordinates for the SCOURBASE and ECHOBASE systems. This is accomplished through processing routines where scour fix positions are passed to the NAVBASE system and exact UTM positions are returned to the scour data bases. This facility has greatly improved the speed and accuracy of SCOURBASE and ECHOBASE data processing operations.

Once the survey line navigation information is stored in digital format, it also allows for digital mapping applications through CSR's GEOCAD system which is capable of multi-parameter mapping and plotting operations.

It was determined that a data base containing survey line and related parameters would be the optimum method for storage and use of navigation information. As a separate data base, it could be used as a stand alone system to derive navigation-related information, or could be interfaced with the scour data bases to normalize various scour parameters. Thus, NAVBASE was created to fulfill these needs. One alternative to a stand-alone system that was considered in the planning stages, was the addition of extra records into ECHOBASE and SCOURBASE, containing navigation information only. This alternative was rejected due to difficulties in coding this information into those formats and subsequent problems in data interpretation operations.

4.2 NAVBASE Parameters

The most important NAVBASE parameters are; fix mark, geographic position, bathymetry, physiographic area, data source and the start-and end-of-line part information. Each record corresponds to a specific location along a survey line. For any survey line, there are; start-and end-of-line records, start-and end-of-line parts, and regular position fixes at intervals along the survey line. The reader is referred to Appendix 3 for a complete listing of NAVBASE parameters and the format of the NAVBASE structure.

In the design of the NAVBASE structure, two factors were carefully considered:

1. Standardization of information from different years' survey data sets and

2. Compatibility with the SCOURBASE and ECHOBASE data bases.

Accordingly, the following conventions were adopted:

1. All fields which were identical in SCOURBASE and ECHOBASE were of the same length and type in NAVBASE, to ensure compatibility among the data bases.

2. All positions were converted to Universal Transverse Mercator grid positions referenced to Zone 8 (Central Meridian 135 degrees W longitude). Although there were minor problems introduced by this system (see Appendix 3 for discussion), using one zone for position information was considered less confusing than using x,y data referenced to 3 zones for the Beaufort shelf.

3. All bathymetric information was taken from hydrographic sources, instead of surveyed bathymetry, as the bathymetry from the former source was corrected for tides. NAVBASE thus stores bathymetry from the Canadian Hydrographic Service, which uses the low tide water depth as a standard for charting.

4. All fixes that were shot in time (for example, some Government surveys fix at 5 minute GMT intervals) were transformed and stored as cumulative minutes. This allows the time of day to be retained, but also provides, a sequential numbering system that does not revert to zero at 2400 hours.

4.3 NAVPRO Data Processing System

4.3.1 NAVPRO Description

NAVBASE is designed to be used as a complete data base, or broken down into subsets, either by the creation of data subsets or through the use of filters in a programming environment. In order to accurately calculate line distances, duplicate UTM and fix records are inserted at points where a survey line crosses a geographic boundary or a 5m bathymetric contour line. This allows the user to select the required lines and gain the exact line distance within each selected region. This concept is illustrated by the graphic and NAVBASE example shown in Fig. 17. In this example, ESRF84 line 2DA crosses both a bathymetric and a physiographic area boundary crossover. At both crossover locations, the exact fix and UTM value are interpolated, rounded to the nearest value, and the resulting duplicate records are inserted into the NAVBASE format. Since the ESRF84 data used a single numeral increment for each 200 metres, the <u>rounded</u> value often may reflect the previous or next fix value. This may yield 3 records with the same fix number, as shown in Fig. 17, for the region crossover boundary. Although not a problem, the user should be aware of this irregularity which applies primarily to ESRF84 data. As seen in Fig. 17, each area boundary is clearly marked and therefore line distances can be calculated accordingly.

The types of navigation data used in creating NAVBASE were varied, and a systematic method of reading data, formatting it to the NAVBASE structure, and inserting additional data to the NAVBASE structure was required. The NAVPRO navigation processing software system was completely designed, coded and used at CSR to accomplish these tasks. A series of programs were prepared and written in the Foxbase programming language or FORTRAN, when calculation-intensive tasks dictated a need for processing speed. Each program was designed to do a task or set of tasks aimed at data base preparation or information extraction in a convenient and flexible fashion.

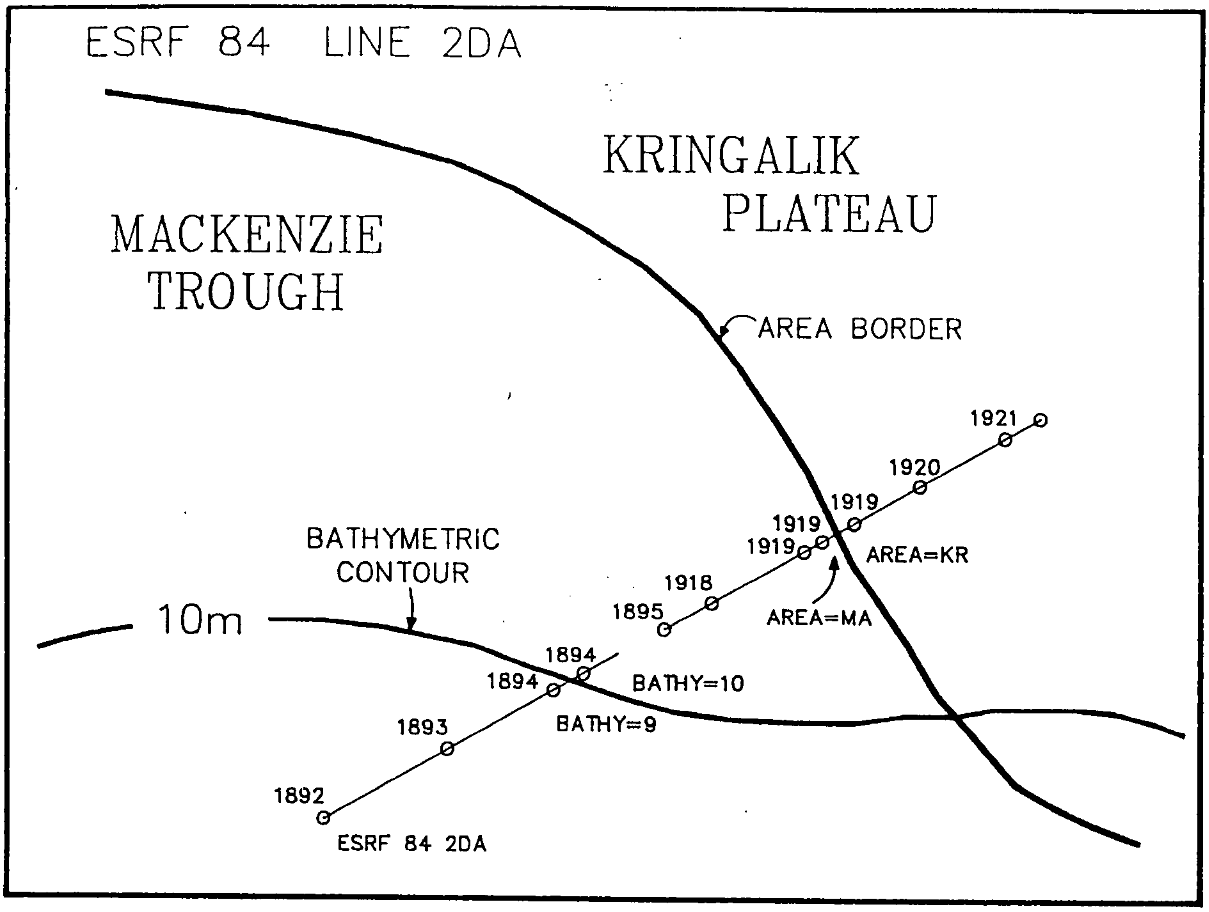
The NAVPRO system is composed of a series of discrete steps, as described in the flow diagram of Fig.18. Data from a number of surveys were used in the compilation of NAVBASE, but can be grouped into 4 sources:

A. Original ESRF data interpreted by Geoterrex

B. Yukon Shelf (Tully 85 and Banksland 84) data interpreted by Shearer

C. ESRF 84 data interpreted by CSR, and

D. Tully 85 and 86 data interpreted by CSR.



NAVBASE EXAMPLE OF LINE 2DA

RECORD#	COMP	YEAR	LINE	ESPART	SSPART	FIX	EAST	NORTH	BATHY	AREA	ORIGIN	COMMENT
1	ESRF	84	2DA	2	1	1892	448834	7725451	9	MA	NT	
2	ESRF	84	2DA	2	1	1893	448730	7725624	9	MA	NT	
3	ESRF	84	2DA	2	1	1894	448622	7725792	9	MA	NT	BATHY CROSSOVER
4	ESRF	84	2DA	2	1	1894	448622	7725792	10	MA	NT	BATHY CROSSOVER
5	ESRF	84	2DA	2	1	1895	448506	7725958	10	MA	NT	
6	ESRF	84	2DA	2	1	1896	448388	7726120	10	MA	NT	
7	ESRF	84	2DA	2	1	1897	448271	7726284	10	MA	NT	
8	ESRF	84	2DA	2	1	1898	448158	7726452	10	MA	NT	
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
26	ESRF	84	2DA	2	1	1916	446269	7729511	11	MA	NT	
27	ESRF	84	2DA	2	1	1917	446139	7729663	11	MA	NT	
28	ESRF	84	2DA	2	1	1918	446037	7729831	11	MA	NT	
29	ESRF	84	2DA	2	1	1919	445883	7729971	11	MA	NT	
30	ESRF	84	2DA	2	1	1919	445861	7730000	11	MA	I	AREA BORDER
31	ESRF	84	2DA	2	1	1919	445861	7730000	11	KR	I	AREA BORDER
32	ESRF	84	2DA	2	1	1920	445763	7730127	12	KR	NT	
33	ESRF	84	2DA	2	1	1921	445646	7730294	12	KR	NT	
34	ESRF	84	2DA	2	1	1922	445541	7730454	12	KR	NT	

FIG **17** EXAMPLES OF BATHY AND REGION BOUNDARY CROSSOVER RECORDS

Often the method of manipulating data was determined by the medium and structure in which it was received. Regardless of the format of the entered data, the sequence of steps involved in the NAVPRO operation are;

A. Data Preparation

B. Enter Navigation Information

C. Add Bathymetry Data

D. Add Area Data, and

E. Post-Assembly Error Checks.

4.3.2 Data Preparation

Data sources for the line were examined, and where there was more than one source of data for a given line, the most accurate data were used. For example, navigation data for the ESRF 84 survey could be derived from the original navigation tapes or digitized from the trackplots. Because the original navigation tape data was more accurate than the digitized trackplot positions, the tape data was used as the source of position information.

4.3.3 Enter Navigation Information

The navigation information was entered into NAVBASE using the general program MAIN.PRG. This program was designed to accept navigation data from a variety of sources as dictated by the different data types for the SCOURBASE system.

The primary source of navigation information for the Geoterrex/ESRF survey was from ECHOBASE data. This data was used rather than that from digitized trackplots, in order to maximize the accuracy of survey position data for potential repetitive resurveys. Where ECHOBASE data was not present or not common, SCOURBASE data positions were processed to yield the x,y UTM values. In some cases, the Geoterrex trackplot at a scale of (1:250,000) was used for start- and end-of-line positions or to document the location of a sharp turning point.

The prime source of navigation data for the Yukon Tully 85 survey was a navigation tape containing a file of line fixes (in time) and latitude and longitude positions. The fixes in time were converted to cumulative minutes using the NAVPRO program HM_TO_CM.PRG, and the latitude and longitude positions were converted to UTM positions using the FORTRAN program TULLY.FOR. The Yukon Banksland 84 navigation information was derived from SCOURBASE data. The scour positions were in UTM Zone 7 coordinates, which were converted to UTM Zone 8 coordinates using the Fortran program BANKSLAND.FOR.

The source of navigation information for the ESRF 84 survey was a complete digital navigation tape. The fix values were regular numeric increments, and navigation positions were in UTM Zone 8 coordinates, which were imported directly into NAVBASE. The survey log was used to determine start-and end-of-line points.

The Update Tully 85 and 86 navigation tapes were used as the prime source of navigation information for those surveys. The fixes (in time) were converted to cumulative minutes and the positions, (based in latitude and longitude) were converted to UTM positions as previously discussed.

After the data was entered, it was visually checked against the list of start-and end-of-line positions as shown by Fig. 18. The UTM position fields EAST and NORTH were checked using the NAVPRO program UTMCHK.PRG which calculated the distance between two adjacent NAVBASE records and compared this value to an estimated threshold tolerance. Results which exceeded the pre-determined threshold were checked and corrected if required.

4.3.4 Add Bathymetry Data

Bathymetry data was entered into NAVBASE by first locating each line on a trackplot bearing 5.0m bathymetric contours and compiling a list of fix versus bathymetry information for each 5.0m crossover location. This list would include the fix and bathymetry of the start-of-line and end-of-line positions, as well as the positions where the line crossed a 5m bathymetric contour. Generally speaking, there were anywhere from 2 to 20 fix versus bathymetry records for each line, with a mean of 6-7 records. After this list was compiled, it was entered into a data base, which was used by the NAVPRO program BATHIN.PRG to enter the information into NAVBASE. (Refer to Fig. 18 for details). The program BATHIN.PRG also inserts duplicate records in the NAVBASE structure at the 5m bathymetry contour crossover points (see previous NAVPRO section for explanation of duplicate records).

The Geoterrex/ESRF and ESRF 84 track plots were used for the data source for bathymetry data for these surveys, with bathymetric contours at the 5m intervals added from the Canadian Hydrographic Service Natural Resource Series (1:250,000). For the Banksland 84 survey, the survey trackplot was used with bathymetry added from a CHS bathymetry field sheet obtained from Earth and Oceans Research Ltd.

After the bathymetry data was added, the data base was visually checked for gaps or deviations, and any errors were corrected.

4.3.5 Add Area Data

NAVBASE contains information relating each fix record to a physiographic area using the standard areas established by O'Connor (1982). (See Appendix 3 for area codes). Similarly, as for bathymetric crossover data, there are duplicate records inserted that correspond

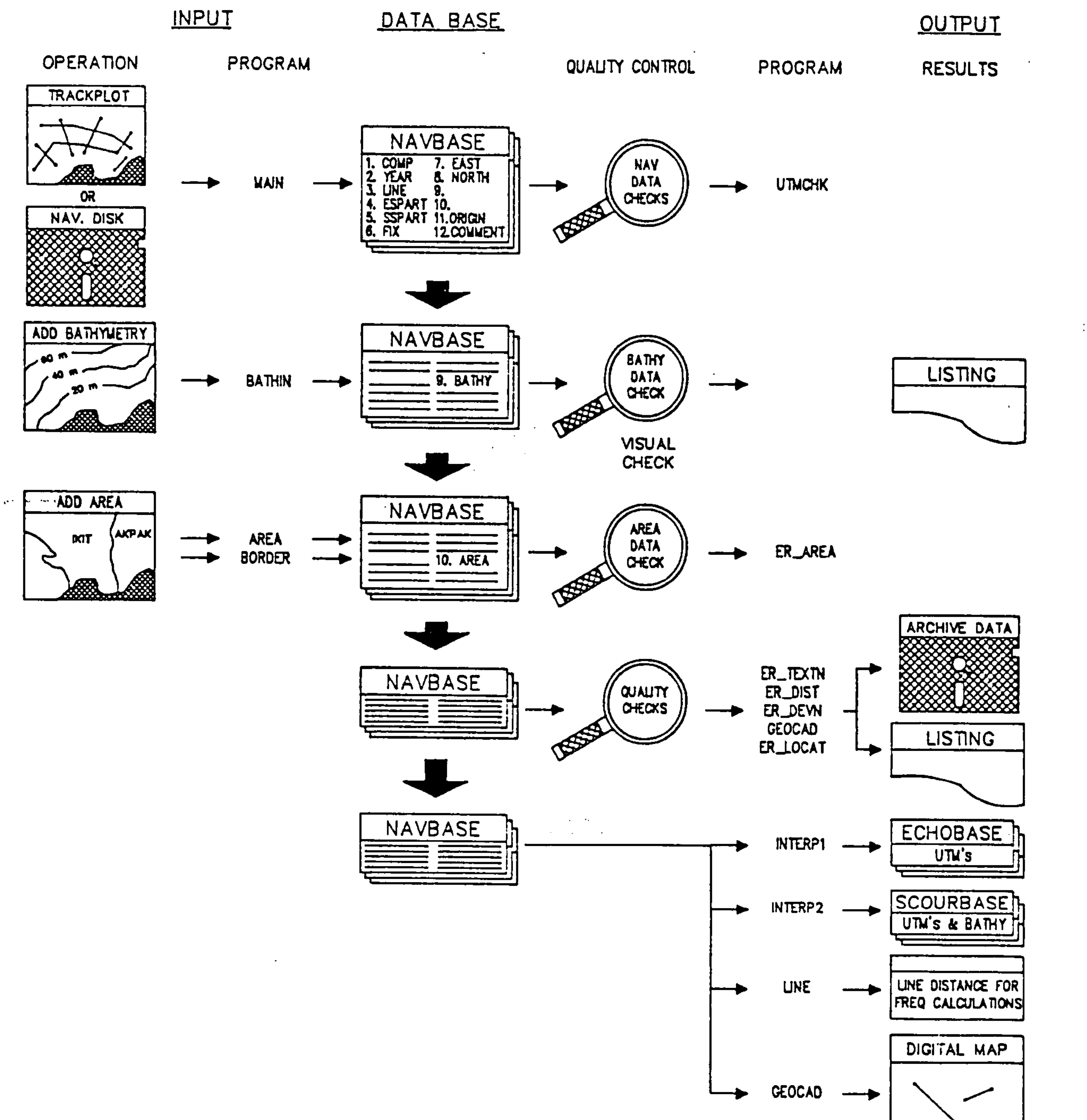


FIG 18 FLOW DIAGRAM FOR NAVPRO SYSTEM

CSR

to the exact location where the survey line crosses each area boundary. These extra records allow the isolation of all survey lines for a single physiographic area, if desired.

Area border information was entered into NAVBASE as follows: A set of area data bases were constructed, each storing the UTM boundaries of one geographic area. The NAVPRO program AREA.PRG was used to compare the location of each successive record in a NAVBASE file to the set of area data bases. If the record location was bounded by one of the area data bases, a code corresponding to that area was inserted into NAVBASE for that record location. Following entry of area codes for all the records in NAVBASE, a second NAVPRO program called BORDER.PRG, was used to search for locations where a survey line crossed from one area to another. Wherever this occurred, the area data bases were examined by the program BORDER.PRG for the exact border location. At that position, UTM and FIX values were interpolated and stored in NAVBASE, thus flagging the exact position where the line crosses into a new region. Two records were inserted at each crossover position, each containing different codes for their respective areas, but also containing the same UTM x,y position. As a result of these records being located together at the exact border location, distance calculations for either area border are exact.

After area records were inserted,the data base was checked using the NAVPRO program ER_AREA. This program checked for any missing or erroneous codes in the AREA field, and rechecked each record position against the area data bases to ensure the area was properly encoded.

4.3.6 Post-Assembly Error Checks

After NAVBASE was assembled, it was stringently checked for errors. This was accomplished by a comprehensive set of error-checking programs. These NAVPRO programs are illustrated in Fig. 18 and described briefly here.

A. Program ER_TEXTN.PRG checked for errors in the text, such as spelling, numbers exceeding allowable ranges in numeric fields, and the correct codes in character fields.

B. Program ER_DIST.PRG checked for the correct distance between fixes for different survey data sets and flagged exceedance values.

C. Program ER_DEVN.PRG checked for fixes deviating from the survey line, by using a floating-point line average algorithm comparing the distance between a given NAVBASE fix and the calculated fix on the line.

D. As a final check, the data was plotted using Cdn. Seabed Research's GEOCAD system at a scale of 1:250,000 and scrutinized visually for potential errors. The plot was helpful in giving a visual interpretation of data density and quality.

Checks for correct duplication of records at bathymetric and area contour crossover points were performed by the program ER_LOCAT.PRG, and by splitting the data into area and bathymetric subgroups and calculating line distances. If a record was missing, it would be evident, as the individual line distances would not sum to the correct total distance. On completion of error checks, listings were produced and NAVBASE was archived on two 1.2 meg. diskettes as shown by Fig. 18.

4.3.7 NAVBASE Interpretation System

The primary reason for the creation of NAVBASE is to calculate line distances for different regions of the Beaufort Sea, to be used in linear frequency and scour density studies. An in-house program LINE.PRG was written to provide a highly flexible system for deriving outputs from the NAVBASE system. This program allows the calculation of line distances for a number of data combinations including the following:

1. The entire data base,

2. A user-specified square region termed a 'window', eg. line distances in the window bounded by Northings 7,500,000-7,000,000 and Eastings 500,000-450,000,

3. A breakdown into bathymetric regions, eg. line distances in the regions between 10m bathymetric contours,

4. A breakdown of physiographic areas, eg. line distances in the Mackenzie Trough, Akpak Plateau, etc., or

5. Any combination of the above. For example, the user can select a windowed region and calculate the total line distance, the line distance in each geographic area contained in the window, the line distance between each 5 or 10m contour in the window, or the line distance bounded by area, 10m contour and the window.

Another direct function of NAVBASE is to insert UTM positions and bathymetry values for ECHOBASE data. The program INTERP1.PRG allowed interpolation of UTM positions for ECHOBASE, based on the fix number of the scour record. Similarly, positions for scour records in SCOURBASE were interpolated using NAVBASE and the SCOURPRO program INTERP2.PRG.

4.4 NAVBASE Results

4.4.1 NAVBASE Overview

The prototype NAVBASE system has been successfully developed through a compilation of data building NAVPRO utilities. Building NAVBASE was found to be quite a labour intensive project, however the advantages of this system are immediately obvious. These include the following:

- Scour parameter distributions can now be normalized for survey density information.
- Survey lines and interpreted scour parameters can be digitally mapped.
- UTM and Bathymetry data can be interpolated for SCOURBASE and ECHOBASE data during data processing operations.
- NAVBASE establishes a digital navigation track data base for the Beaufort Sea, from which future resurvey information can easily be derived.

An example of a completed NAVBASE record set is shown by Fig. 19.

FIG 19 EXAMPLE OF NAVBASE SYSTEM

COMP	YEAR	LINE	ESPART	SSPART	FIX	EAST	NORTH	BATHY	AREA	ORIGIN	COMMENT
DOME	80	507	1		11265	409908	7770375	55	KR	E	
DOME	80	507	1		11285	409751	7770335	58	KR	E	
DOME	80	507	1		11296	409664	7770311	59	KR	E	
DOME	80	507	1		11300	409633	7770303	59	KR	I	
DOME	80	507	1		11300	409633	7770303	60	KR	I	
DOME	80	507	1	4	11311	409546	7770281	60	KR	E	
DOME	80	507	1	4	11359	409168	7770183	60	KR	E	
DOME	80	507	1	4	11383	408979	7770135	61	KR	E	
DOME	80	507	1	4	11449	408461	7770000	61	KR	I	AREA BORDER
DOME	80	507	1	4	11449	408461	7770000	61	MA	I	AREA BORDER
DOME	80	507	1	4	11463	408350	7769971	62	MA	E	
DOME	80	507	1	4	11523	407868	7769835	62	MA	E	

The completed NAVBASE contains information from 14 separate surveys, from 1970-1986, which consists of 203 separate survey lines. There are 22,669 records in NAVBASE, and the physical size of the data base is 1.5 MB. See Table 6 for a breakdown of records for each data set. The data base contains data for 6587km of side scan sonar survey lines, and 5041km of echo sounder survey lines. A substantial portion of the data base has a record density which greatly exceeds the required amount of data. This results in no adverse effects with regard to outputs from the data base. However, the excessive records have the effect of slowing the use of some application programs which use a substantial portion of the data base. The physical size of the data base is also increased, making storage more difficult and transfer of data somewhat slower.

TABLE 6 COMPILATION OF NAVBASE DATA SETS

STUDY GROUP	SURVEY NAME	COMPANY	YEAR	# RECORDS	SUBTOTAL
Cdn. Seabed Research Ltd.	ESRF Update	ESRF	84	5970	
		TULLY	85	404	
		TULLY	86	1029	
					7,403
Shearer	YUKON SHELF	EMR	84	1502	
		EMR	85	1036	
					2,538
Geoterrex	ESRF 86	BEAU	76	527	
		DOME	80	4024	
		DOME	81	698	
		DOME	82	1119	
		ESSO	83	106	
		GULF	81	2904	
		GULF	82	2127	
		GULF	83	1089	
		HUDN	70	134	
					12,728

TOTAL NAVBASE RECORDS = 22,669

TOTAL FOXBASE SPACE REQUIRED = 1.5 Meg.

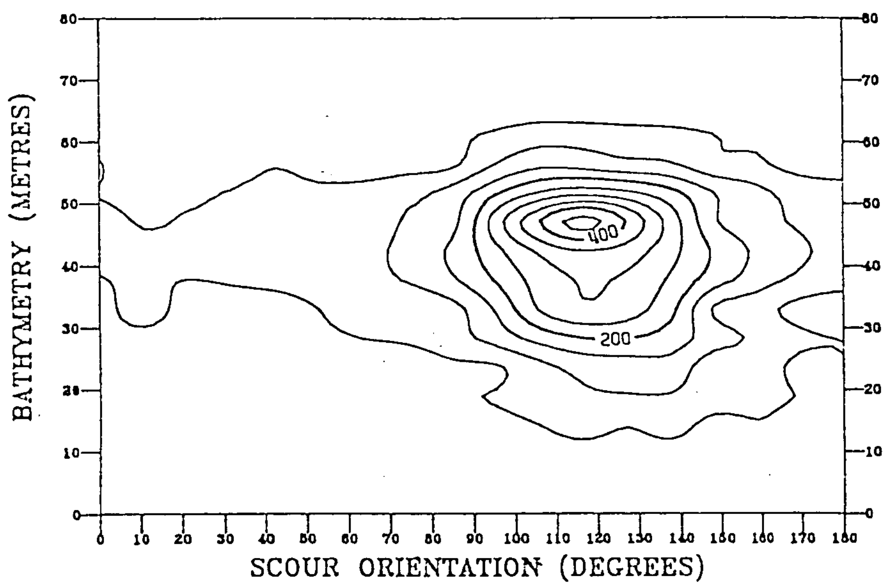
4.4.2 Spatial Scour Frequency Normalization

NAVBASE was used to calculate line distances for SCOURBASE survey lines, in 10m bathymetric contour intervals, for 5 different physiographic regions, as part of a separate contract for the Geological Survey of Canada. These values were used to normalize

PANEL A

BIVARIATE CONTOUR PLOT

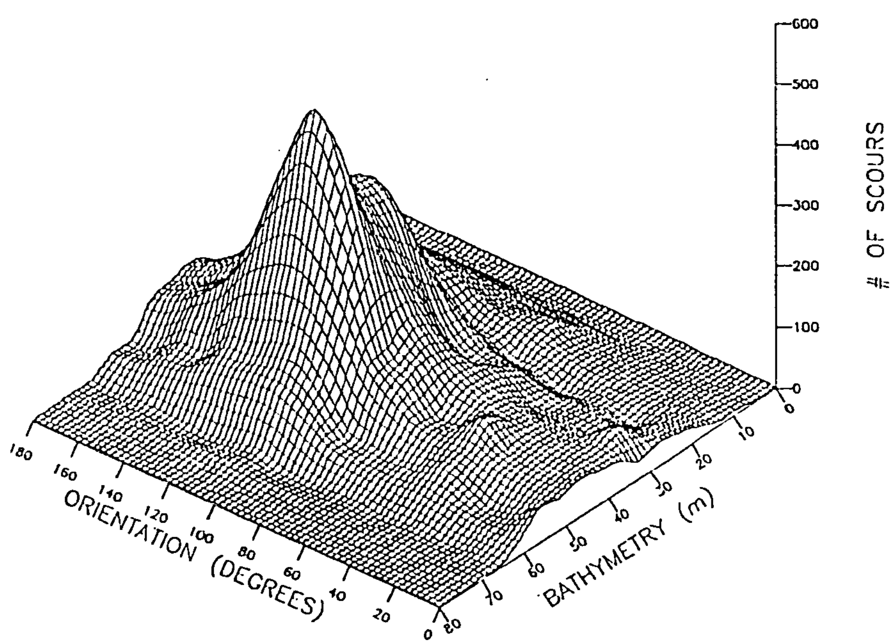
SPATIAL ORIENTATION DISTRIBUTION
Z = NUMBER OF SCOURS
REGION : YUKON n = 8290 SMOOTH = 0



3-D PERSPECTIVE PLOT

SPATIAL ORIENTATION DISTRIBUTION

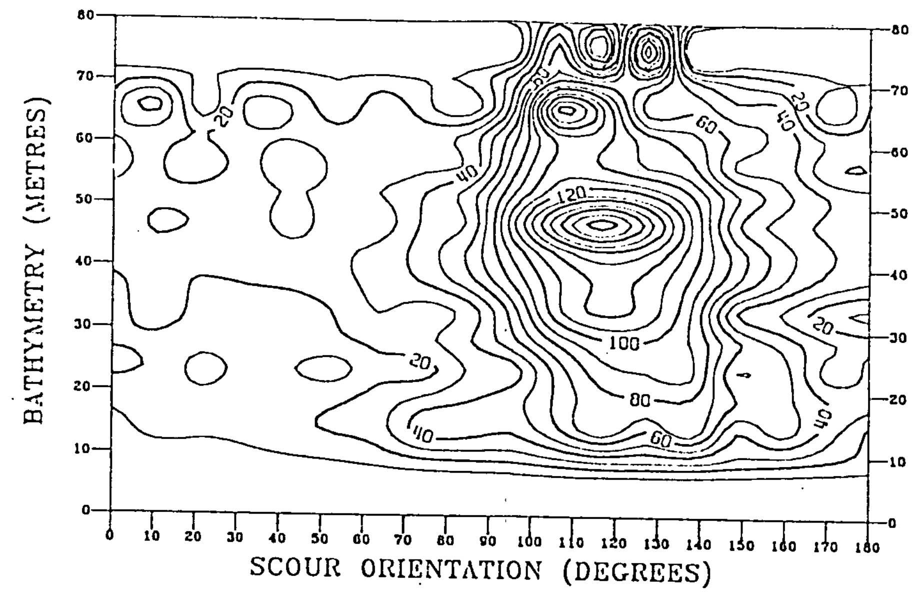
REGION : YUKON n = 8290 SMOOTH = 0



PANEL B

BIVARIATE CONTOUR PLOT

SPATIAL ORIENTATION DISTRIBUTION
Z = NUMBER OF SCOURS/100km
REGION : YUKON n = 8290 SMOOTH = 0



3-D PERSPECTIVE PLOT

SPATIAL ORIENTATION DISTRIBUTION

REGION : YUKON n = 8290 SMOOTH = 0

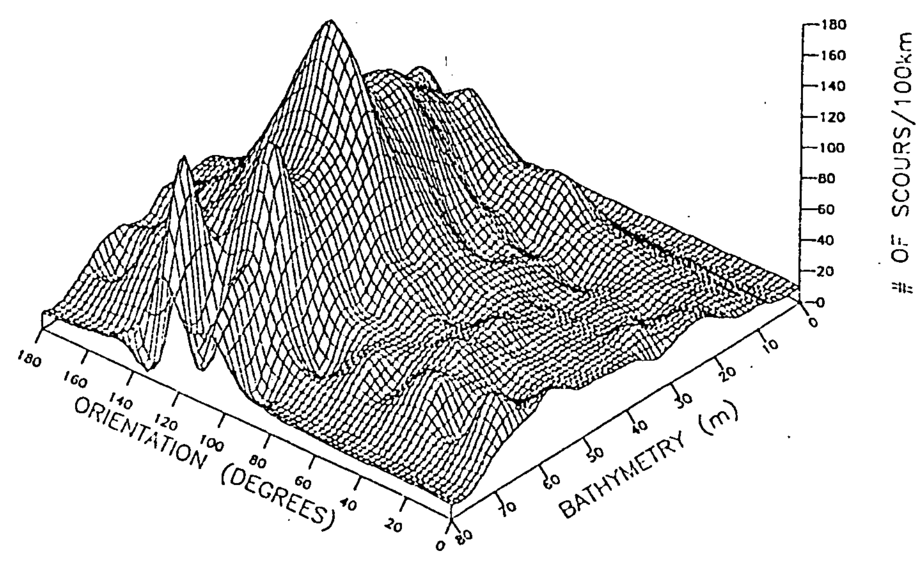


FIG 20 SPATIAL SCOUR FREQUENCY NORMALIZATION

bivariate contour plots of scour orientation versus water depth, as shown in Fig. 20. This figure shows contour plots and their 3 dimensional equivalents for both uncorrected scour data, (panel A) and frequency corrected (# of scours/100kms) in panel B from the Yukon Shelf Region. The plot in panel A shows orientation in the x-axis, bathymetry in the y-axis, and scour occurrence (# of scours) in the z-axis. This form of plot is useful in displaying scour orientation distribution information, with increasing water depth. The data must be normalized by survey line density, however, as the scour occurrence information is directly related to the amount of survey coverage in each bathymetric region and not necessarily to any underlying scour process information. When line distances from NAVBASE are used to normalize the data to number of scours per 100 kilometres and this information is displayed on a similar plot (panel B), considerably different deep and shallow water density trends of the orientation parameter can be observed, which were not evident in the uncorrected plot. This figure illustrates one important aspect of the NAVBASE system in correcting scour parameter information such that direct comparisons are possible.

In addition to line distances in each 10m water depth interval over the entire Beaufort Sea, NAVBASE was used to calculate distances for the Yukon Shelf, the East Main Shelf and the West Main Shelf, as well as distances in 10m bathymetric intervals for each of these areas. These values were used in the generation of bivariate plots, (similar to Fig. 20) that are presented in a separate study for the Geological Survey of Canada (Gilbert and d'Apollonia (a), in prep).

4.4.3 Interpolations for the SCOURBASE System

NAVBASE was used successfully to linearly interpolate UTM positions and bathymetry values for ECHOBASE and SCOURBASE data, for the present ESRF update data using the program INTERP.PRG. NAVBASE was also used to replace all bathymetry codes in the original ESRF SCOURBASE system with a bathymetry value in metres, in order to increase the accuracy of the SCOURBASE bathymetry parameter.

5.0 NEWBASE (NEW SCOUR DATA BASE)

5.1 Introduction

A "new" scour is one that has been identified by comparing side scan sonar images from identical areas of the seabottom over time. The period between repetitive mapping surveys may vary considerably depending on ice problems and general offshore activity such that a "maximum age" only can be attributed to scour events identified by this technique.

Correlating scour events, with temporal ice activity, is extremely important in understanding the degree to which the scouring process poses a threat to potential subsea facilities in the Beaufort Sea. For example, scour dimensions such as length, width, and especially depth can be quantified for scours that are known to be recent. The temporal frequency of the scouring process can also be estimated by calculating return periods (# scours/km/year). Perhaps one of the most important aspects of analyzing NEWBASE data is that certain scour parameter distributions can be compared to those derived from SCOURBASE data. If these distributions are statistically similar, the SCOURBASE data set, rather than just the NEWBASE data may be considered acceptable for use in modelling present-day risk. This represents a significantly larger pool of data than that which NEWBASE has to offer (66,549 versus 882 scour records).

The scour parameters stored in the NEWBASE system are very similar to those stored in the SCOURBASE system. The reader is referred to Appendix 4 for a complete description of NEWBASE parameter descriptions and the format specifications in which the data resides. Some parameters, however, are unique to NEWBASE and these will be discussed briefly in this section.

PCOMP, PYEAR describe the previous company and previous year from which the repetitive survey was undertaken. This information along with the present company and year information is used to determine the maximum scour age.

MAGE This refers to the maximum scour age in years as defined by an initial and a subsequent repetitive scour mapping survey.

OPART This parameter is similar to the PART parameter in the SCOURBASE system, however, due to the repetitive nature of the two survey lines, it refers to that section of both lines that show complete overlap. A new OPART section may be created by poor data quality or a broken survey section from data on either survey line.

SOURCE identifies whether the repetitive mapping information has arisen from a mosaiced site area or one of the regional corridor locations on the Beaufort Shelf.

DEPTH relates to scour depth as it does in the SCOURBASE system. This value, however, is obtained from echo sounder data, wherever possible, such that the most accurate scour depth value can be documented in the NEWBASE system. The extra effort involved in measuring this value, from the echo sounder data rather than the third channel subbottom profile data is felt justified in light of the importance the scour depth parameter plays in modelling modern day subsea pipeline designs.

SBP refers to the type of instrument utilized in deriving the scour depth value. In some cases, echo sounder data may not be available and the measurement must be made from high resolution geophysical data sets.

1 - refers to subbottom profile,

2 - echo sounder,

3 - echo sounder on third channel,

4 - no echo sounder or subbottom profile available.

These numbers may be prefixed by 1 (eg. 12). This code signifies that this scour cuts the ship's path, thus has been sampled by the profiling device and therefore has the potential to record a measurable scour depth in the NEWBASE system. This is a useful parameter for scours that cut the ship's path but do not record a depth (within the resolution of the geophysical equipment and ECHOPRO data processing system). Such scours in the future may be included in future analyses of scour depth distributions.

5.2 NEWPRO Data Processing System

The data processing software developed for the processing of new scour data to produce NEWBASE is similar to that previously described for the SCOURBASE system. The reader is therefore referred to the SCOURPRO section for a comprehensive outline of these data processing utilities.

The only unique parameter in the new scour processing system requiring discussion is found in the navigation data base for the new scour data; called NNAVBASE. The parameter SSPART records the exact location of overlap between repetitive survey line data. For example, if one line or the other is broken for any reason, (eg. data quality) this break will be reflected by a blank part number in the SSPART field. When complete overlap is restored, the successive part number will record the exact fix and UTM position where this occurs. In this way the exact distance for each high quality line part of data may be summed to reflect the total line distance.

5.3 NEWBASE Results

5.3.1 NEWBASE OVERVIEW

An example section of data with parameter names from the NEWBASE system is shown below in Fig. 21.

The NEWBASE system now contains a total of 882 records, compiled mostly through the present update study. A breakdown of the number of new scours found on each corridor or mosaic line is shown in Table 7. Refer to the trackmap in the map pocket for a location reference for the lines processed for this survey.

TABLE 7 COMPILATION OF NEWBASE DATA SETS

COMPANY	YEAR	LINE	SOL FIX	EOL FIX	FIX TYPE	# SCOURS	SBP	MAX AGE	PREV COMP	PREV YEAR	SOURCE	LOCATION
GOVT	78	PULNK	1	15	F	80	2	4	GULF	74	M	PULLEN MOSAIC
DOME	81	3	97	187	F	115	2	2	GOVT	79	C	TAR-NEKTORALIK
ESRF	84	2B	84	95	F	14	2	1	ESSO	83	M	KADLUK MOSAIC
ESRF	84	2E	1954	1960	F	1	2	1	ESSO	83	M	MINUK MOSAIC
ESRF	84	8B	3417	3441	F	13	2	1	ESSO	83	M	KAUBVIK MOSAIC
ESRF	84	2DA	1945	1947	F	1	2	1	ESSO	83	M	MINUK MOSAIC
ESRF	84	3CE	7906	7925	F	28	2	1	ESSO	83	M	KAUBVIK MOSAIC
ESRF	84	3DA	1533	1595	F	29	2	1	ESSO	83	M	KAUBVIK+NIPTERK
ESRF	84	5CA	2494	2555	F	9	2	5	GOVT	79	M	TINGMIARK MOSAIC
ESRF	84	8BN	5902	5905	F	4	2	2	GULF	82	M	KOGYUK MOSAIC
ESRF	84	8BS	8039	8142	F	12	2	1	ESSO	83	M	KADLUK + MINUK
ESRF	84	9F2	5091	5465	F	4	2	3	DOME	81	C	TINGMIARK/UVILUK
ESRF	84	11AW	4816	5001	F	7	2	3	DOME	81	C	KAGLULIK CORRIDOR
ESRF	84	2DAW1	9140	9162	F	11	2	1	ESSO	83	M	MINUK MOSAIC
ESRF	84	EMAC1	7094	7229	F	19	2	5	GOVT	79	C	E. MAC. CORR.
ESRF	84	PULL4	2914	2968	F	155	2	6	GOVT	78	M	PULLEN MOSAIC
ESRF	84	SAUVC	6707	6765	F	34	2	2	GULF	82	M	SAUVRAK MOSAIC
ESRF	84	TARN1	6600	6640	F	40	2	3	DOME	81	C	TAR/NEKTORALIK
ESRF	84	TARN2	9432	9560	F	4	2	3	DOME	81	C	TAR/NEKTORALIK
ESRF	84	TINGN	5467	5662	F	15	2	3	DOME	81	C	TINGMIARK/NERLERK
ESRF	84	TINGW	5663	5828	F	6	2	3	DOME	81	C	TINGMIARK/NERLERK
NAHE	86	1	50	162	F	50	2	2	ESRF	84	C	ESRF 10DN1
TY86	86	1	630	1235	C	215	2	2	ESRF	84	C	ESRF 11B,11AW
TY86	86	5	1265	1545	C	3	2	2	ESRF	84	C	ESRF 9F,9F2
TY86	86	7	1395	1495	C	8	2	2	ESRF	84	C	ESRF SAUVC
TY86	86	8	65	200	C	5	2	2	ESRF	84	C	ESRF SAUVC

TOTAL # OF NEW SCOURS = 882
TOTAL FOXBASE SPACE REQ'D = 0.1 meg

FIG 21 EXAMPLE OF NEWBASE SYSTEM

COMPANY	YEAR	LINE	OPART	FIX	HEADING	EASTING	NORTHING	NUMBER	ORIENT	FORM	MORPH	SMOOTH	MAGE	LENGTH	WIDTH	AREA	DEPTH	SBP	S FILL	SS DEF	SED THK	SED TYPE	BATHY	QUALITY	PCOMP	PYEAR	SOURCE	COMMENT
GOVT	78	PULNK	1	1	236	526646	7766360	0	36	1	5	8	4	200	20	4000	0.0	2	0.0	0.0	99.0	C	18	F	GULF	74	M	
GOVT	78	PULNK	1	1	236	526646	7766360	0	81	1	4	8	4	410	10	4100	0.8	12	0.0	0.0	99.0	C	18	F	GULF	74	M	
GOVT	78	PULNK	1	1	236	526646	7766360	0	96	2	4	8	4	290	45	13050	0.7	12	0.0	0.0	99.0	C	18	F	GULF	74	M	
GOVT	78	PULNK	1	1	236	526646	7766360	0	16	2	4	8	4	220	90	19800	1.0	12	0.0	0.0	99.0	C	18	F	GULF	74	M	
GOVT	78	PULNK	1	1	236	526646	7766360	0	106	2	4	8	4	240	20	4800	0.5	12	0.0	0.0	99.0	C	18	F	GULF	74	M	
GOVT	78	PULNK	1	1	236	526646	7766360	0	117	1	4	8	4	220	10	2200	1.2	12	0.0	0.0	99.0	C	18	F	GULF	74	M	
GOVT	78	PULNK	1	2	236	525984	7765914	0	131	1	4	8	4	200	10	2000	0.7	12	0.0	0.0	99.0	C	18	F	GULF	74	M	
GOVT	78	PULNK	1	2	236	525984	7765914	0	166	2	4	8	4	30	18	540	0.0	2	0.0	0.0	99.0	C	18	F	GULF	74	M	
GOVT	78	PULNK	1	2	236	525984	7765914	0	65	1	6	8	4	210	15	3150	0.0	2	0.0	0.0	99.0	C	18	F	GULF	74	M	
GOVT	78	PULNK	1	2	236	525984	7765914	0	105	1	4	8	4	260	19	4940	0.5	12	0.0	0.0	99.0	C	18	F	GULF	74	M	
GOVT	78	PULNK	1	2	236	525984	7765914	0	37	1	5	8	4	830	10	8300	0.2	12	0.0	0.0	99.0	C	18	F	GULF	74	M	
GOVT	78	PULNK	1	3	236	525335	7765447	0	67	2	4	8	4	1150	50	57500	0.0	12	0.0	0.0	99.0	C	17	F	GULF	74	M	
GOVT	78	PULNK	1	3	236	525335	7765447	0	158	2	5	8	4	210	110	23100	0.8	12	0.0	0.0	99.0	C	17	F	GULF	74	M	
GOVT	78	PULNK	1	3	236	525335	7765447	0	6	1	4	8	4	20	15	300	0.0	2	0.0	0.0	99.0	C	17	F	GULF	74	M	
GOVT	78	PULNK	1	3	236	525335	7765447	0	175	1	4	8	4	220	15	3300	0.8	12	0.0	0.0	99.0	C	17	F	GULF	74	M	
GOVT	78	PULNK	1	3	236	525335	7765447	0	115	1	4	8	4	240	20	4800	1.2	12	0.0	0.0	99.0	C	17	F	GULF	74	M	
GOVT	78	PULNK	1	4	236	524665	7764985	0	81	1	5	8	4	30	18	540	0.0	12	0.0	0.0	99.0	C	16	F	GULF	74	M	
GOVT	78	PULNK	1	4	236	524665	7764985	0	160	1	4	8	4	180	10	1800	0.0	12	0.0	0.0	99.0	C	16	F	GULF	74	M	
GOVT	78	PULNK	1	4	236	524665	7764985	0	56	1	6	8	4	260	10	2600	0.6	12	0.0	0.0	99.0	C	16	F	GULF	74	M-	BI-DIRECTIONAL
GOVT	78	PULNK	1	4	236	524665	7764985	0	171	1	5	8	4	160	12	1920	0.3	12	0.0	0.0	99.0	C	16	F	GULF	74	M	
GOVT	78	PULNK	1	4	236	524665	7764985	0	116	2	4	8	4	210	10	2100	0.6	12	0.0	0.0	99.0	C	16	F	GULF	74	M	
GOVT	78	PULNK	1	4	236	524665	7764985	0	77	1	6	8	4	280	10	2800	0.6	12	0.0	0.0	99.0	C	16	F	GULF	74	M	
GOVT	78	PULNK	1	4	236	524665	7764985	0	175	1	4	8	4	70	15	1050	0.0	2	0.0	0.0	99.0	C	16	F	GULF	74	M	
GOVT	78	PULNK	1	4	236	524665	7764985	0	157	1	4	8	4	170	20	3400	0.4	12	0.0	0.0	99.0	C	16	F	GULF	74	M	
GOVT	78	PULNK	1	5	236	524019	7764523	0	26	2	4	8	4	350	20	7000	0.8	12	0.0	0.0	99.0	C	16	F	GULF	74	M	
GOVT	78	PULNK	1	5	236	524019	7764523	0	6	2	5	8	4	190	30	5700	0.8	12	0.0	0.0	99.0	C	16	F	GULF	74	M	
GOVT	78	PULNK	1	5	236	524019	7764523	0	56	1	5	8	4	480	10	4800	0.6	12	0.0	0.0	99.0	C	16	F	GULF	74	M	
GOVT	78	PULNK	1	5	236	524019	7764523	0	56	2	5	8	4	320	18	5760	0.4	12	0.0	0.0	99.0	C	16	F	GULF	74	M	
GOVT	78	PULNK	1	5	236	524019	7764523	0	105	2	4	8	4	90	50	4500	0.0	12	0.0	0.0	99.0	C	15	F	GULF	74	M	
GOVT	78	PULNK	1	6	236	523366	7764051	0	116	2	4	8	4	180	140	25200	0.8	12	0.0	0.0	99.0	C	16	F	GULF	74	M	
GOVT	78	PULNK	1	6	236	523366	7764051	0	95	1	4	8	4	200	10	2000	0.0	2	0.0	0.0	99.0	C	16	F	GULF	74	M	
GOVT	78	PULNK	1	6	236	523366	7764051	0	71	2	4	8	4	550	35	19250	0.8	12	0.0	0.0	99.0	C	16	F	GULF	74	M	
GOVT	78	PULNK	1	6	236	523366	7764051	0	124	2	4	8	4	70	20	1400	0.0	2	0.0	0.0	99.0	C	16	F	GULF	74	M	
GOVT	78	PULNK	1	6	236	523366	7764051	0	6	2	4	8	4	210	140	29400	0.6	12	0.0	0.0	99.0	C	16	F	GULF	74	M	
GOVT	78	PULNK	1	7	236	522738	7763594	0	4	2	5	8	4	190	15	2850	0.4	12	0.0	0.0	99.0	C	16	F	GULF	74	M	
GOVT	78	PULNK	1	7	236	522738	7763594	0	115	1	4	8	4	180	5	900	0.4	12	0.0	0.0	99.0	C	16	F	GULF	74	M	
GOVT	78	PULNK	1	7	236	522738	7763594	0	88	1	4	8	4	270	10	2700	0.7	12	0.0	0.0	99.0	C	16	F	GULF	74	M	
GOVT	78	PULNK	1	7	236	522738	7763594	0	179	1	4	8	4	210	20	4200	1.2	12	0.0	0.0	99.0	C	16	F	GULF	74	M	
GOVT	78	PULNK	1	7	236	522738	7763594	0	90	1	4	8	4	60	8	480	0.0	2	0.0	0.0	99.0	C	16	F	GULF	74	M	
GOVT	78	PULNK	1	8	236	522072	7763123	0	150	2	4	8	4	150	15	2250	0.4	12	0.0	0.0	99.0	C	16	F	GULF	74	M	
GOVT	78	PULNK	1	8	236	522072	7763123	0	56	2	6	8	4	220	12	2640	0.8	12	0.0	0.0	99.0	C	16	F	GULF	74	M	
GOVT	78	PULNK	1	8	236	522072	7763123	0	125	1	4	8	4	170	10	1700	1.4	12	0.0	0.0	99.0	C	16	F	GULF	74	M	
GOVT	78	PULNK	1	9	236	521375	7762673	0	117	2	4	8	4	190	340	64600	1.8	12	0.0	0.0	99.0	C	16	F	GULF	74	M	
GOVT	78	PULNK	1	9	236	521375	7762673	0	106	1	4	8	4	230	20	4600	1.6	12	0.0	0.0	99.0	C	16	F	GULF	74	M	
GOVT	78	PULNK	1	9	236	521375	7762673	0	80	2	4	8	4	270	10	2700	0.0	12	0.0	0.0	99.0	C	16	F	GULF	74	M	
GOVT	78	PULNK	1	9	236	521375	7762673	0	35	1	4	8	4	100	15	1500	0.0	2	0.0	0.0	99.0	C	16	F	GULF	74	M	
GOVT	78	PULNK	1	9	236	521375	7762673	0	175	2	4	8	4	250	25	6250	0.6	12	0.0	0.0	99.0	C	16	F	GULF	74	M	
GOVT	78	PULNK	1	9	236	521375	7762673	0	75	2	4	8	4	210	10	2100	0.8	12	0.0	0.0	99.0	C	16	F	GULF	74	M	

5.3.2 New Scour Depth Distributions

Meaningful analysis of scour depth data from NEWBASE is, at present, constrained by the limited number of scour records in this system. Of the total 882 observations in NEWBASE, only 331 events recorded a measurable scour depth. Based on previous analyses, (Refer to ISIS Outputs and Data Deficiencies Section) this value represents an extremely limited data set for statistical analysis. This limitation would be further increased if one wished to concentrate on a particular physiographic or bathymetric partition of the Beaufort shelf.

Irrespective of this limitation, the distribution of scour depths for all new scours (331 events) are compared to a relevant ECHOBASE subset in Fig. 22 with some interesting results. This comparison was done using ECHOBASE data from the recent update data set (ECHO87) representing a total of 13,337 records. This data set was chosen as opposed to the total ECHOBASE distribution for two reasons. Firstly, in order that the comparison be meaningful, data from similar water depths should be compared. Both the recent update data and the NEWBASE scours represent data from broadly similar, less than 40m, bathymetric depths. Secondly, as described in the ECHOBASE section, the update scour depth data was measured as accurately as possible to depths as low as 0.2m and therefore is compatible with the NEWBASE data measurement technique. It is evident when making such comparisons that it is extremely important to remove data biases from the input data sets.

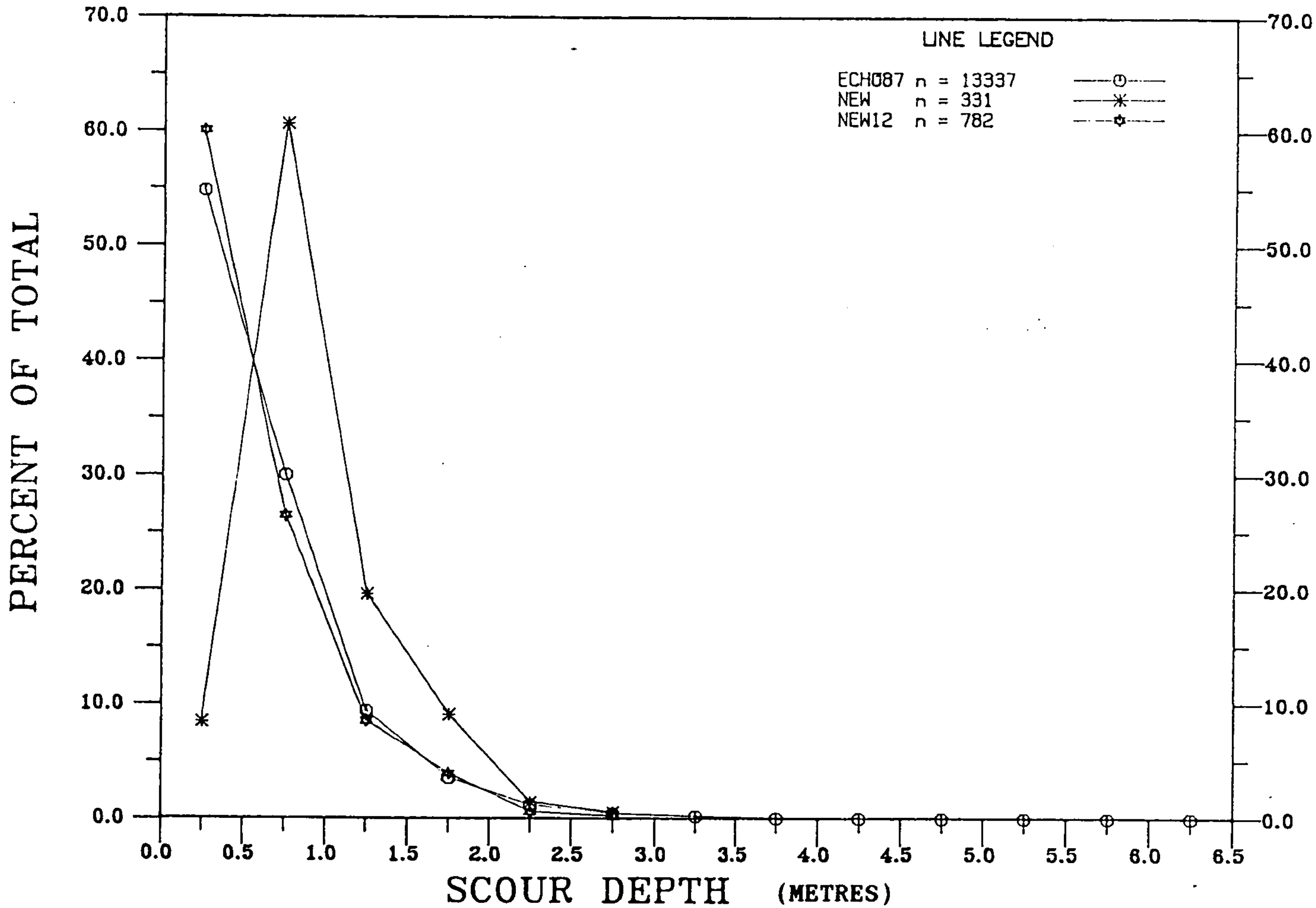
Fig. 22 displays the resultant scour depth distribution which is binned at 0.5m intervals due to the data limited NEW scour data. The poor correlation between the ECHO87 and NEW data sets is thought to largely result from the significant resolution truncation occurring below the 0.75m bin in the NEW data. (Reasons for resolution truncation are explained in ECHOBASE section). If one interpreted only these results, any sense of correlation between the 2 distributional forms would not be obvious. A third distribution NEW12, however, was plotted which correlates quite well with the ECHO87 data. The only obvious difference is the location of the maximum scour depths (2.75m versus 6.25m respectively). This distribution arises from the utilization of the newly created SBP field found only in the NEWBASE data set. As explained in the NEWBASE section, if a scour is observed on side scan data to cut the ship's path and hence offer the potential for recording a scour depth, the SBP value is preceded by 1, hence the NEW12 notation. To derive the NEW12 distribution we made the assumption that any recognizable scour cutting the ship's path must have a scour depth greater than zero. This allowed us to incorporate an additional 451 new scours into the first bin of the scour depth distribution. The impact that this reasonable assumption has on the form of the depth distribution is considerable and thus should in future be explored more rigorously. Unfortunately, the ECHOBASE data does not bear the SBP field, due to the difficulties in matching exact scour occurrences from one acoustic data set to the other. It is interesting to speculate, however, if this value was present how different the statistical scour depth distributions might appear given the results of Fig. 22.

FIG 22

SCOUR DEPTH DISTRIBUTION (ECHOBASE)

NEW SCOURS vs ECHOBASE SUBSET

SCOURS > 0.0m ONLY



5.3.3 New Scour Mapping

The spatial distribution of new scour events on the Beaufort shelf is illustrated by map 2 in the report cover jacket. New scours, with orientation directions referenced to True North, are plotted as vector bars on the track lines that bear complete overlap from the previous survey. This map illustrates that new scour occurrences are generally found in water depths shallower than 30 metres. Before further comparative information can be drawn from the data, it must be normalized by survey kilometre and year information. All mapped data including track line length is digitally referenced in the NNAVBASE and GEOCAD mapping system such that Temporal Scour Frequency (# scours/km/year) can be computed and plotted.

It should also be noted that certain large new scours identified by Shearer et al. (1986) at Gulf site W-2 could not be put into the NEWBASE format. Those scours were specifically surveyed throughout their entire length and therefore represent unique events, not conducive in deriving temporal scour frequency information.

6.0 CONCLUDING REMARKS

6.1 Summary

1. The Beaufort Sea SCOURBASE System represents a unique and powerful tool for studying the statistical attributes of ice scour features in the Beaufort Sea. This data base has been updated with an additional 1600km of high quality data yielding a combined total of 116,991 records, requiring just over 13 megabytes of storage space. A number of parameter upgrades, format changes and error correction operations, have been applied to all SCOURBASE data sets, such that compatibility is retained within the system as a whole. SCOURBASE users, upon request, will be supplied with the revised system and it is advised that old versions be discarded.

2. This study represents the first time that the SCOURBASE system has successfully been created, archived and interpreted totally in a microcomputer-based environment. An integrated sequence of in-house data processing utilities were written that processed the numerical data into the respective data base formats. For interpretation purposes, the Ice Scour Interpretation System (ISIS) was developed, that included a number of data processing, as well as, statistical and graphical utilities. Bivariate contour and 3-dimensional perspective plots were produced using the ISIS system to illustrate important SCOURBASE relationships for the scour parameter; orientation in relation to the environmental parameter; bathymetry. One such illustration helped to demonstrate that the SCOURBASE System is data deficient in various locations on the Beaufort Shelf. The GEOCAD digital mapping system was also developed during this project and used to produce digital track maps of survey lines stored by the NAVBASE system. The GEOCAD software takes full advantage of the multi-parameter SCOURBASE system by spatially plotting and overlaying various user-defined parameters on a referenced digital base map.

3. The ECHOBASE system underwent a format change and upgrade during this study that resulted in greater operating efficiency. The ECHOPRO data processing utilities included a digitizing routine that was found to be accurate (given the data constraints) and relatively time efficient. It was found that the seafloor smoothing and digitizing operation introduced the greatest degree of uncertainty, hence error, into the measurement of any one scour depth value. For this reason and the fact that digitizing is a time consuming process, CSR recommends that an automated, digital acquisition system be utilized for future data collection operations. CSR now has such a system called the Seafloor Quantification System (SQS), whereby, echo sounder data is digitally logged in the field and seafloor features, such as ice scours will be detected, measured, and geographically referenced in a data base environment.

ECHOBASE results indicate a high scour frequency of 8.2 scours/km (for echo sounder data) for this survey update data. This value is higher than for previous studies, as scour depths less than 0.5m in depth were measured to illustrate distributional trends for very shallow scour depths. The data confirm an exponential-like distribution until resolution truncation reverses this trend around the 0.25m scour depth value. Results of this study also indicate that scour depths should be binned using standard statistical methods, at a bin interval greater than the one decimal place accuracy of the data. A maximum error bound of +/- 0.21 metres was found for scour depths of the ESRF update data resulting from the error analysis study. These results and subsequent statistical operations have suggested that scour depth data be measured to two decimal places in the future. This new ECHOBASE addition is recommended by CSR with some degree of caution, as we feel the data cannot be measured to that level of accuracy. The second decimal place would, however, improve the present numerical processing operations and with the advent of the more accurate SQS system, such results may take on more realistic meaning at that time.

4. The SCOURBASE system has been improved and upgraded by this study. A number of parameters including orientation, smoothness and bathymetry were standardized for the three major data sets and minor errors corrected. The SCOURPRO data processing software was written to facilitate data entry, quality control and data base building operations. These routines functioned smoothly, resulting in the production of high quality SCOURBASE data for the present update study. A major processing advantage was realized through the UTM and Bathymetry interpolation utility that incorporated the new NAVBASE system as its main component.

SCOURBASE results have been interpreted by CSR in this study and by Gilbert and d'Apollonia (a), (in prep), funded by the Geological Survey of Canada. Selected examples from these studies, including; rose diagrams, width weighted orientation distributions and bivariate contour and perspective plots are used to illustrate data deficient regions within the SCOURBASE system. These data gaps are accentuated upon regionalization of the Beaufort Shelf data such that statistical interpretive objectives are considerably constrained. To resolve this problem, appropriate normalization of the data must be undertaken and additional SCOURBASE data should be collected in areas that are presently data deficient.

5. NAVBASE is an important new data base that stores survey line navigation, bathymetry and related parameters in a format readily usable by SCOURBASE and ECHOBASE. This system was created by CSR to normalize scour parameter data by survey line distance, thereby yielding estimates of spatial scour frequency (# of scours/km). A flexible software system was developed which calculates the total line distance values for user input criteria which might include; the whole data base, a UTM bounded window, bathymetric intervals of 5.0m (or greater), physiographic area(s) or any combination of the above. The importance of correcting scour data for spatial scour frequency is illustrated by contour and 3 dimensional perspective plots of the parameters orientation and bathymetry. The corrected data reveal a denser deep water scouring process, which confirms that additional research using frequency corrected data and this form of graphical display is recommended.

6. A new data base has been created to store new scour data derived by comparing side scan images from repetitive mapping surveys. This data base is important in deriving estimates of modern day impact rates and temporal scour frequency data that are used in subsea engineering pipeline design. Results from NEWBASE indicate that this data base is extremely data limited, especially when partitioned by water depth or physiographic area. Despite these limitations, a scour depth comparison was undertaken for all new scours bearing a scour depth value (always derived from echo sounder) and a large ECHOBASE subset. Resolution truncation in the NEW distribution was observed which in part contributed to a poor correlation. This comparison was improved, however, through the use of a new SBP parameter which helps to flag those shallow scours that cross the ship's path and therefore likely record a scour depth greater than zero. These scours are not recorded in the ECHOBASE data set. Application of this correction significantly improved the correlation between the NEW and ECHOBASE populations. This may suggest that given a large population, the scour depth distribution for NEW data may approximate one from the total ECHOBASE data set. Further research and more data are required before this conclusion can be drawn.

6.2 Recommendations

DATA COLLECTION

This project, as well as that performed by Gilbert and d'Apollonia (a), (in prep) have illustrated that serious data gaps are present in the SCOURBASE system. It is recommended that good quality but as yet unprocessed data from the ESRF84, Tully85 and 86 data sets be incorporated into the system. Additional data are required for the new scour data base NEWBASE which requires a complete resurvey of the ESRF corridors established in 1984. New corridors in the deeper water locations are also recommended by CSR, for determining deep water scour impact rates.

SCOURBASE UPGRADE

SCOURBASE parameters have generally remained quite consistent since 1983, however, some deletions and improvements are suggested. It is recommended that the SBP field or third channel source indicator, (present in NEWBASE) be incorporated into the SCOURBASE system. This would document the source for a scour depth measurement, whether it result from echo sounder or subbottom profile data or in some cases where both data sets are absent. The user could then associate scour depth analyses with some relevant indication of confidence or error based on resolution of the depth recording instrumentation. Another recommendation relates to the sediment thickness parameter. This parameter is not consistent within the data base and could be upgraded to reflect new geological information from interpreted regional seismic lines. Once this parameter was upgraded, a major analysis of scour depth versus sediment thickness information is recommended. The SCOURBASE system could also be down-sized slightly by removing inactive fields such as, Standard Deviation and perhaps Scour Number.

SCOURBASE INTERPRETATION

A major SCOURBASE interpretation project is recommended that statistically compares scour and environmental parameters in various physiographic and bathymetric subdivisions of the Beaufort Shelf. Specific problems that require attention include; sub-scour deformation, scour frequency, scour depth versus sediment thickness, scour/geotechnical parameter comparisons and new scour modelling and extreme depth analyses.

SCOURBASE FIELD TESTING

The Beaufort Sea SCOURBASE System is now totally stored in a self-contained microcomputer based environment. This system may therefore be taken on-board future surveys for interpretive and plotting operations. The use of NAVBASE, in the field especially, represents a new, unique, capability that offers a digital reference of exact line coordinates for all the SCOURBASE survey lines.

ECHOBASE PROCESSING

CSR is continuing to develop the Seafloor Quantification System (SQS) which digitally logs and processes echo sounder data in the field. Seafloor filtering and ice scour depths can be accurately measured, linked with a UTM x,y coordinate and downloaded to a formatted ECHOBASE file. This tool will alleviate most of the tedious ECHOPRO operations performed in this study and at the same time produce more accurate, unbiased results that can be re-interpreted digitally, as new information becomes available. The SQS system is therefore recommended for future data acquisition surveys. This system is also interfaced with a Raytheon DE-719 sounder which is the standard equipment used for most field surveys, including the ESRF84 dedicated ice scour survey. For this reason and the fact that the error estimate work performed during this study is based on the Raytheon equipment specifications, we recommend this sounder be the standard for future ice scour surveys.

ERROR ANALYSIS

The error analysis work performed in this study has yielded interesting results and should be continued in the future. It appears that a narrow beam transducer would yield more precise bottom feature measurements than the commonly used 8 degree transducer. A comparative field study is therefore suggested that would utilize both transducers and compare the degree of relative error. The results of this survey could then be used to re-calibrate scour depth values presently residing in ECHOBASE.

The use of the SQS system for future scour depth processing, would also further reduce the error values analyzed in this report for scour depth measurements. For this reason, as well as the problems encountered in binning the data (see ECHOBASE section), it is recommended that the ECHOBASE scour depth parameter be measured to a precision of two decimal places.

NAVBASE UPKEEP AND IMPROVEMENTS

The NAVBASE system now archived at Cdn. Seabed Research Ltd. should be maintained and upgraded to allow operation with increased efficiency and accuracy. This would also increase the scope of the tasks that can be performed by this system. The following upgrades are presently necessary;

A. Revise the Geoterrex/ESRF lines to improve the accuracy and consistency of the position information.

B. Selectively reduce the size of NAVBASE by deleting extra records now present. This will simplify the system, improve accuracy and increase operating performance.

C. Expand the size of NAVBASE to include the boundaries of other parameters such as sea ice zonation and sediment thickness information.

These recommendations originate as the result of the compilation and use of NAVBASE, and are intended to increase the accuracy and usefulness of the system.

NAVBASE DATA COLLECTION RECOMMENDATIONS

Documenting and archiving navigation data on digital tape should be commonplace for future surveys in the Beaufort Sea. Correct and comprehensive field documentation of survey and navigational parameters, are necessary to enhance NAVBASE interpretive outputs. A standard distance (eg. 200m) between fix increments should be used in future surveys. This allows greater accuracy in relating fix numbers to position than larger intervals, and a standard distance would increase the ease of processing data. Surveyors should prepare a navigation report with all relevant information documented for the project authority. The information, in addition to fix versus position information, should include:

A. Details of the survey (correct line names, survey times) including start-of-line and end-of-line fixes; and

B. The navigation equipment used, and an estimate of the accuracy of the position. The navigation equipment manufacturer's specifications should be used here.

NEWBASE IMPROVEMENTS

The format of the NEWBASE data base and its associated navigation data base is somewhat limited in terms of adding additional years of repetitive survey information. Problems arise when data quality breaks create a number of line segments along a corridor that may not match previous years' data sets. The calculation of scour frequency, over time, becomes increasingly difficult in these situations which constrains the utility of the NEWBASE system.

Another discontinuity is created by new scours that were identified through grounded ice ridge surveys in the winter and surveyed, in detail, the following summer by the ESRF 84 mapping program. These scours are somewhat unique as they are difficult to include in the regionally-mapped NEWBASE system. Additional thought should be given to these events for incorporation into the system. These concepts should be addressed as part of the next repetitive scour mapping project.

7.0 REFERENCES

APOA 19,32 & 69, Hunting Geology and Geophysics Limited, Investigation of Sea-Bed Scouring (Phase II), prepared for APOA, February 1973.

BRAGG, G.M., 1974. Principles of Experimentation and Measurement. Prentice - Hall, Inc., New Jersey.

DAHEL, Dr.(pers comm). Dept of Applied Mathematics, Technical University of Nova Scotia, Halifax, Nova Scotia.

EATON, R.M., 1968. Sounding Accuracy. Atlantic Oceanography Laboratory, Bedford Institute, Internal Note 1968-18-I.

GILBERT, G., K. O'NEILL and R. Rincker, 1983. Gulf 1983 Ice Scour Data Base. Prepared by Geoterrex Ltd. for Gulf Canada Resources Inc.

GILBERT, G., S. BLASCO, T. STIRBYS, and M. LEWIS, 1985. Beaufort Sea Ice Scour Analysis using a Computerized Data Base. Offshore Technology Conference Paper 4969.

GILBERT, G.R. and K. PEDERSEN, 1986. Ice Scour Data Base for the Beaufort Sea. Environmental Studies Research Funds, Report No. 055. Ottawa 99p.

GILBERT, G.R. and S. d'APOLLONIA (a), in prep. SCOURBASE, Physiographic and Bathymetric Scour Parameter Analyses. Report prepared for the Geological Survey of Canada.

GILBERT, G.R., and S. d'APOLLONIA (b), in prep. Geographic Information Systems (GIS) and Statistical Packages for use in Ice Scour Analyses-Beaufort Sea. Report Prepared for the Geological Survey of Canada

GOODWIN, C.R., J.C. FINLEY, and L.M. HOWARD, 1985. Ice Scour Bibliography. Environmental Studies Research Funds Report No. 010. Ottawa, 99 p.

HNATIUK, J. and K. BROWN, 1977. Sea Bottom Scouring in the Canadian Beaufort Sea. Proceedings of the Offshore Technology Conference, Houston, Texas.

INGHAM, A.E., 1974. Hydrography for the Surveyor and Engineer. Granada Publishing Ltd.

KING, Dr.L. (pers comm). (ret'd), Geological Survey of Canada, Bedford Institute of Oceanography, Dartmouth, Nova Scotia.

LEWIS, C.F.M, 1977. Bottom Scour by Sea Ice in the Southern Beaufort Sea. Geological Survey of Canada, Atlantic

Geoscience Centre, Bedford Institute of Oceanography, Dartmouth, Nova Scotia. Beaufort Sea Technical Report 23:27-100.

LEWIS, C.F.M., D.R. PARROTT, P.G. SIMPKIN, and J.T.BUCKLEY (eds). 1986. Ice Scour and Seabed Engineering. Environmental Studies Research Funds Report No. 049. Ottawa. 322 p.

MACPHEE, S.B., 1976. Developments in Narrow Beam Echo Sounders, International Hydrographic Review, Monaco L111(1).

NESSIM, M., S. DUBEC, and S. LANTOS, 1988. Pilot Study to Examine Ice Scour Statistics. Report prepared for the Geological Survey of Canada.

O'CONNOR, M.J., 1982. Physiographic Regions of the S. Beaufort Sea Shelf. Geological Survey of Canada Report. March 1982 (Job No. 10-127).

PELLETIER, B. R., 1971. Side Scan Sonar Surveys and Ice Scouring In the Beaufort Sea. Proceedings of the Can. Seminar on Icebergs held at Can. Forces Maritime Warfare School, CFB Halifax, Halifax.

PELLETIER, B. and J. SHEARER, 1972. Sea Bottom Scouring in the Beaufort Sea of the Arctic Ocean. Proceedings of the 24th International Geological Congress, Section 8 p251-261.

PELLETIER, B., S.M. BLASCO and G.R. GILBERT, in prep. Marine Sciences Atlas of the Beaufort Sea. Geological Survey of Canada Report.

RAYTHEON, 1979. Raytheon DE - 719C Fathometer Depth Sounder Instruction Manual, Raytheon Company, Lexington, Mass., U.S.A.

SHEARER, J.M., 1971. Preliminary Interpretation of Shallow Seismic Reflection Profiles from the West Side of Mackenzie Bay, Beaufort Sea. GSC Paper 71-1B, p 131-138

SHEARER, J. and S. BLASCO, 1975. Further Observations of the Scouring Phenomena in the Beaufort Sea. Report of Activities, Part A, Geological Survey of Canada, Paper 75-1A:483-93.

SHEARER, J., B. LAROCHE, and G. FORTIN, 1986. Canadian Beaufort Sea 1984 Repetitive Mapping of Ice Scours. Environmental Studies Research Funds Report 032. Ottawa.

SHEARER, J. and K. PEDERSEN, in prep. Yukon Shelf SCOURBASE Update. Report prepared for the Geological Survey of Canada.

WAHLGREN, R.V., 1979. Ice-Scour Tracks in Eastern MacKenzie Bay and North of Pullen Island, Beaufort Sea. Current Research, Part B, Geological Survey of Canada, Paper 79-1B:674-687.

8.0 APPENDICES

Appendix 8.1 ECHOBASE FORMAT AND PARAMETER DESCRIPTIONS

FORMAT: ECHOBASE

TOTAL # of records = 24,801
TOTAL FOXBASE SPACE = 2.5 megabytes

FIELD	FIELD NAME	TYPE	WIDTH	DECIMAL PT.
1	COMP	Character	4	
2	YEAR	Numeric	3	
3	LINE	Character	5	
4	PART	Numeric	3	
5	FIX	Numeric	8	1
6	EAST	Numeric	7	
7	NORTH	Numeric	8	
8	DEPTH	Numeric	4	1
9	BATHY	Numeric	6	1
10	QUAL	Character	2	
11	COMMENT	Character	49	

TOTAL FORMAT LENGTH = 99

PARAMETER DESCRIPTIONS: ECHOBASE

FIELD NAME	DESCRIPTION	DATA TYPE (WIDTH)
1) COMP	COMPANY	Character(4)

The reference name for each major data set. The following update values are listed:

ESRF - Environmental Studies Research Funds 1984 data
TY85 - Tully 85 EMR data
TY86 - Tully 86 EMR data
EMR - EMR 84 & 85 comprised of Banksland 84 & Tully 85 data for Yukon Shelf. (Processed by Shearer)

2) YEAR	YEAR	Numeric(3)

The year of data acquisition.

3) LINE	LINE	Character(5)

Survey line identifier.

ESRF line A1 was changed to 1A to reflect name used in navigation file. ESRF line labels for 8B and 8BS are reversed on trackplot from Shearer et al. (1986).

4) PART	PART	Numeric(3)

Refers to a break in a line at a specific fix due to poor data quality.

5) FIX FIX Numeric(8.1)

Records an interpolated fix value at the deepest position of a scour measured on echo sounder data through digitization by the ECHOPRO program MAC1.BAS. This fix is the reference location from which the scour x,y position will be calculated.

6,7) EAST,NORTH EASTING, NORTHING Numeric(7,8)

Precise UTM scour position as calculated at each fix location. UTM's for present data are interpolated through SCOURPRO system utilizing NAVBASE information, Yukon Shelf data are measured manually from trackplot while original ESRF data was interpolated from navigation files. All data are referenced to UTM zone 8 (central meridian 135 degrees longitude)

8) DEPTH SCOUR DEPTH Numeric(4.1)

Scour depth as measured in metres by the ECHOPRO digitizing routine. Values are rounded to one decimal place and attempts were made to measure minimal scour depths, as accurately as possible, (See ECHOPRO section). The original ESRF data does not record scour depth values less than 0.5m in depth and obtains the depth values through a computerized filtering and scour detection system.

9) BATHY SEABED DEPTH Numeric(6.1)

Water depth as digitized to a visually smoothed reference datum. This depth is taken at the exact fix for each scour depth value. Note that the original ESRF data referenced the seabed depth to a smoothed seafloor position as obtained by a digital running average filter.

10) QUAL DATA QUALITY Character(2)

A subjective description of general data quality which may vary dependant on weather conditions and equipment malfunctions.

G = GOOD
F = FAIR
P = POOR

11) COMMENT COMMENTS Character(23)

Pertinent comments for certain aspects of data like site locations, sand bodies, pingos, gas seeps etc.

Appendix 8.2 SCOURBASE FORMAT AND PARAMETER DESCRIPTIONS

FORMAT: SCOURBASE

TOTAL # of records = 66,549
TOTAL FOXBASE SPACE = 8.9 megabytes

FIELD	FIELD NAME	TYPE	WIDTH	DECIMAL PT.
1	COMP	Character	4	
2	YEAR	Numeric	3	
3	LINE	Character	5	
4	PART	Numeric	3	
5	FIX	Numeric	5	
6	HEAD	Numeric	4	
7	EAST	Numeric	7	
8	NORTH	Numeric	8	
9	SCNUM	Numeric	5	
10	ORIENT	Numeric	4	
11	SD	Numeric	4	
12	FORM	Numeric	2	
13	MORPH	Numeric	2	
14	SMOOTH	Numeric	2	
15	RAGE	Character	2	
16	LEN	Numeric	6	
17	WID	Numeric	4	
18	AREA	Numeric	7	
19	DEPTH	Numeric	4	1
20	FIX1	Numeric	5	
21	SFILL	Numeric	5	1
22	SSDEF	Numeric	3	1
23	STHK	Numeric	6	1
24	STYPE	Character	3	
25	BATHY	Numeric	4	
26	QUAL	Character	2	
27	COMMENT	Character	23	

TOTAL FORMAT LENGTH = 132

PARAMETER DESCRIPTIONS: SCOURBASE

FIELD NAME	DESCRIPTION	DATA TYPE (WIDTH)
1) COMP	COMPANY	Character(4)

The reference name for each major data set. The following update values are listed:

ESRF - Environmental Studies Research Funds 1984 data
TY85 - Tully 85 EMR data
TY86 - Tully 86 EMR data
EMR - EMR 84 & 85 comprised of Banksland 84 & Tully 85 data for Yukon Shelf. (Processed by Shearer)

2) YEAR YEAR Numeric(3)

The year of data acquisition.

3) LINE LINE Character(5)

Survey line identifier. ESRF line A1 was changed to 1A to reflect name used in navigation file. ESRF line labels for 8B and 8BS are reversed on trackplot from Shearer et al. (1986)

4) PART PART Numeric(3)

Refers to a break in a line at a specific fix due to poor data quality.

5) FIX FIX Numeric(5)

Refers to the reference fix location from which the scour x,y position is derived. For all update and Yukon data, fix is taken at position where scour cuts ship's path or the closest location for scours that do not cut the path. For the original ESRF data, the fix is taken at the "leftmost" position of each scour. Fixes recorded in time were changed to cumulative minutes that keep accumulating after 2400 hours.

DATA	FIX TYPE
ESRF 84	Numeric
TY85 85	Time
TY86 86	Time
EMR 84	Numeric
EMR 85	Time

6) HEAD HEADING Numeric(4)

General value for ship's heading which may change along line. Exact heading values can be calculated using x,y positions.

7,8) EAST,NORTH EASTING, NORTHING Numeric(7,8)

Precise UTM scour position as calculated at each fix location. UTM's for present data are interpolated through the SCOURPRO system, utilizing NAVBASE information. Yukon Shelf data were measured manually from trackplot, while original ESRF data was interpolated from navigation files. All data are referenced to UTM zone 8 (central meridian 135 degrees longitude)

9) SCNUM SCOUR NUMBER Numeric(5)

Reference scour counter that may be input and utilized at user's discretion.

10) ORIENT SCOUR ORIENTATION Numeric(4)

Scour orientation value referenced to true north and expressed by convention between 0-179 degrees inclusive. No indication of true ice movement can be inferred form this measure. This value was measured manually from data for present update and Yukon data and measured digitally for original ESRF data. All recent side scan data are speed corrected such that records are distortion-free.

11) SD STANDARD DEVIATION OF ORIENTATION Numeric(4)

This value was not computed for update and Yukon data but is present for original ESRF data.

12) FORM FORM Numeric(2)

Determined manually from data sets.

1 - Single-keeled scour
2 - Multi-keeled scour
3 - Zone of multikeels used when it is not possible to isolate separate events.

13) MORPH MORPHOLOGY Numeric(2)

4 - Linear Scour
5 - Arcuate or Curved Scour
6 - Sinuous Scour changes orientation more than once.

14) SMOOTH SMOOTHNESS Numeric(2)

Smoothness is a highly subjective description, based on the sharpness of acoustic returns, which may vary dependant on; angle of scour sonification, data quality, water depth and sediment type.

7 - Very rough: Opaque reflectance from scour floor with sharply defined berm walls. This value may relate to the most recent scour events.
8 - Rough: strong acoustic signature, evidence of rubble on berm or in scour.
9 - Moderately Smooth.
10 - Smooth: reduced signal contrast, no rubble, very smooth appearing morphology, often infilled.

The very rough parameter is new for the present update and Yukon data sets. The original ESRF data does not record this value. Refer to Fig. 10 for example of scour smoothness types.

15) RAGE RELATIVE AGE Character(2)

This parameter is based on smoothness and general morphology in relation to the level of background scouring. It is input only rarely when a high degree of confidence exists for the age of unusually distinct scours.

+ Old :smooth appearing, likely infilled and crosscut.

- Recent: rough appearing, uniquely distinct amongst background scouring.

. Uncut:input only for recent events that are not crosscut by other scouring events.

16) LEN LENGTH Numeric(6)

Scour length as measured manually along scour's longest axis. Scour length unfortunately is often a product of the range limitations of the side scan system and therefore is of limited value.

17) WID WIDTH Numeric(4)

Scour width as measured manually from the data as an average value between the tops of the berms and perpendicular to the long axis of the scour.

18) AREA AREA Numeric(7)

Scour area as calculated by scour length times width.

Area for original ESRF data was computed as the polygonal area of the digitized scour points.

19) DEPTH SCOUR DEPTH Numeric(4.1)

Scour depth value measured from the third channel side scan information for those scours that cut the ship's path. Substantial differences in resolution arise whether the data was 3.5 kHz subbottom profile data or 100 kHz echo sounder data. Depths less than 0.5m are generally not measured and it is recommended that bin intervals not less than 0.5m be used in histogram analyses. If a scour is identified as a multikeel, the deepest keel depth of that scour is chosen.

20) FIX1 FIX Numeric(5)

The scour depth fix records the position of the scour depth for the original ESRF data only.

21) SFILL SEDIMENT INFILL Numeric(5.1)

Records the thickness of scour infill in 0.5m intervals as measured from third channel subbottom profile data. It should be noted that echo sounding devices mounted in the side scan fish will likely not reveal sediment infill values due to lack of penetration.

22) SSDEF SUB-SCOUR DEFORMATION Numeric(3.1)

Records the depths of sub-scour disruption of stratigraphy due to ice loading. This parameter is highly speculative at present and therefore is rarely input. Apparent sub-scour disruption of continuous beds may result from acoustic focusing/defocusing of seismic energy. Note this is only recognizable for third channel data bearing a subbottom profiling device.

23) STHK SEDIMENT THICKNESS Numeric(6.1)

Thickness of surficial sediment to the Unit C unconformity. Most values are based on a map recently published by O'Connor (1982). Values are input to 10.m only, therefore thickness greater than 10 are referenced by 10.0 in the data base. Unknown values where data are unavailable or as yet not interpreted are referenced as 99.0.

24) STYPE SEDIMENT TYPE Character(3)

Sediment type as interpreted from acoustic data sets and site interpretation reports.

C - Clay
S - Sand
CS - Clay over Sand
SI - Silt

25) BATHY BATHYMETRY Numeric(4)

Water depth derived from interpolation from NAVBASE data sets. Note that the original ESRF data had a alphanumeric code A=0-5m, B=5-10m etc. This has now been upgraded to a numeric system representing bathymetry values at one metre intervals.

26) QUAL DATA QUALITY Character(2)

A subjective description of general data quality which may vary dependant on weather conditions and equipment malfunctions.

G = GOOD
F = FAIR
P = POOR

27) COMMENT COMMENTS Character(23)

Pertinent comments for certain aspects of data like site locations, sand bodies, pingos, gas seeps etc.

Appendix 8.3 NAVBASE FORMAT AND PARAMETER DESCRIPTIONS

FORMAT: NAVBASE

TOTAL # of records = 22,669
TOTAL FOXBASE SPACE = 1.5 megabytes

FIELD	FIELD NAME	TYPE	WIDTH	DECIMAL PT.
1	COMP	Character	4	
2	YEAR	Numeric	3	
3	LINE	Character	5	
4	ESPART	Character	2	
5	SSPART	Character	2	
6	FIX	Numeric	5	
7	EAST	Numeric	7	
8	NORTH	Numeric	8	
9	BATHY	Numeric	4	
10	AREA	Character	3	
11	ORIGIN	Character	3	
12	COMMENT	Character	20	

TOTAL FORMAT LENGTH = 66

<u>PARAMETER DESCRIPTIONS: NAVBASE</u>

FIELD NAME   DESCRIPTION   DATA TYPE (WIDTH)

1) COMP   COMPANY   Character (4)

The operator who collected the field data.
The company parameters are listed as follows:

- BEAU - Beaufort Delta
- DOME - Dome Petroleum Ltd.
- EMR - Energy, Mines and Resources
- ESRF - Environmental Studies Research Funds
- ESSO - Esso Resources Ltd.
- GULF - Gulf Canada Resources Inc.
- HUDN - Government Hudson 70
- TY85 - Government Tully 85
- TY86 - Government Tully 86

2) YEAR   YEAR   Numeric (3)

Year of data acquisition. Range 1970-1986.

3) LINE   LINE   Character (5)

Survey line number.

4) ESPART ECHO SOUNDER PART NUMBER Character (2)

Refers to a break in the line due to an echo sounder paper break or poor data quality. Parts start at the number 1 and proceed sequentially. The first record with a particular part number is the start of that part, and the last record with that part number is the end of that part. Records with no echo sounder part number are places where echo sounder data are absent due to poor quality.

5) SSPART SIDE SCAN SONAR PART NUMBER Character (2)

Refers to a break in the line due to a side scan sonar paper break or poor data quality. Refer to ESPART description for more information.

6) FIX REFERENCE FIX MARK Numeric (5)

The reference shot number. Most data types have sequential increments of whole numbers with the exception of Government surveys where fixes were in time. These data are converted to cumulative minutes. Distance increments vary with type of survey and navigation equipment used.

7,8) EAST, NORTH EASTING AND NORTHING Numeric (7,8)

The x,y position of each fix position expressed in the Universal Transverse Mercator system. Data collected in Latitude/Longitude has been changed using conversion software. All positions are in Zone 8, which is based on a Central Meridian of 135 degrees West. Note that with the extension of this coordinate system into the two adjoining zone, errors of scale increase.

9) BATHY BATHYMETRY Numeric (4)

The charted water depth corresponding to the position of that record, to the nearest meter. Note that this is derived from corrected Hydrographic charts, and therefore may differ from ECHOBASE or SCOURBASE values for that same fix. There are duplicate records in NAVBASE which contain bathymetry values which differ by 1m (eg. 39m and 40m), which are used to delimit bathymetry contour crossover points.

10) AREA PHYSIOGRAPHIC AREA Character (3)

Physiographic area in the Beaufort Sea as defined by O'Connor (1982). Codes for the different areas are as follows:

AK - Akpak Plateau
BA - Baillie Plain
IK - Ikit Trough
KR - Kringalik Plateau
KU - Kugmallit Channel
MA - Mackenzie Trough
NI - Niglik Channels

TI - Tingmiark Plain
YU - Yukon Shelf

When a survey line crosses a border of one of these areas, duplicate records are placed in NAVBASE. These can be identified by the comment ' AREA BORDER' in the COMMENT field.

11) ORIGIN OF DATA Character (3)

Original source of the navigation data corresponding to each record in the data file. Codes for the different origins are as follows:

NT - Navigation tape.
TP - UTM positions derived manually from trackplot.
DC - Fix and UTM position digitized from trackplot.
E - Fix and UTM position taken directly from ECHOBASE.
S - Fix and UTM position taken directly from SCOURBASE.
XS - UTM positions extrapolated from SCOURBASE records.
XE - UTM positions extrapolated from ECHOBASE records.
I - UTM positions extrapolated from existing records in NAVBASE.

12) COMMENT Character (20)

Comments pertinent to NAVBASE. Commonly used comments are:

xx RECORDS USED - This indicates that the position of that record was extrapolated from ECHOBASE or SCOURBASE, with the number of records used to form a least-squares line for the extrapolation (see section on Extrapolation/Interpolation).

AREA BORDER - This comment indicates the position of the survey line where it crosses an area border.

Appendix 8.4 NEWBASE FORMAT AND PARAMETER DESCRIPTIONS

FORMAT: NEWBASE

TOTAL # of records = 882
TOTAL FOXBASE SPACE = 0.1 megabytes

FIELD	NAME	TYPE	WIDTH	DECIMAL PT.
1	COMP	Character	4	
2	YEAR	Numeric	3	
3	LINE	Character	5	
4	OPART	Numeric	3	
5	FIX	Numeric	7	1
6	HEAD	Numeric	4	
7	EAST	Numeric	7	
8	NORTH	Numeric	8	
9	SCNUM	Numeric	5	
10	ORIENT	Numeric	4	
11	FORM	Numeric	2	
12	MORPH	Numeric	2	
13	SMOOTH	Numeric	2	
14	MAGE	Numeric	2	
15	LEN	Numeric	6	
16	WID	Numeric	4	
17	AREA	Numeric	7	
18	DEPTH	Numeric	4	1
19	SBP	Numeric	3	
20	SFILL	Numeric	4	1
21	SSDEF	Numeric	3	1
22	STHK	Numeric	5	1
23	STYPE	Character	3	
24	BATHY	Numeric	4	
25	QUAL	Character	2	
26	PCOMP	Character	4	
27	PYEAR	Numeric	3	
28	SOURCE	Character	2	
29	COMMENT	Character	23	

TOTAL FORMAT LENGTH = 132

PARAMETER DESCRIPTIONS: NEWBASE

FIELD NAME	DESCRIPTION	DATA TYPE (WIDTH)
1) COMP	COMPANY	Character(4)

The reference name for each major data set. The following update values are listed:

ESRF - Environmental Studies Research Funds 1984 data
TY85 - Tully 85 EMR data
TY86 - Tully 86 EMR data
EMR - EMR84 & 85 comprised of Banksland 84 &Tully 85 data for Yukon Shelf. (Processed by Shearer)

2) YEAR Numeric(3)

The year of data acquisition.

3) LINE Character(5)

Survey line identifier. ESRF line A1 was changed to 1A to reflect name used in navigation file. ESRF line labels for 8B and 8BS are reversed on trackplot from Shearer et al. (1986).

4) OPART OVERLAP PART Numeric(3)

This parameter is similar to the PART parameter in the SCOURBASE system, however due to the repetitive nature of the two survey lines it refers to that section of both lines that show complete overlap. A new OPART section may be created by poor data quality or a broken survey section from data on either survey line.

5) FIX Numeric(7.1)

Refers to the reference fix location from which the scour x,y position is derived. For all update and Yukon data, fix is taken at position where scour cuts ship's path or the closest location for scours that do not cut the path. For the original ESRF data fix is taken at the "leftmost" position of each scour. Fixes recorded in time were changed to cumulative minutes that keep accumulating after 2400 hours.

DATA	FIX TYPE
ESRF 84	Numeric
TY85 85	Time
TY86 86	Time
EMR 84	Numeric
EMR 85	Time

6) HEAD HEADING Numeric(4)

General value for ship's heading which may change along line. Exact heading values can be calculated using x,y positions.

7,8) EAST,NORTH EASTING, NORTHING Numeric(7,8)

Precise UTM scour position as calculated at each fix location. UTM's for present data are interpolated through the SCOURPRO system, utilizing NAVBASE information. Yukon Shelf data are measured manually from trackplot while original ESRF data was interpolated from navigation files. All data are referenced to UTM zone 8 (central meridian 135 degrees longitude).

9) SCNUM SCOUR NUMBER Numeric(5)

Reference scour counter that may be input and utilized at user's discretion.

10) ORIENT SCOUR ORIENTATION Numeric(4)

Scour orientation value referenced to true north and expressed by convention between 0-179 degrees inclusive. This value was measured manually from data for present update and Yukon data and measured digitally for original ESRF data. All recent side scan data are speed corrected such that records are distortion-free.

11) FORM Numeric(2)

Determined manually from data sets.

1 - Single-keeled scour
2 - Multi-keeled scour
3 - Zone of multikeels used when it is not possible to isolate separate events.

12) MORPH MORPHOLOGY Numeric(2)

4 - Linear Scour
5 - Arcuate or Curved Scour
6 - Sinuous Scour changes orientation more than once.

13) SMOOTH SMOOTHNESS Numeric(2)

Smoothness is a highly subjective description based on the sharpness of acoustic returns which may vary dependant on; angle of scour sonification, data quality, water depth and sediment type.

7 - Very rough: Opaque reflectance from scour floor with sharply defined berm walls. This value may relate to the most recent scour events.
8 - Rough: strong acoustic signature, evidence of rubble on berm or in scour.
9 - Moderately Smooth.
10 - Smooth: reduced signal contrast, no rubble, very smooth appearing morphology, often infilled.

The very rough parameter is new for the present update and Yukon data sets. The original ESRF data does not record this value. Refer to Fig. 10 for example of scour smoothness types.

14) MAGE MAXIMUM AGE Numeric(2)

This refers to the maximum scour age in years as defined by an initial and a subsequent repetitive scour mapping survey.

15) LEN LENGTH Numeric(6)

Scour length as measured manually along scour's longest axis. Scour length unfortunately is often a product of the range limitations of the side scan system and therefore is of limited value.

16) WID WIDTH Numeric(4)

Scour width as measured manually from the data as an average value between the tops of the berms and perpendicular to the long axis of the scour.

17) AREA Numeric(7)

Scour area as calculated by scour length times width. Area for original ESRF data was computed as the polygonal area of the digitized scour points.

18) DEPTH SCOUR DEPTH Numeric(4.1)

DEPTH relates to scour depth as it does in the SCOURBASE system. This value, however, is obtained from echo sounder data wherever possible such that the most accurate scour depth value can be documented in the NEWBASE system. The extra effort involved in measuring this value from the echo sounder data rather than the third channel subbottom profile data is felt justified in light of the importance the scour depth parameter plays in modelling modern day subsea pipeline designs.

19) SBP THIRD CHANNEL SOURCE Numeric(3)

SBP refers to the type of instrument utilized in deriving the scour depth value. In some cases, echo sounder data may not be available and the measurement must be made from high resolution geophysical data sets.

1 - refers to subbottom profile,
2 - echo sounder,
3 - echo sounder on third channel,
4 - no echo sounder or subbottom profile available.

These numbers may be prefixed by 1 (eg. 12). This code infers that this scour cuts the ship's path, thus has been sampled by the profiling device and therefore has the potential to record a measurable scour depth in the NEWBASE system. This is a useful parameter for scours that cut the ship's path but do not record a depth (within the resolution of the geophysical equipment and ECHOPRO data processing system). Such scours in the future may be included in the analyses of scour depth distributions.

20) SFILL SEDIMENT INFILL Numeric(5.1)

Records the thickness of scour infill in 0.5m intervals as measured from third channel subbottom profile data. It should be noted that echo sounding devices mounted in the side scan fish will likely not reveal sediment infill values due to lack of penetration.

21) SSDEF SUB-SCOUR DEFORMATION Numeric(3.1)

Records the depths of sub-scour disruption of stratigraphy due to ice loading. This parameter is highly speculative at present and therefore is rarely input. Apparent sub-scour disruption of continuous beds may result from acoustic focusing/defocusing of seismic energy. Note this is only recognizable for third channel data bearing a subbottom profiling device.

22) STHK SEDIMENT THICKNESS Numeric(6.1)

Thickness of surficial sediment to the Unit C unconformity. Most values are based on a map recently published by O'Connor (1982). Values are input to 10.m only, therefore thickness greater than 10 are referenced by 10.0 in the data base. Unknown values where data are unavailable or as yet not interpreted are referenced as 99.0.

23) STYPE SEDIMENT TYPE Character(3)

Sediment type as interpreted from acoustic data sets and site interpretation reports.

C - Clay
S - Sand
CS - Clay over Sand
SI - Silt

24) BATHY BATHYMETRY Numeric(4)

Water depth derived from interpolation from NAVBASE data sets. Note that the original ESRF data had a alphanumeric code A=0-5m, B=5-10m etc. This has now been upgraded to a numeric system representing bathymetry values at one metre intervals.

25) QUAL DATA QUALITY Character(2)

A subjective description of general data quality which may vary dependant on weather conditions and equipment malfunctions.

G = GOOD
F = FAIR
P = POOR

26) PCOMP PREVIOUS COMPANY Character(4)

PCOMP describes the previous company from which the repetitive survey was undertaken.

27) PYEAR PREVIOUS YEAR Numeric(3)

PYEAR describes the previous year from which the repetitive survey was undertaken. This information along with the present year information is used to determine the maximum scour age.

28) SOURCE DATA SOURCE LOCATION Character(2)

SOURCE identifies whether the repetitive mapping information has arisen from a mosaiced site area or one of the regional corridor locations on the Beaufort Shelf.

29) COMMENT COMMENTS Character(23)

Pertinent comments for certain aspects of data like site locations, sand bodies, pingos, gas seeps etc.

Appendix 8.5 NNAVBASE FORMAT AND PARAMETER DESCRIPTIONS

FORMAT: NNAVBASE

TOTAL # of records = 2090
TOTAL FOXBASE SPACE = 0.1 megabytes

FIELD	FIELD NAME	TYPE	WIDTH	DECIMAL PT.
1	COMP	Character	4	
2	YEAR	Numeric	3	
3	LINE	Character	5	
4	ESPART	Character	2	
5	SSPART	Character	2	
6	FIX	Numeric	5	
7	EAST	Numeric	7	
8	NORTH	Numeric	8	
9	BATHY	Numeric	4	
10	AREA	Character	3	
11	ORIGIN	Character	3	
12	COMMENT	Character	20	

TOTAL FORMAT LENGTH = 66

PARAMETER DESCRIPTIONS: NNAVBASE

FIELD NAME	DESCRIPTION	DATA TYPE (WIDTH)
1) COMP	COMPANY	Character (4)

The operator who collected the field data.
The company parameters are listed as follows:

BEAU - Beaufort Delta
DOME - Dome Petroleum Ltd.
EMR - Energy, Mines and Resources
ESRF - Environmental Studies Research Funds
ESSO - Esso Resources Ltd.
GULF - Gulf Canada Resources Inc.
HUDN - Government Hudson 70
TY85 - Government Tully 85
TY86 - Government Tully 86

2) YEAR	YEAR	Numeric (3)

Year of data acquisition. Range 1970-1986

3) LINE	LINE	Character (5)

Survey line number.

4) ESPART	ECHO SOUNDER PART NUMBER	Character (2)

Not utilized in NNAVBASE.

5) SSPART SIDE SCAN SONAR PART NUMBER Character (2)

Records the exact location of overlap between repetitive survey line data. If one line or the other is broken for any reason (eg. data quality) this break will be reflected by a blank part number in the SSPART field. When complete overlap is restored, the successive part number will record the exact fix and UTM position where this occurs.

6) FIX REFERENCE FIX MARK Numeric (5)

The reference shot number. Most data types have sequential increments of whole numbers with the exception of Government surveys where fixes were in time. These data are converted to cumulative minutes. Distance increments vary with type of survey and navigation equipment used.

7,8) EAST, NORTH EASTING AND NORTHING Numeric (7,8)

The x,y position of each fix position expressed in the Universal Transverse Mercator system. Data collected in Latitude/Longitude has been changed using conversion software. All positions are in Zone 8, which is based on a Central Meridian of 135 degrees West. Note that with the extension of this coordinate system into the two adjoining zone, errors of scale increase.

9) BATHY BATHYMETRY Numeric (4)

The charted water depth corresponding to the position of that record, to the nearest meter. Note that this is derived from corrected Hydrographic charts, and therefore may differ from ECHOBASE or SCOURBASE values for that same fix. There are duplicate records in NAVBASE which contain bathymetry values which differ by 1m (eg. 39m and 40m), which are used to delimit bathymetry contour crossover points.

10) AREA PHYSIOGRAPHIC AREA Character (3)

Physiographic area in the Beaufort Sea as defined by O'Connor (1982). Codes for the different areas are as follows:

AK - Akpak Plateau
BA - Baillie Plain
IK - Ikit Trough
KR - Kringalik Plateau
KU - Kugmallit Channel
MA - Mackenzie Trough
NI - Niglik Channels
TI - Tingmiark Plain
YU - Yukon Shelf

When a survey line crosses a border of one of these areas, duplicate records are placed in NAVBASE. These can be identified by the comment ' AREA BORDER' in the COMMENT field.

11) ORIGIN ORIGIN OF DATA Character (3)

Original source of the navigation data corresponding to each record in the data file. Codes for the different origins are as follows:

NT - Navigation tape.
TP - UTM positions derived manually from trackplot.
DC - Fix and UTM position digitized from trackplot.
E - Fix and UTM position taken directly from ECHOBASE.
S - Fix and UTM position taken directly from SCOURBASE.
XS - UTM positions extrapolated from SCOURBASE records.
XE - UTM positions extrapolated from ECHOBASE records.
I - UTM positions extrapolated from existing records in NAVBASE.

12) COMMENT COMMENT Character (20)

Comments pertinent to NAVBASE. Commonly used comments are:

xx RECORDS USED - This indicates that the position of that record was extrapolated from ECHOBASE or SCOURBASE, with the number of records used to form a least-squares line for the extrapolation (see section on Extrapolation/Interpolation).

AREA BORDER - This comment indicates the position of the survey line where it crosses an area border.

BEAUFORT SEA
MACKENZIE BAY
KUGMALLIT BAY
TUKTOYAKTUK
TUKTOYAKTUK PENINSULA
RUSSEL INLET
LIVERPOOL BAY
WOOD BAY
HARROWBY BAY
LEGEND
NAHE 87 1 SURVEY LINE IDENTIFIER
1700 NAVIGATION FIX MARK
20 BATHYMETRIC CONTOURS IN METRES
BOTH ECHO SOUNDER AND SIDE SCAN DATA COLLECTED
SIDE SCAN DATA ONLY
ECHO SOUNDER DATA ONLY
NO DATA COLLECTED
0 5 10 15 20 25 30 KILOMETRES
BASE MAP COMPILED FROM 1:250,000 CANADIAN HYDROGRAPHIC SERVICE NATURAL RESOURCE MAP SERIES 22994, 22998, 23092, 23096, 23190, 26504 26508, 26502, 26606, 26700.
NOTE : All tracklines and scour data are referenced to UTM coordinates in Zone 8, extended to Zone 9 and 7 between 127°W and 141°W
CDN SEABED RESEARCH LTD. HALIFAX, NOVA SCOTIA (902) 422-2840
FOR ENVIRONMENTAL STUDIES RESEARCH FUNDS
MARINE GEOPHYSICS AND GEOLOGY
SURVEY LINE LOCATIONS
MAP 1 OF 2
SCALE : 1:500,000
PROJECTION : UTM Zone 8
DRN. BY : K. H. M.
CHKD. BY : G. G.
DATE : MARCH 30, 1989
CSR PROJECT# : 86-05


BEAUFORT SEA
MACKENZIE BAY
KUGMALLIT BAY
TUKTOYAKTUK PENINSULA
RUSSEL INLET
LIVERPOOL BAY
McKinley Bay
Hutchison Bay
Kittigazuit Bay
Kiklualt Bay
TUKTOYAKTUK
Pullen Island
Hooper Island
Pelly Island
Kendall Island
Hendrickson Island
Campbell Island
Atkinson Pt.
Warren Pt.
Toker Pt.
Tibjak Point
Topkak Point
LEGEND
NAHE 87 1 SURVEY LINE IDENTIFIER
1700 NAVIGATION FIX MARK
NEW SCOUR 882 SCOURS
COMPLETE OVERLAP BETWEEN REPETITIVE LINES
NO OVERLAP BETWEEN REPETITIVE LINES
BATHYMETRIC CONTOURS IN METRES
KILOMETRES
BASE MAP COMPILED FROM 1:250,000 CANADIAN HYDROGRAPHIC SERVICE NATURAL RESOURCE MAP SERIES 22994, 22998, 23092, 23096, 23190, 26504 26508, 26502, 26606, 26700.
NOTE : All tracklines and scour data are referenced to UTM coordinates in Zone 8, extended to Zone 9 and 7 between 127°W and 141°W.
CDN. SEABED RESEARCH LTD.
HALIFAX, NOVA SCOTIA
(902) 422-2840
FOR ENVIRONMENTAL STUDIES RESEARCH FUNDS
MARINE GEOPHYSICS AND GEOLOGY
NEW ICE SCOUR LOCATIONS
MAP 2 OF 2
SCALE : 1:500,000
PROJECTION : UTM Zone 8
DRN. BY : K. H. M.
CHKD. BY : G. G.
DATE : MARCH 21, 1989
CSR PROJECT# : 86-05