Environment Canada

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Spill Technology Newsletter Volume 3 - 1978

Economic and Technical Review Report
EPS 3-EC-79-1

Environmental Impact Control Directorate
March 1979

ENVIRONMENTAL PROTECTION SERVICE REPORT SERIES

Economic and Technical Review Reports relate to state-of-the-art reviews, library surveys, industrial inventories, and their associated recommendations where no experimental work is involved. These reports will either be undertaken by an outside agency or by the staff of the Environmental Protection Service.

Other categories in the EPS series include such groups as Regulations Codes, and Protocols; Policy and Planning; Technology Development; Surveillance; Training Manuals; Briefs and Submissions to Public Inquires; and Environmental Impact and Assessment.

Inquiries pertaining to Environmental Protection Series should be directed to the Environmental Protection Service, Department of the Environment, Ottawa, Ontario, Canada, K1A 1C8.

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SPILL TECHNOLOGY NEWSLETTER
VOLUME 3 - 1978

Environmental Emergency Branch
Environmental Impact Control Directorate
Environmental Protection Service
Ottawa, Ontario

EPS 3-EC-79-1

March 1979

REVIEW NOTICE

This report has been reviewed by the Environmental Impact Control Directorate, Environmental Protection Service, and approved for publication. Approval does not necessarily infer that the content reflects the views and policies of the Environmental Protection Service. Mention of trade names or commercial products does not constitute endorsement for use.

FOREWORD

This publication is a compilation of all the issues of the bimonthly periodical, "Spill Technology Newsletter", for the year 1978. The pages of the Newsletter are numbered in two ways: the cumulative number appears on the outside top corner of the page and the issue number appears on the centre of the page. All articles are indexed on the basis of the cumulative numbering system.

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An informal newsletter published bi-monthly by the Environmental Emergency Branch, Environmental Protection Service, Ottawa, Canada.

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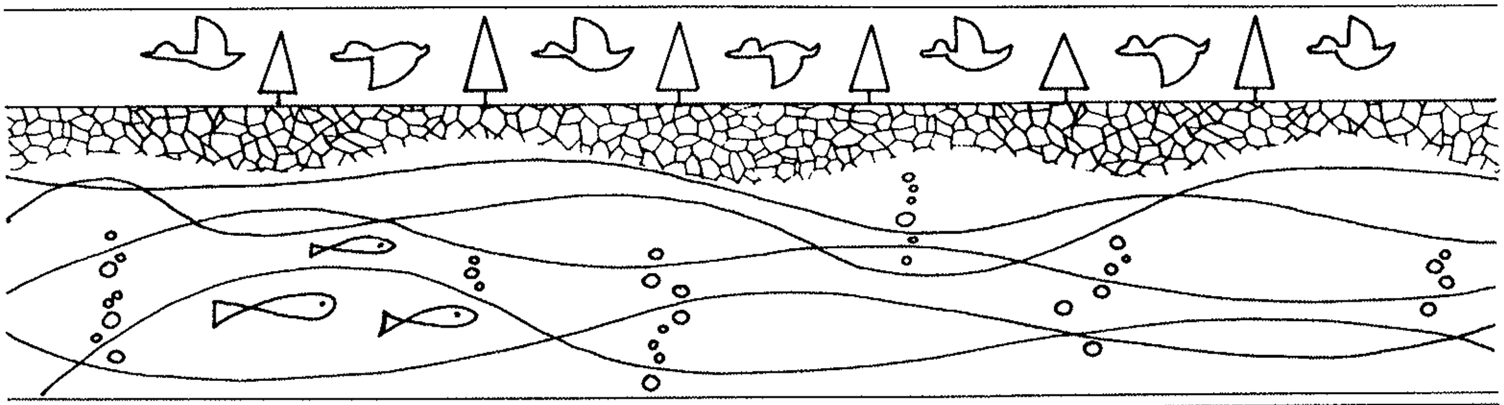

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EDITORS

Dr. S.L. Ross & Mr. M. Fingas

Research and Development Division
Environmental Emergency Branch
Environmental Impact Control Directorate
Environmental Protection Service
Department of Fisheries and The Environment
Ottawa, Ontario
K1A 1C8

Phone: (819) 997-3921

The Spill Technology Newsletter was started with modest intentions in 1976 to provide a forum in Canada for the exchange of information on oil spill countermeasures and other related matters. The interest in it was such that we now have almost 2,000 subscribers in Canada and around the world.

To broaden the scope of this newsletter, and to provide more information on industry and foreign activities in the field of oil spill control and prevention, readers are encouraged to submit articles on their work and views in this area.

INTRODUCTION

In this issue we have a rather interesting mix of articles.

Our first article summarizes the national spill statistics from 1974 to 1976. Although, as indicated, these do not provide a total picture of environmental emergencies in Canada, we have found the data to be very useful in helping us determine the scope of problems in this area, and in developing programs and projects to cope with them.

Dr. Kingham, director of the environmental emergencies program in the government, provides us with an interesting insight into the mysterious (for most of us) world of international conferences and committees. In particular, the deliberations of the recent London conference on Tankers which dealt with the problems of oil spill prevention are discussed and reviewed.

We are pleased to have a short article from Dr. Shawn Gill of the Canadian Coast Guard discussing some of the activities in Canada relating to the development of a capability to deal with oil spills using chemical dispersants.

Two articles from our American friends discuss a new oil spill control training school in Texas, and the severe effects of an oil spill that took place in Maine in 1971.

The problems of potential oil spills in the Labrador Sea, from one Labradorian viewpoint are discussed in a short but hard-hitting article.

And finally, our resident mathematical wizard, Dr. Dave Thornton, describes in some detail the possible behaviour and fate of an underwater oil blowout in waters such as the Labrador Sea.

Good Reading!

REPORTS AND PUBLICATIONS

- The 23rd issue of "Offshore Report", a publication on the exploration and development activities conducted by the oil and gas industry in the Canadian Offshore, is available upon request from:

  Director
  Resource Management and Conservation Branch
  Department of Energy, Mines and Resources
  580 Booth Street
  Ottawa, Ontario
  K1A 0E4

- The Fall issue of Oceanus (Volume 20, Number 4) was dedicated to the subject of oil pollution and included the following articles:

  "The Composition of Oil - A Guide For Readers"
  by Paul R. Ryan.
  "The Biogeochemistry of Oil in The Ocean"
  by John W. Farrington.
  "The West Falmouth Spill - Florida, 1969"
  by Howard L. Sanders.
  "Salt Marsh Grasses and Number 2 Fuel Oil"
  by George R. Hampson and Edwin T. Moul.
  "The Chedabucto Bay Spill - ARROW, 1970"
  by John H. Vandermeulen.
  "ARGO Merchant: A Scientific Communities Response"
  by John D. Milliman.
  "A Genetic Look at Fish Eggs and Oil"
  by A. Crosby Longwell.
  "Fate and Effects of Oil in Marine Animals"
  by John J. Stegeman.
  "The Effects of Oil on Lobsters"
  by Jelle Atema.
  "Tankers in U.S. Waters"
  by Robert J. Stewart.
  "The Cleanup of Oil Spills From Unprotected Waters: Technology and Policy"
  by Jerome Milgram.

- The Environmental Emergency Branch has released five new publications; a list of these appears below with the abstract pertinent to each report. These publications may be obtained, upon request, from the editor(s) of this Newsletter.

Assessment of Rigid Urethane Foams as Liners for Petroleum Product Storage Areas in Northern Canada - (EPS-4-EC-77-13)

In previous studies, spray-in-place rigid urethane foam was identified as having potential, in terms of feasibility of application and relative cost, for use as an impermeable liner in northern tank farms constructed from pervious granular materials. However, little was known about the strength, cold temperature performance and durability of this material. This report summarizes knowledge gathered in a review of pertinent literature and a laboratory assessment of foam samples of several densities and one weathered five-year old sample.

A brief review of existing knowledge about urethane foams did not reveal any deficiencies which would disqualify the material from use as a tank farm liner. The two areas of potential concern identified were flammability and deterioration over time, particularly as related to freeze-thaw breakdown. Technology is available to formulate foams with low flame-spread ratings, but because predictive tests are only just being developed, acceptability with the appropriate authorities has not been established. Mechanical breakdown of cellular structure through moisture absorption and freeze-thaw action appeared to be the major mechanism of foam deterioration in exposed conditions.

Laboratory testing confirmed that the coefficient of thermal contraction was small and that new foam was virtually impermeable (although permeability increases as open cell content increases through aging). Foam is resistant to petroleum products and bases, but subject to attack by acids and organic solvents. Resistance to such attack is greater in foams of greater density. In general, strength values are adequate for use as liners and, with the exception of impact resistance, do not appear to be adversely affected by low temperatures or freeze-thaw cycling. Similarity in water absorption values for samples subjected to freeze-thaw cycling and samples not subjected indicate that, although weathering certainly affects foam quality, freeze-thaw cycling may not be the major mechanism.

The use of higher density foams appears to offer an effective approach of extending service life of urethane foam tank farm liners. However, the potential of this material can only be confirmed through field application.

Selected Bibliography On The Fate And Effects Of Oil Pollution Relevant To The Canadian Marine Environment - (EPS-3-EC-77-23)

A selected and indexed bibliography is presented on the fate and effects of oil pollution in cold waters.

References were selected from the primary and technical scientific literature, both Canadian and otherwise, on the basis of their relevance to the Canadian environment.

The bibliography consists of two sections - an alphabetic listing of all references listed, and a KWIC Index, allowing full and rapid access to the listed references by author, key words, and subject.

A Selected Bibliography On Oil Spill Dispersants - (EPS-3-EC-78-2)

A selected and indexed bibliography on the chemistry, biological effects, use and effectiveness of oil spill dispersants is presented. It contains 364 references, compiled alphabetically and indexed by author and keyword to allow rapid access.

KEYWORDS: Bibliography, Dispersants, Dispersing, Oils, Pollution, Surfactants, Toxicology, Water Pollution.

Field Evaluation Of Oil Spill Recovery Devices: Phase Two - (EPS-4-EC-77-14)

In 1976 the Research and Development Division of the Environmental Emergency Branch of the Department of Fisheries and the Environment directed an evaluation of nine mechanical oil skimmers. Additional testing of one skimmer was conducted in May, 1977. Two of the machines were tested as mobile units, while four were examined in a current and four in a boomed-off area. One device was presented with oil in both a stationary and current situation. The current and mobile-type skimmers were evaluated primarily on the basis of Oil Recovery Factor, the volume of oil recovered by the device versus the volume presented to it, and Oil Content Factor, the percentage of oil in the recovered liquid. The stationary skimmers were evaluated on the basis of Oil Content Factor, and Oil Recovery Rate, the rate at which the device recovers oil. Both constant layer and diminishing thickness tests were conducted in the case of the stationary skimmers. These parameters were measured using diesel, Iranian crude, Canadian Western crude and emulsified oil at varying thicknesses and under differing environmental conditions. Results indicate that, generally, the skimmers tested were effective for the recovery of specific oil types under defined operating conditions. Comments have been included on each skimmer to reflect handling, operation, suggestions for machine improvements, as well as environmental and test conditions.

Pumps For Oil Spill Cleanup - (EPS-4-EC-78-3)

A testing program was conducted by Arctec Canada Limited for the Environmental Protection Service whereby various commercially available pump designs were evaluated with respect to the requirements for general-purpose transfer pumping in oil spill cleanup situations. In addition to making comments about the specific units tested, effort was devoted towards the development of criteria for pumps to be utilized for this application. These criteria and the test observations led to generalizations about classes of pump designs in relation to oil spill operations.

The key performance criteria were determined to be:

- developing suction lift and self-priming with high viscosity fluids;
- debris tolerance;
- low shear of the pumped fluid;
- ease of handling and repair; and
- reliability at below-freezing temperatures.

Eleven pumps were tested representing a range of hydrodynamic and positive displacement designs. Results indicate that a solids-tolerant positive displacement pump has application for spill cleanup use, whereas diaphragm designs show much potential for an effective pumping system.

The following reports are available from the U.S. Department of Commerce, National Technical Information Service, Springfield, Virginia, 22161; telephone (703) 321-8543. Most reports are also available on Microfiche at $2.25 (U.S.) each. Canadian buyers add $2.50 to each paper copy and $1.50 for each microfiche report.

"Background Information On National And Regional Hydrocarbon Emissions From Marine Terminal Transfer Operations". C.E. Burklin, W.C. Micheletti and J.S. Sherman. Radian Corp., Austin, Texas. August, 1977. 127 p. PB-275 484/4SL. $6.00

"The Flux Of Light Hydrocarbons Into The Gulf Of Mexico Via Run Off". J.M. Brooks. Texas A & M University, College Station. 1977. 21 p. PB-275 285/5SL. $3.50

"Environmental Assessment Of The Alaskan Continental Shelf. Northeast Gulf Of Alaska. Annual Reports Summary For The Year". NOAA, Boulder, Colorado. May, 1977. 300 p. PB-275 212/9SL. $9.25

"Petroleum Hydrocarbons In The Northern Puget Sound Area. A Pilot Design Study". W.D. MacLeod, J.R. Brown et al. NOAA, Boulder, Colorado. September, 1977. 64 p. PB-274 591/7SL. $4.50

"An Efficient Computational Alternative To 'Using Linear Programming To Design Oil Pollution Detection Schedules'". L.E. Daniel, S. Hart and T.J. Hodgson. Department of Industrial and Systems Engineering, Gainsville, Florida. October, 1977. 16 p. AD-A047 028/6SL. $3.50

"OPC-3000 Coalescing Plate Oil/Water Separator Evaluation". J. Mittleman. Naval Coastal Systems Lab., Panama City, Florida. November, 1977. 62 p. AD-A046 123/6SL. $4.50

"Methods of Identifying Source of Petroleum Found In The Marine Environment. Report 11". M.E. Scolnick, M.E. Scott and M. Anbar. Stanford Research Inst., Menlo Park, California. November, 1976. 94 p. AD-A046 256/4SL. $11.00

"Oil Water Separators (A Bibliography With Abstracts)". M.F. Smith. NTIS, Springfield, Virginia. November, 1977. 145 p. NTIS/PS-77/1004/9SL. $25.00.

"Ocean Law (A Bibliography With Abstracts)". R.J. Brown, NTIS, Springfield, Virginia. November, 1977. 315 P. NTIS/PS-77/0948/8SL. $25.00

"The Impact Of Oil And Gas Exploration Development On The Outer Continental Shelf Of Louisiana". S. Farber and D.B. Johnson. Louisiana State Planning Office, Baton Rouge. July, 1976. 159 p. PB-273 159/4SL. $6.75

"Oil Pollution Detection And Sensing. Volume 2. 1976 - November 1977 (A Bibliography With Abstracts)". M.F. Smith. NTIS, Springfield, Virginia. November, 1977. 107 p. NTIS/PS-77/0934/8SL. $25.00.

"Tanker Pollution Abatement Report; A Study Of Tanker Construction, Design, Equipment and Operating Features Related To ....". Maritime Administration, Washington, D.C. July, 1977. 17 p. PB-273 867/2SL. $3.50

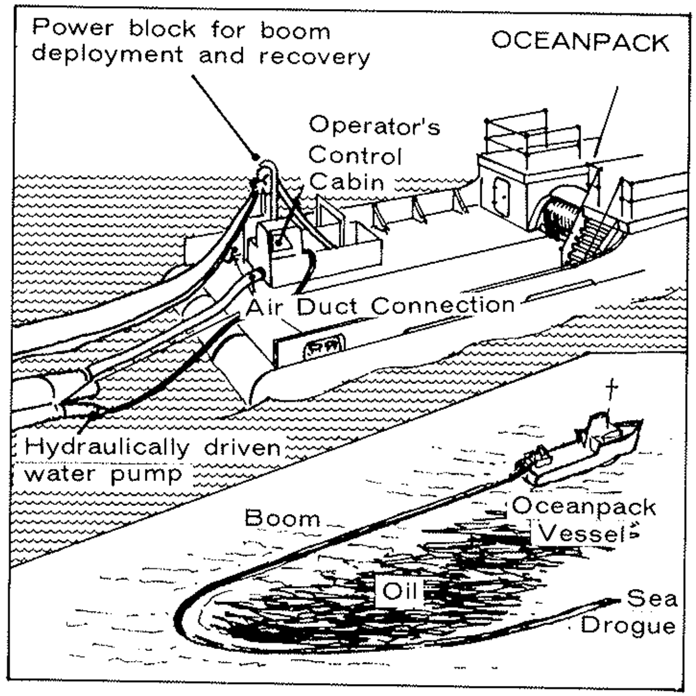
"Tanker Pollution Abatement Report: A Study Of Tanker Construction, Design, Equipment And Operating Features Related To ....". Maritime Administration, Washington, D.C. July, 1977. 273 p. PB-273 868/0SL. $9.50

"Railroad Accident Report - Derailment Of A Burlington Northern Freight Train At Belt, Montana, November 26, 1976". National Transportation Safety Board, Washington, D.C. September, 1977. 21 p. PB-273 915/9SL. $3.50

"The CANOL Pipeline Project. A Historical Review". H. Veda, D.E. Garfield and F.D. Haynes. CRREL, Hanover, New Hampshire. October, 1977. 37 p. AD-A-46 707/6SL. $4.00

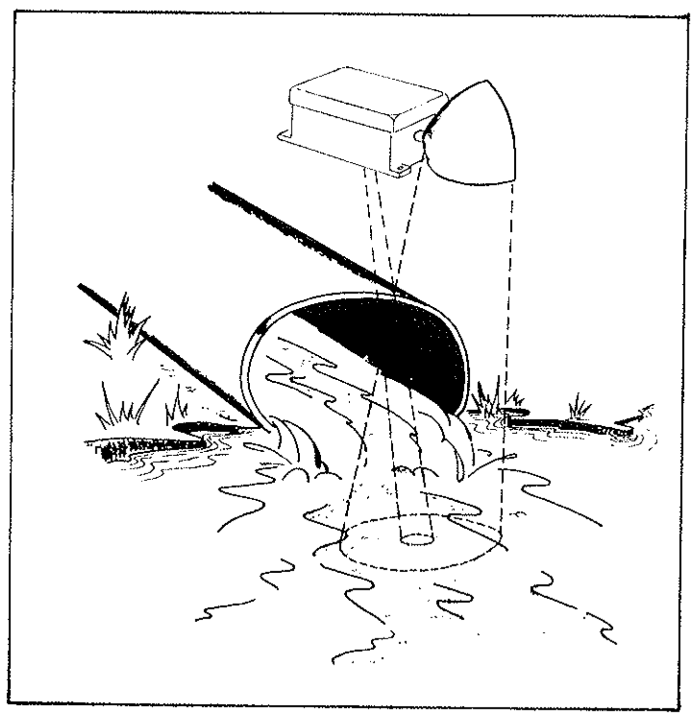
NEW PRODUCTS

Vikoma International Limited has announced the development of the Vikoma Oceanpack, a boom system similar to the Seapack but for the more rigorous condition in offshore areas. The system includes a vessel which will provide 500 metres of inflatable boom for rapid deployment. The Canadian distributor of this product is Marine Equipment Limited, Barrington Commercial Centre, 3695 Barrington Street, Halifax, Nova Scotia, B3K 2Y3, Phone: (902) 429-3240.

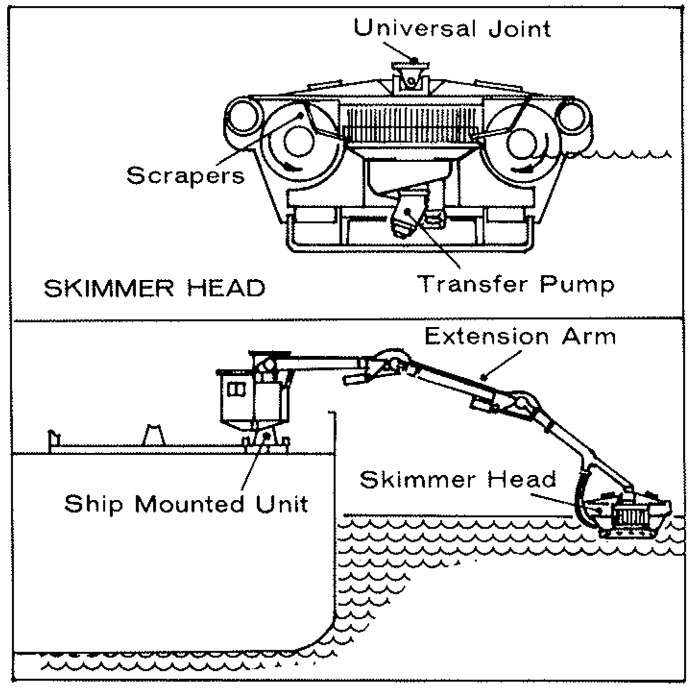


VIKOMA Oceanpack

Wright & Wright, Inc. (P.O. Box A, Oak Bluffs, Mass. 02557 - phone (617) 693-2608) manufactures a series of infrared detectors which are mounted over cooling water streams, holding ponds, storm drains, sewers, tanker berths, etc., to provide early warning of spilling oil. Instruments employ a transmitter and receiver with optional remote readout accessories including permanent chart records. Explosion-proof and economy models (illustrated) are available, as well as evaluation rental options.



● Frank Mohn Ltd. (P.O. Box 98-N5051 Nesttun, Bergen, Norway, Phone: (05) 100600) is now commercially producing the Framo ACW-400 skimmer. The skimmer operates on the principle of oleophilic discs.



FRAMO ACW—400

BRIEF NOTES

The newly-formed "Eastern Arctic Winter School", sponsored by the University of Alberta, is scheduled for March 27 - April 4, 1978 at Igloolik, N.W.T.

Aimed at reducing cultural shock and developing awareness of how personally-made decisions can create environmental, political and sociological impacts on the North, this course shall better acquaint present or prospective Northern workers with "the North in the wintertime". Lectures will be held on such topics as the Northern climate, engineering problems encountered as a result of climatic conditions, government structures in the North and the history of native peoples. Field excursions have been organized to provide participants with a first-hand look at community life and contact with Northern residents.

The enrollment fee for the "Eastern Arctic Winter School" is $1,350, which includes transportation from Montreal, Quebec to Igloolik, N.W.T. and return, plus meals and accommodation. Winter paraphenalia is not supplied. Registrations should be sent by March 10, 1978 to Anne Prideaux or the Faculty of Extension at:

The University of Alberta
82 - 112th Street
Edmonton, Alberta
P6G 2G4

Telephone: (403) 432-5061

The University of Alberta has and continues to sponsor similar-type courses to introduce "the North in the summertime". The "Arctic Summer School" is scheduled for June 26 - July 10, 1978. After a brief start at Edmonton, the course moves on to Hay River, Yellowknife, Inuvik, returning to Edmonton. The registration fee is $1,725. The "Yukon Summer School" will be held in Whitehorse and Dawson, the departure point being Edmonton as well. Course dates have been set for August 21-29, 1978, and the cost is $950 (subject to change). Advance registrations or information requests can be directed to the University of Alberta.

UPCOMING CONFERENCES

JOINT MMT/END WORKSHOP ON MANAGEMENT AND CONTROL OF OIL BLOWOUTS IN THE NORTH SEA AND ENVIRONMENTAL STANDARD SETTING.

Objectives

The objectives of this joint workshop include the following:

(1) Discuss the disaster organisation and management for oil blowouts associated with offshore production platforms in the North Sea by generating data for determining the critical decision points, the risk assessment, and the overall impact in the attempt to prevent, control, and manage oil blowout disasters.

(2) Review and discuss the methodological and applied research on standard setting in the IIASA Energy Program with special consideration of chronic and accidental oil pollution standards.

(3) Provide suggestions for future research on disaster management and regulatory decision making for both IIASA and the NMOs.

Process

The joint workshop would be highly structured as to those invited to give papers, the methodology employed and the discussion generated. The joint workshop will not attempt to actually solve conflicts over environmental decision making, but rather attempt to clarify the parameters of the problem so that all concerned are aware of the organisation and management problem.

The oil blowout part of the workshop will discuss four major topics: prevention, control, clean-up, and environmental impacts. Papers will be presented covering both physical (engineering, equipment) and human (organisation, management) aspects; however, stress will be placed on the human factor. The first paper will be from an operator (UK or Norwegian oil subsidiary), the second from a regulator (UK or Norway), and the third an outlined paper by an IIASA staff member. The papers will be attempt to answer the following points:

- problem description and current solutions,
- current advantages, disadvantages, and conflicts in the solutions employed,
- possible alternative solutions to the problem,
- changes necessary to employ alternatives,
- changes necessary under more adverse events.

The standard setting part of the workshop will consist of methodological papers and case studies presented by IIASA staff members. These papers will be discussed by experts from the NMOs and an attempt will be made to assess the usefulness of methodological approaches to improve regulatory decision making.

Format

The workshop will be divided into two distinct parts:

(1) Oil blowout management and control, April 26-28, 1978;
(2) Standard setting, May 2-3, 1978.

Participants in the oil blowout part would not all be essential to the standard setting part. However, they are encouraged to stay over for this important problem.

First Part: Oil Blowouts, Wednesday, April 26 - Friday, April 28

Wednesday morning: Introduction

1. Purpose of the workshop,
2. Outlined of the workshop, framework of study,
3. What the regulator needs to know prior to a blowout and strategies for obtaining it,
4. What the regulator needs to know during a blowout and strategies for obtaining it.

Wednesday afternoon: Prevention

1. How the operator plans for prevention of blowouts,
2. How the regulator plans for prevention of blowouts,
3. Risk analysis of the prevention phase,
4. Discussion and data collection.

Thursday morning: Control

1. How the operator copes with control of blowouts,
2. How the regulator copes with the operator and control of blowouts,
3. Alternatives, other events, and decision points,
4. Discussion and data collection.

Thursday afternoon: Clean-up

1. How the operator plans and copes with clean-up,
2. How the regulator plans and copes with clean-up,
3. Alternatives, other events, and decision points,
4. Discussion and data collection.

Friday morning: Environmental effects

1. What are international dimensions?
2. What is an adequate systems view?
3. What models are use,
4. Future research directions and role of IIASA and NMOs.

Second Part: Standards, Tuesday, May 2 - Wednesday, May 3

Tuesday morning: Methodologies

1. Introduction,
2. Formal approaches to standard setting: Decision and game theory,
3. Institutional approaches to standard setting: Policy analysis,
4. Invited discussion paper.

Tuesday afternoon: Case studies (oil)

1. Setting emission standards for chronic oil discharges in the North Sea,
2. Setting safety standards to prevent blowout risks from North Sea production platforms,
3. Invited discussion paper.

Wednesday morning: Case studies (CO_2, noise)

1. CO_2 standards,
2. Noise standards for Shinkansen trains in Japan,
3. Invited discussion paper.

Wednesday afternoon: Future directions

1. Formal vs. institutional approaches to standard setting,
2. How to deal with uncertainties and risks,
3. Conflict resolution procedures in standard setting.

Invitees

NMOs are encouraged to suggest participants for attending both parts of the workshop. Should any NMO organisation or professional analyst wish to present a paper along the lines indicated in the above topics, please contact the following:

(1) Oil blowouts: D.W. Fischer -
(2) Standard setting: D.V. Winterfeldt.

For further information contact:

International Institute for Applied Systems Analysis
A-2361 Laxenburg
Schloss Laxenburg, Austria.

Tel: 02236-7521
Telex: 079137

The U.S. Environmental Protection Agency, U.S. Coast Guard, and the Hazardous Materials Control Research Institute, announce the FOURTH NATIONAL CONFERENCE AND EXHIBITION ON CONTROL OF HAZARDOUS MATERIAL SPILLS, April 10-14, 1978, in the Beauville Hotel, Miami Beach, Florida.

Highlights of this conference include:

More Than 80 Technical Papers
Hazardous Substances Spills Regulations Workshop
Five Concurrent Spill Simulation Exercise Workshops
ASTM Organizational Meeting on Hazardous Material Incidents
Comprehensive Exhibition
Film Festival

The technical sessions (Tues.-Thurs., April 11-13, 1978) will explore all the aspects involve in detecting, identifying, responding to and controlling hazardous material spills. The papers will be presented by the foremost experts in the field, representing government, private industry, and the technical, academic and scientific communities.

Complementing these presentations, there will be a special workshop (Thurs., April 13, 1978) introducing the conference attendees to the latest developments and requirements by EPA in the implementation of the new Hazardous Substances Spill Regulations.

And once again, the National Conference and Exhibition on Control of Hazardous Material Spills will spotlight an all encompassing exhibition, featuring advances in technology, equipment and services in the highly specialized and relatively new toxic and hazardous materials response field.

Another unique aspect of the conference is the five concurrent Spill Simulation Exercises (Mon., April 10, 1978). Each workshop is limited to a maximum of 15 participants and is designed to allow each person to react and interact under simulated circumstances that occur during any actual spill. Due to the tremendous response to an earlier mailing for workshop participants, it appears that only 20 more openings are available.

Additionally, a special meeting will take place the day after the conference (Fri. April 14, 1978) to organize a new ASTM standards writing activity dealing with hazardous material incidents.

Film Festival

A continuous film festival to highlight clean up procedures, equipment and methods employed in responding to hazardous material spills will be another feature of the Fourth National Conference and Exhibition on Control of Hazardous Material Spills.

All those who wish to submit a Super 8 or 16mm film, must forward the material to the "Film Festival" Program Committee by March 1, 1978. Direct all material and correspondence to Ira Wilder, Industrial Environmental Research Laboratory, U.S. EPA, Edison, New Jersey 08817.

Accepted films will be returned after the conference unless otherwise indicated. Films not accepted will be returned promptly.

ASTM Organizational Meeting

A new ASTM standards writing activity dealing with Hazardous Material Incidents will be organized on Friday, April 14, 1978 (the day following the Fourth National Conference on Control of Hazardous Material Spills), at the Deauville Hotel, Miami Beach, Florida. The new activity will be launched as a proposed subcommittee of ASTM Committee F20, Spill Control Systems. The proposed scope of the activity developed during a meeting at ASTM on November 22, 1977, is as follows: "The development of standard equipment specifications, methods of test, practices, definitions, guidelines, and documentation for the control of hazardous material incidents". Everyone interested in the work of this activity is invited to attend. For information, contact Robert D. Bauer, ASTM, 1916 Race Street, Philadelphia, PA 19103. Telephone: (215) 299-5481.

REGISTRATION FEES

		Luncheon
Full Conference (HMCRI members)	$85.00	Included
Full Conference (non-members)	$95.00	Included
One-Day Attendance	$50.00	$9.00

Registration for the full conference includes a copy of the Proceedings.

PREREGISTRATION

Attendance at this conference will be limited. Consequently, to insure participation, we strongly urge you to preregister at this time. A Registration Payment in full or a purchase order should accompany your registration form. Please make the check or purchase order payable to Information Transfer Inc. Your preregistration will be confirmed.

EXHIBITION

A comprehensive show consisting of approximately 50 exhibitors will feature the latest advances in both equipment and services. All registrants of the Conference will automatically be issued a pass to the Exhibit.

The hours are as follows:

Tuesday, April 11.............10:00 AM - 7:00 PM
Wednesday, April 12..........10:00 AM - 7:00 PM
Thursday, April 13...........10:00 AM - 4:00 PM

CANCELLATIONS & REFUNDS

Cancellations of preregistrations must be received prior to April 1, 1978 for full refund of registration fee. A $25.00 charge will be made for late cancellations after April 1. An additional charge of $25.00 will be made for cancellations after April 10, 1978.

ALL ATTENDEES MUST REGISTER

Those not preregistered must fill out registration forms at the Conference Registration Desk during the following hours:

Monday, April 10 (Spills Workshop only)..7:30 AM - 8:30 AM
Monday, April 10........................6:30 PM - 9:00 PM
Tuesday, April 11.......................7:30 AM - 6:00 PM
Wednesday, April 12.....................7:30 AM - 6:00 PM
Thursday, April 13......................7:30 AM - 10:00 AM

HOTEL RESERVATIONS

Persons desiring hotel accommodations should complete a Hotel Reservation Form. When reservations are made by means other than the form, please make sure you designate that you are attending the National Conference and Exhibition on Control of Hazardous Material Spills in order that you avail yourself of the special conference rates.

PROCEEDINGS

The papers presented at the Conference will be published in a Proceedings.

FOR ADDITIONAL INFORMATION

Write or call:

Spills Conference Coordinator
Information Transfer Inc.
Suite 202, 1160 Rockville Pike
Rockville, Maryland 20852

Telephone: (301) 279-7969.

- THE SIXTH CONFERENCE ON THE PREVENTION, BEHAVIOR, CONTROL, AND CLEANUP OF OIL POLLUTION WILL BE HELD ON MARCH 19-22, 1979 AT THE BONAVENTURE HOTEL, LOS ANGELES, CALIFORNIA. More than 1,500 persons from a score of countries and ninety exhibitors attended the Fifth Conference in New Orleans during March, 1977.

TECHNICAL, SCIENTIFIC, AND SOCIO-ECONOMIC-LEGAL PAPERS FOR PRESENTATION AT THE 1979 CONFERENCE ARE INVITED - Abstracts of 200 to 250 words should be submitted in English by June 10, 1978. The ninety papers to be presented to and published by the Conference will be selected from these submitted abstracts. Information being reported on must not be already described in any other open technical or scientific publication. Authors will be notified of paper selection on or before August 1, 1978; smooth copies of the actual paper will be due on November 1978.

The Conference will stress pollution prevention, development of new techniques for use in inland, coastal, deepwater and Arctic oil spill control operations, and pollution liability and damage assessment. Papers are particularly sought in:

- Clean-Up Operations
- Cooperatives
- Training Techniques
- Monitoring
- New Prevention and Control Techniques
- New Equipment Developments
- Oil Transfer Practices
- Dispersants
- Fate and Effects of Oil
- Natural Resource Damage Assessment
- Socio-Economic-Legal Aspects: National International

The Program Committee is interested in technical and scientific papers rather than in detailed descriptions of the benefits of proprietary products. The format of this latter type of presentation could best be served by showing the products and processes in the Equipment Exhibit which is a major part of the Conference.

Submit Abstracts No Later than June 10, 1978 to:

Dr. Charles C. Bates,
Program Chairman,
c/o U.S. Coast Guard (G-DS/62),
Washington, D.C., 20590

Telephone: (202) 426-1037/1038.

From April 9-15, 1978, the School of the Environment at The Banff Centre will be offering a workshop on Environmental Impact Assessment. Organized with the cooperation of Patrick Duffy of the Federal Environmental Assessment Review Office, Ottawa, the workshop will feature the following topics:

MAJOR PROJECT PLANNING - Cases drawn from the extractive and renewable resources industries and the energy sector.

ASSESSMENT METHODS AND THEIR LIMITS - The economic, legal and knowledge limits of environmental planning.

PUBLIC INFORMATION AND PARTICIPATION - Disclosure of project plans and preparation for public review.

In addition to Patrick Duffy, the workshop will be conducted by top-flight resource people, including Steven H. Janes, Vice-President, Planning and Resource Management, James F. MacLaren Limited of Willowdale, Ontario; John Hnatiuk, Manager of Frontier Environmental Research for Gulf Oil Canada Limited, Calgary, Alberta; Suzanne Veit, socio-economic consultant from Vancouver, B.C.; and Alistair R. Lucas, Professor of Law, University of Calgary.

The workshop will feature a combination of lecture, seminar, casework and field study. It is designed for project managers and administrators of planning, design and management groups in North American industrial and resource development companies, as well as for representatives of government departments at the federal, provincial, state and municipal levels. In addition, consultants, academics and the public are expected to attend.

The workshop fee will be $750, which is all inclusive of single occupancy accommodation, meals, tuition, field trip transportation and teaching materials. Complete details and registration information are available from:

John R. Amatt, Manager
School of the Environment
The Banff Centre
Box 1020
Banff, Alberta TOL OCO

Phone: (403) 762-3391, ext. 310
Telex: 03-826657 ARTS BNF

● The first annual meeting of the Society of Petroleum Industry Biologists, ENERGY/ENVIRONMENT '78 will be held at the Biltmore Hotel, Los Angeles, 22-23 August 1978.

Papers on three general topics are requested from the scientific community.

1. Environmental aspects of energy development (baseline studies, impact assessments, case studies, etc.).
2. Rehabilitation and restoration of damaged ecosystems (mining, etc.).
3. Minimizing the environmental impacts of oil spills (ecological effects of oil spill cleanup, response planning, etc.).

Abstracts of papers must be received by 1 April 1978. However, if you are considering submitting a paper or attending the meeting, please return the form below as soon as possible.

Papers will be published in a Proceedings volume.

Check appropriate box(es).

I would like to receive future mailings about ENERGY/ENVIRONMENT '78.
I will try to attend the meeting.
I would like to present a paper.
Tentative title: ______________________________

Name : ______________________________
Institution : ______________________________
Address : ______________________________
____
Phone : ______________________________

Please return to: Dr. June Lindstedt Siva
Atlantic Richfield Company
515 South Flower Street
Los Angeles, CA. 90071
Phone: (213) 486-0741.

● The Fourth International Biodeterioration Symposium will be held in Berlin, West Germany 28 August - 1st September 1978. The conference is designed to bring together scientists interested in various aspects and problems of biodeterioration and biodegradation of materials. The intention is to provide a forum for the presentation and discussion of new theoretical and applied information on these disciplines and their technology including research, development, applied engineering and economics. Included on the program topics are: fuels and lubricants, biodegradation including hydrocarbon spillages and biocides and industrial effluents. Registration will be £60 until 1st May, 1978 and may be paid in advance to:

International Biodeterioration Society
c/o Dr. K.J. Seal
University of Aston in Birmingham,
80 Coleshill Street
Birmingham B4 7PF England.

CANADIAN ENVIRONMENTAL EMERGENCIES EVENT SUMMARIES FOR 1974, 1975 AND 1976

Submitted by: R.A. Beach, Manager
K.M. Meikle, Deputy Manager
National Environmental Emergency Centre
Environmental Protection Services
Ottawa, Ontario.
K1A 1C8

Phone: (819) 997-3742

Oil and other hazardous material spills in Canada were summarized for 1974 and 1975 in the May-June 1976 edition of the Newsletter. The summaries were compiled from the information then available from NATES, the National Analysis of Trends in Emergencies System.

NATES is a computerized data system developed to enable Environment Canada and other participating government agencies to store and analyse information on oil spills and other environmental emergencies.

In the interim, NATES has been extensively revised to simplify data entry and to accommodate additional information on emergency events; the process took somewhat longer than was originally expected and it was November 1977 before the system was once again fully operational and all currently available 1976 data had been entered.

The revised NATES permits a more detailed breakdown of the non-transportation events previously lumped together as "Other Sources". A second major change was the conversion of all amounts to metric tons, thereby eliminating the previous mixture of pints, barrels, pounds, grams, cubic feet, etc. The summary format has been modified to take advantage of these changes and we have therefore provided new tables for 1974 and 1975 to facilitate comparison with the 1976 data.

We have also incorporated the pipeline and production field event information for 1975 and 1976 provided through the excellent cooperation of the Alberta Energy Resource Conservation Board (ERCB). As a result, the total number of events on record for 1975 is now 1,484 instead of 916 as previously reported. On the other hand, the total for 1974 has been reduced from 934 to 891; a number of duplications were exposed and deleted in the process of converting our records to the revised NATES field structure.

As explained in our earlier article, NATES does not tell the full story. The extent to which spill information is obtained and relayed is governed by local reporting regulations and by federal/provincial or interdepartmental bilateral agreements. These are not uniform for all of Canada and are subject to change; for example, Ontario Ministry of the Environment data is included in the 1974 and 1975 summaries but is not available for 1976 and 1977.

When comparing the summaries for the three years, the following factors must also be taken into account:

a. In 1974 a special one-year project was undertaken to collect data on oil slicks on the St-Lawrence River in the Montreal area; the result is reflected in the significantly larger number of "Other Watercraft" and "Other Sources" events for that year.

b. Alberta ERCB production field data (entered as "Mines and Wells") was not retroactive to 1974.

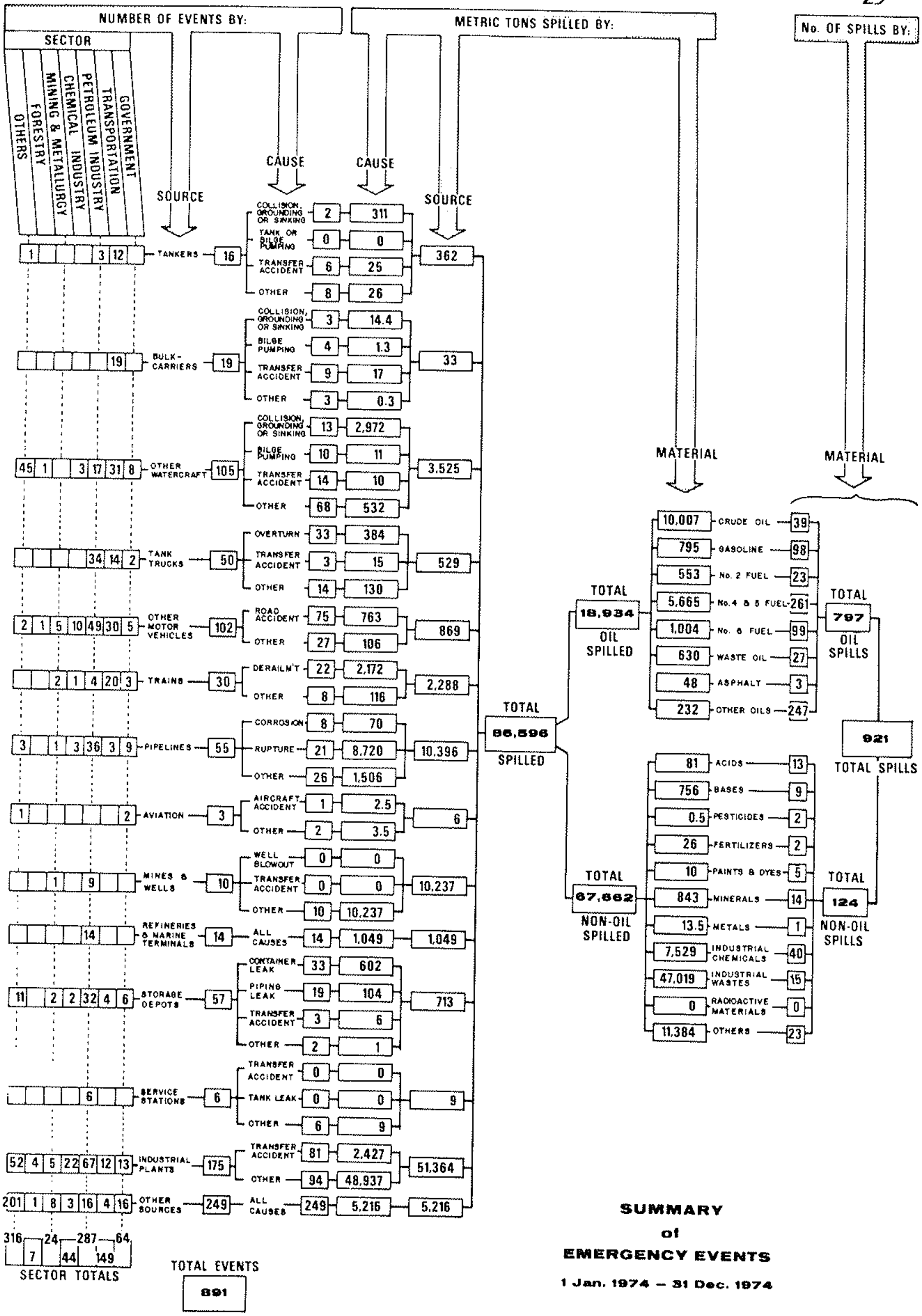
c. 1976 data was entered directly, whereas the data for 1974 and 1975 had to be converted from the less specific information already computerized. It is probable that numerous events recorded as "Other Motor Vehicles" in 1974 and 1975 were actually tank truck accidents but resources do not permit the detailed research of the original source data to verify that assumption.

d. The number of spills differs from the number of events because more than one material may be spilled in a single event (a train derailment, for example) or, as may be the case in a ship grounding, an environmental emergency can occur without any spillage.

Human error and equipment failure have accounted for over 40% of the environmental emergencies; the following table gives the percentage breakdown for the most common reasons on record:

Year	Number of Events	Human Error	Equipment Failure	Material Failure	Other Reasons
1974	891	26.5	6.3	6.5	60.7
1975	1,484	21.8	22.2	13.0	43.0
1976	1,070	21.9	23.2	23.3	31.6
Overall	3,445	23.0	18.4	14.5	44.1

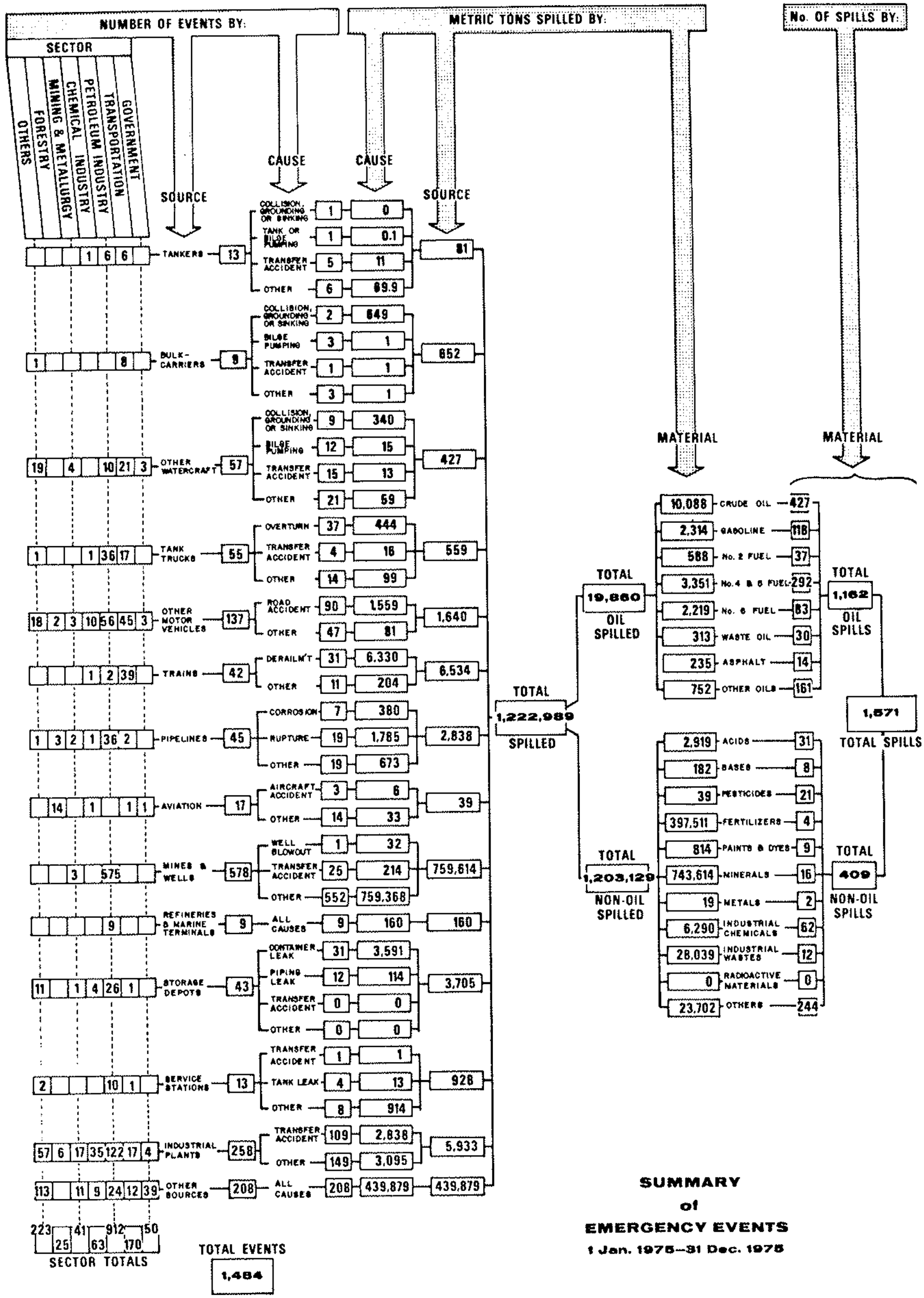
A sincere "Thank You" is extended to all those who have contributed by reporting oil spills and other environmental emergencies. The data for 1977 should be available for analysis within the next few weeks and will be tabulated for publication in a subsequent edition of the Newsletter.



SUMMARY
of
EMERGENCY EVENTS

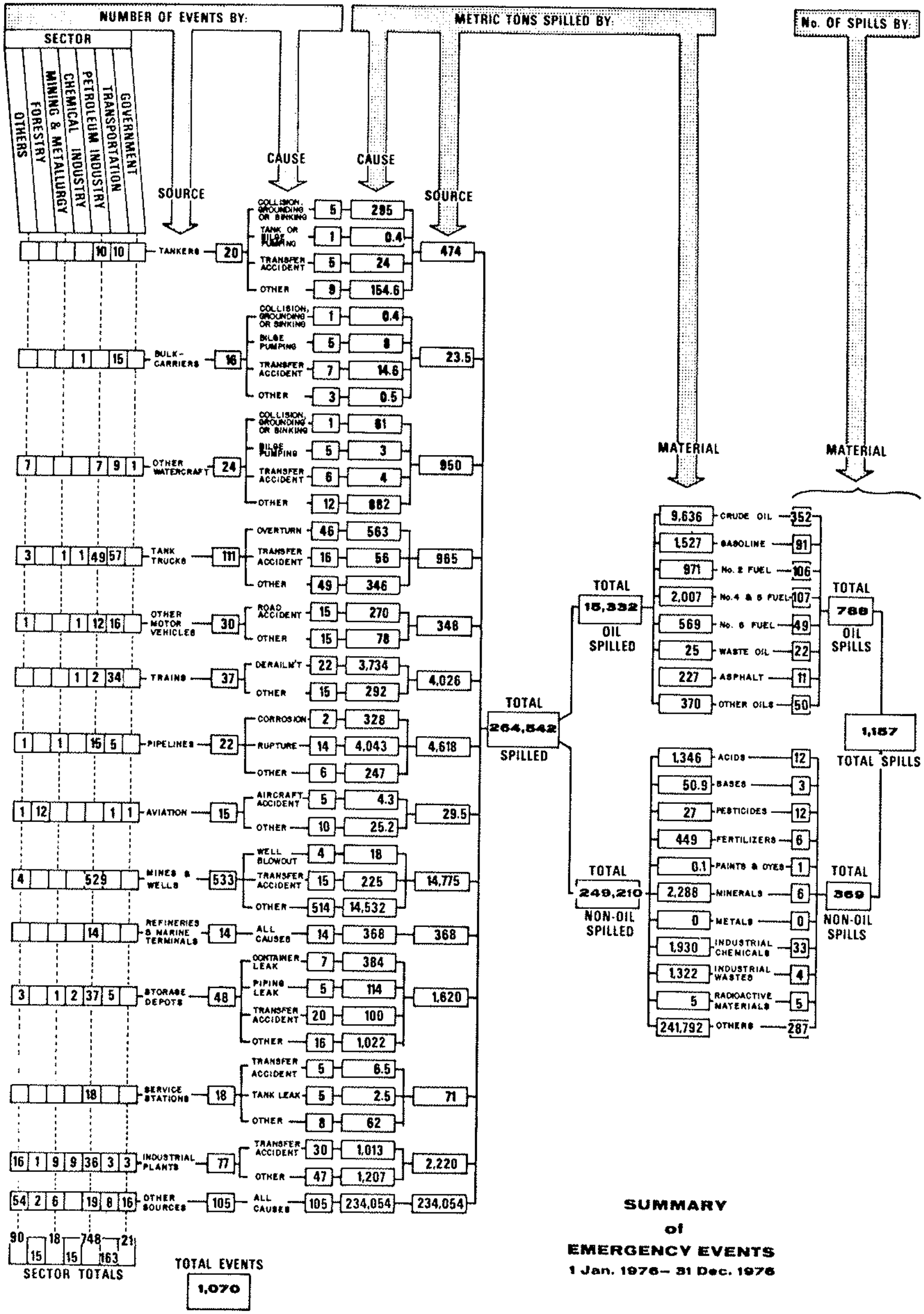
1 Jan. 1974 – 31 Dec. 1974

DFE/EPS/EICD/EEB 17 November 1977



SUMMARY
of
EMERGENCY EVENTS
1 Jan. 1975–31 Dec. 1975

DFE/EPS/EICD/EEB 17 November 1977



SUMMARY

of

EMERGENCY EVENTS

1 Jan. 1976– 31 Dec. 1976

DFE/EPS/EICD/EEB 17 November 1977

OIL SPILL CONTROL TRAINING: NATIONAL SPILL CONTROL SCHOOL

Submitted by: George R. Oberholtzer
Corpus Christi State University
Corpus Christi, Texas 78412

The National Spill Control School, a new program of Corpus Christi State University, Corpus Christi, Texas, now offers a course in oil spill control. The School is located in a natural laboratory of a heavily petroleum-oriented harbor which has been called the cleanest port in America. The course covers all aspects of oil spill control with special emphasis on contingency planning. The student receives the latest information, theoretical and practical, on the "state of the art". Hands-on experience in the "state of the art" is provided by the Corpus Christi Area Oil Spill Control Association, a highly successful community cooperative, and one of the principal factors in the cleanliness of the port.

An important feature of the course is the use of guest lecturers to provide authoritative presentations. The "state of the art" presentation is reinforced by discussions with representatives from the regulatory agencies, the EPA and the Coast Guard, and from the spill control industry. Guest lecturers provide instruction on chemical and physical relationships of oil and water, rehabilitation of oiled birds, the biological effects of an oil spill, public relations, and legal matters. Extensive use is made of visual aids prepared especially for the course.

The course is not intended to make instant "experts" but provides the background to recognize good practices and the requisites to initiate comprehensive contingency planning for an oil spill emergency.

For more information on the oil spill control course and class schedules can be obtained by writing:

National Spill Control School
P.O. Box 8263
Corpus Christi, Texas 78412

Phone: (512) 991-8692

OIL SPILL PREVENTION - AN INTERNATIONAL PERSPECTIVE

Submitted by: J.D. Kingham, Director
Environmental Emergency Branch
Fisheries and Environment Canada

To the scientist or technologist, the world of international politics, and the impact of this ethereal domain on the reduction of oil pollution in the marine environment, must seem to move at a discouragingly slow pace. Unquestionably, the international response to real and immediate pollution problems lags many years behind the realization of problems, and the national and industrial development of technology to cope with such problems.

To those of us, including ex-scientists, who have spent a number of years in international fora this discouragingly slow pace is neither unnatural nor inexplicable. When one considers the interests of the parties involved, it is, if anything, surprising that there are achievements to point to in terms of the prevention of oil spills or discharges at sea. For the individual to make decisions on his future course of action takes, in some cases, but a split second. For a Branch or Division, Department or Industry, to agree on a future course of action, may take week or months. For a Government to resolve to deal with manifestly obvious problems sometimes takes years; it is not in the total picture surprising then that the international forum often takes decades. When one draws together a collection of more than a hundred States, some of which are developing, (and far more concerned with national survival than they are with environmental quality), others of which represent massive shipping industries for whom the most modest of alterations involves millions, if not billions, of dollars, and others which have a definite environmental consciousness, to reach agreement on steps that should be taken to protect the marine environment from oil pollution is indeed a remarkable achievement.

Less the uninitiated become disillusioned at the outset that any progress can be achieved, one has but to point to the record. If there were no international control over the oil discharged from operational procedures alone, there would be something of the order of 7 million tons of oil discharged from normal operations associated with the tanker industry. As is shown in Figure 1, the existence of international agreements and projected agreements has had a dramatic effect on oil pollution. Even with the ineffective enforcement and surveillance capability which presently exists at the international level we can see that the discharge is something in the neighbourhood of 1 million tons, which remain because of existing requirements for processing of residual oil left on board tankers when they return to a loading port. A recent proposal which has been partially supported at a conference in London on tanker safety and pollution prevention could reduce that discharge to a quarter of a million tons per year and the ultimate solution proposed at that same conference, which I will deal with later, has the potential to reduce discharge to only 55,000 tons per year.

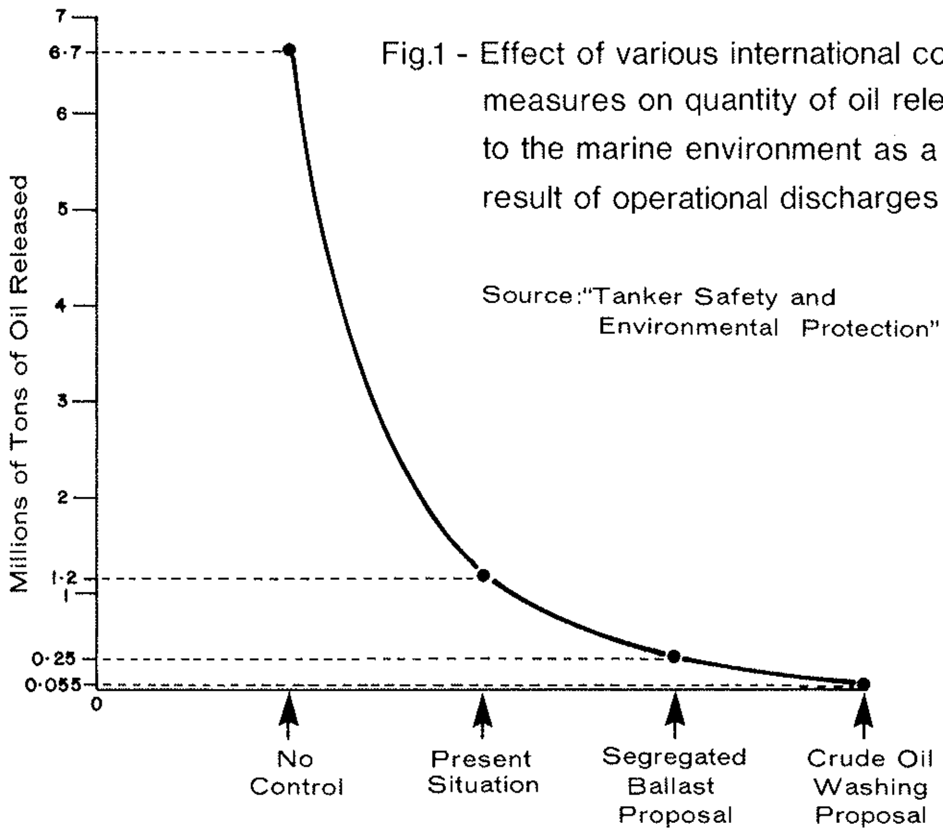


Fig.1 - Effect of various international control measures on quantity of oil released to the marine environment as a result of operational discharges

Source:"Tanker Safety and Environmental Protection" 1978

It is important to remember as well the relative effect of shipping operations on the total introduction of petroleum hydrocarbons into the oceans. This is indicated somewhat by Figure 2, where it is seen that non-shipping operations introduced 65% of the total hydrocarbons in the oceans. This is made up roughly of 41% from land sources, 11% from natural seepage and offshore drilling, 10% from atmospheric fallout, and 3% from refinery effluent. Of the remaining 35%, only 3% arises from accidental pollution; 32% comes from tanker operations.

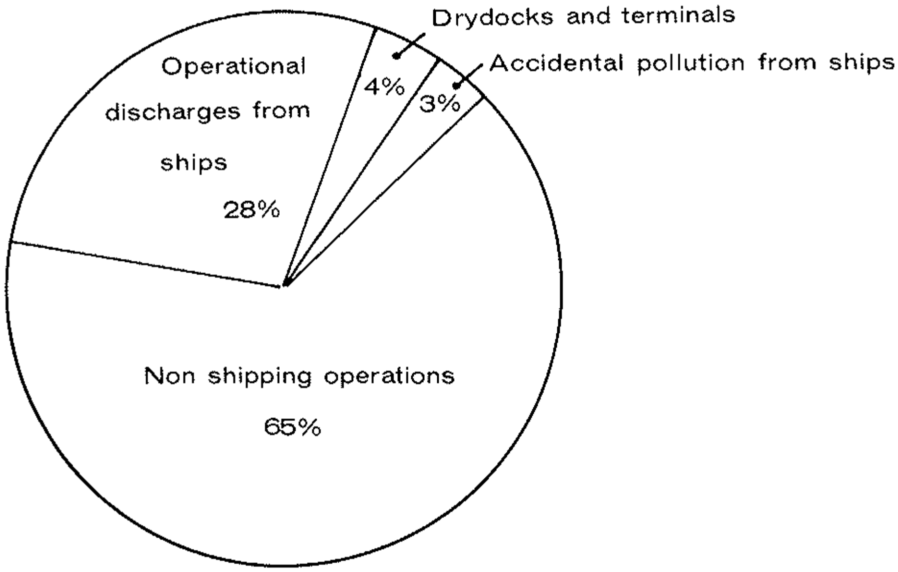


Fig.2 - Relative Contribution of Shipping and other Sources to Marine Oil Pollution

Source "Petroleum in the Marine Environment" 1973

Oil spill technology, in the sense of international measures to reduce pollution from ships, falls into two categories; the reduction of operational pollution and the prevention of accidental pollution. It would be instructive at this point to describe briefly why the operational pollution is so high and then to deal subsequently with the prevention of this pollution. Tankers can be regarded simply as large water-displacing steel shells which, when in an empty condition, are highly susceptible to the vagaries of weather. For this reason tankers do not sail in a completely empty mode. For the cargo voyage, this is of course no problem; the vessel sits low in the water and is extremely stable. But obviously something must be done for the return voyage, and this causes the main pollution problem. Traditionally, tankers have some of their cargo tanks filled with seawater for the return or "ballast" voyage to the loading terminal. Unfilled tanks are routinely cleaned to minimize the build-up of sludge in the bottom of the tanks and clingage to the tank walls. This results in the cleaning of approximately one-quarter of a tanker's cargo tanks on each voyage. The cleaning process is usually followed by a tank-washing procedure in which sea water is sprayed around the tanks under very high pressure so that it scours the tanks' surfaces and bottoms. The resultant wash water, along with whatever dirty ballast water has been loaded into cargo tanks, is then allowed to stand for awhile in order that the mixture of oil and water will separate into three layers: an oil phase, a water phase, and an interphase between the two of emulsified oil in water. The relatively clean bottom water in this mixture is then pumped overboard and the oil and water mixture, plus the oil layer are pumped to a special tank called a slop tank. When all tanks have been cleaned in this fashion and the oily seawater mixture has been stored in the slop tank, this in turn is allowed to settle. Meanwhile, "clean" ballast is placed in the washed tanks in order to maintain the stability of the ship. As the ship approaches the loading terminal, this "clean" ballast is pumped overboard.

In a relatively new development, oil tankers have been required to retain all of the slops on board and to load on top (LOT) a full cargo of oil which is to be completely discharged at the refinery terminal. After the development of this new technology for tankers, it was observed that there were some bad practices in the use of the load-on-top method and, (just like the soap commercials), the industry and the governments concerned came out with a "NEW IMPROVED" load on top. Despite this, there remain some serious non-technical problems associated with LOT techniques. Transferring ballast water from cargo tanks to slop tanks, providing for appropriate settling times, monitoring the different layers of oil, oil emulsion in water and water competently and discharging only clean ballast water is a complex and difficult procedure for a ship at sea. It is also time-consuming and difficult in some instances for the crew to perform. Darkness provides a wonderful opportunity for those operators who are less than fully committed to the environmental movement to solve many problems by "pulling the plug", resulting in the discharge of oily ballast directly to the marine environment. This has created problems for many countries in sensitive areas such as the Mediteranean and along the shorelines of some innocents such as the coastal countries of West Africa.

How does one overcome the serious problem of flagrant violations of international agreements intended to reduce operational pollution? One solution would be to put an international policeman on every ship to make sure that covert discharges do not take place. In the present world, this is clearly impossible, and probably economically inefficient. Another possible solution is to rely on technological developments such as oil content monitoring equipment and oily water separators. This has been tried for years now and found wanting. Finally, one might conceive of a solution which would enable the port authority, during cargo-unloading, to ensure that most of the sludge and clingage is removed from the cargo tanks before the ship loads ballast water for its return voyage.

Yet another apparent solution is to divide the ship into different types of tanks, some of which would carry only cargo, and others which would carry only ballast water for the return voyage. The problem with this latter alternative is that it is not a complete solution because, even though governments would be assured that the ballast water which is ultimately discharged has come from a tank which has never seen oil, they would nevertheless be unable to verify that the routine cleaning of cargo tanks to prevent excessive build-up of sludge and clingage were followed strictly so that the tank washings were discharged to the slop tank an only "clean" wash-water was subsequently discharged to the marine environment.

In trying to deal with the pollution problem, and the coincident problem of excess tanker capacity which resulted from the so-called "energy crisis" of 1973, a proposal was made that all existing tankers should be fitted with segregated ballast tanks. This proposal fit in nicely with an international convention on the subject of marine pollution which was held under the auspices of the Intergovernmental Maritime Consultative Organization (IMCO) of 1973 which required segregated ballast tanks (SBT) on all new tankers over 70,000 deadweight tons. While the proposal would have relieved the pressure on those who had invested heavily in new un-needed tankers by reducing the cargo-carrying capacity of every tanker and thus requiring more tankers to deliver the same quantity of oil, it would not really solve the oil pollution problem to the satisfaction of the environmentalists. It was nevertheless the best solution available to delegates to IMCO's Marine Environment Protection Committee (MEPC) in 1975 and the Canadian delegation supported a suggestion that both new and existing tankers should have segregated ballast tanks to reduce to some extent the amount of oil discharged to the marine environment. In doing so it was recognized that there would be several environmental disadvantages. For one, there would be more oil tankers in the congested waterways of the world to deliver the same tonnage of oil. This would increase the probability of collision and subsequent catastrophic releases of oil. For another, it would be necessary to burn more fuel per ton of oil delivered with the concommitent increase in atmospheric (and subsequently oceanic) pollution and it would accelerate use of a non-renewable resource. But the "energy crisis" produced an unexpected side-effect which will have a dramatic influence on the reduction of operational pollution. Because of the pressure to increase the quantities of oil being shipped and pumped into the refineries ashore, the companies themselves came up with a technological innovation which was so simple that it is only amazing that a crisis was required to stir the imagination of those so close to this problem. Every physical or organic chemist knows that, to remove a sticky substance from a surface, one uses a solvent in which the substance is highly soluble. Thus, it is obvious that seawater is a particular inappropriate medium for washing clingage and sludge out of oil tanks. The answer: instead of washing tankers with seawater at sea, why not recycle the upper fractions of crude oil in a tank through the cargo-washing apparatus as the tank is being emptied, so that it is sprayed under high pressure against the tank walls and bottoms. To no one's surprise, the technique, when tried, proved eminently successful. For a 200,000-ton tanker, approximately 2,000 tons of additional petroleum hydrocarbons could be delivered to the terminal before the ship set out to sea. The cost of installing the necessary pipes and washing machines in the tanks was rapidly repaid by the recovery of the oily material on each voyage.

Unfortunately, by the time this idea came along, the international community seemed to be locked into its previous mistakes. It had already agreed that segregated ballast was "the answer"; it had already written this "answer" into the 1973 Marine Pollution Prevention Convention, and the international community felt committed to this course. A series of serious tanker accidents off the east coast of the U.S. in early 1977 led the new U.S. President, Jimmy Carter, to suggest that bold new initiatives should be undertaken by IMCO to further reduce operational and accidental oil pollution. The advisory panel that was called together to prepare U.S. proposals on this subject concluded that new and existing tankers should be fitted for segregated ballast and a new conference should be called to see that this was done. The conference completed its deliberations in London in February of 1978. The Americans originally appeared at the conference prepared to fight for the principle of segregated ballast retrofit on all tankers. This would have cost between 2 and 6 billion dollars. Many countries that had invested heavily in the construction of new tankers which were sitting idle in various harbours and fjords went along with the American suggestion as a possible solution to get them out of difficult financial times. Meanwhile, having evaluated the various techniques available at this time, the Canadian delegation to the international conference changed from its earlier position. While it had originally supported the retrofit of segregated ballast in 1975, it was convinced that crude oil washing not only offered superior advantages for the reduction of the total amount of oil remaining on board when a ship undertook its ballast voyage, but also offered opportunities for Port State surveillance of the procedure of cleaning out tankers before they made their return voyage. Fortunately then, this option was accepted by the Conference on Tanker Safety and Pollution Prevention (TSPP). The TSPP Conference, in order to provide the maximum flexibility, however, allowed either segregated ballast retrofit or crude oil washing to be employed for existing tankers. In view of its economic advantages it is likely that most operators will choose the crude oil washing technique.

The acceptance of the crude oil washing technique should go a long way to achieving the goal of operational discharges of only approximately 55,000 tons by June 1982, shown in the right-hand side of Figure 1. I mention here the figure 1982 because it is of great significance to note that there has been a dramatic change in international politics concerning the implementation of convention provisions. Traditional practice has been that the provisions of a convention were not to be implemented until after a certain number of States had ratified the convention. It could take years or decades, after the various participants had signed a convention, to ratify it. The new international politics suggest that dates can be written in, after which time States can implement the provisions of a convention, even though that convention itself might not be in force. Thus, any crude oil tanker over 20,000 dwt ordered after June 1979 must be designed with inert gas systems, protective location of segregated ballast tanks and crude oil washing, even though the convention may not be in force. Similarly, tankers for which the keel is laid after January 1980 must comply with these provision, as must those new tankers delivered to operators after June 1982. Perhaps the word "must" is too strong here. It could be argued that the absence of a binding convention, not in force, reduces the obligatory nature of the provisions. It is clear that it would be very foolish, from an economic viewpoint, to not comply with these provisions, since subsequent retrofits, after the convention is in force, would be far more expensive than design provisions made during initial construction. This reference to dates is a major diplomatic innovation. It offers considerable opportunities for accelerating the reduction of future operational oil pollution.

Turning now to the subject of accidental pollution, the first question which springs to mind is: "How serious is this problem in light of modern technology?" Space age technology, after all, can predict, within a fraction of a kilometer, the landing point of a satellite on the moon and can predict to within a few meters, the distance between the moon and the earth. Spy satellites and weather satellites, among others, can provide very fine detail of objects on the earth. International accords on aviation provide for traffic separation and collision avoidance systems for vehicles which are travelling many times the speed of cumbersome oil tankers. But when one looks at the performance of the tanker industry over the past thirteen years, one cannot help but be dismayed. Although the size of the oil tanker fleet has only increased by 41% through this period, the number of tankers lost has increased by 100%. This is obvious from Figure 3.

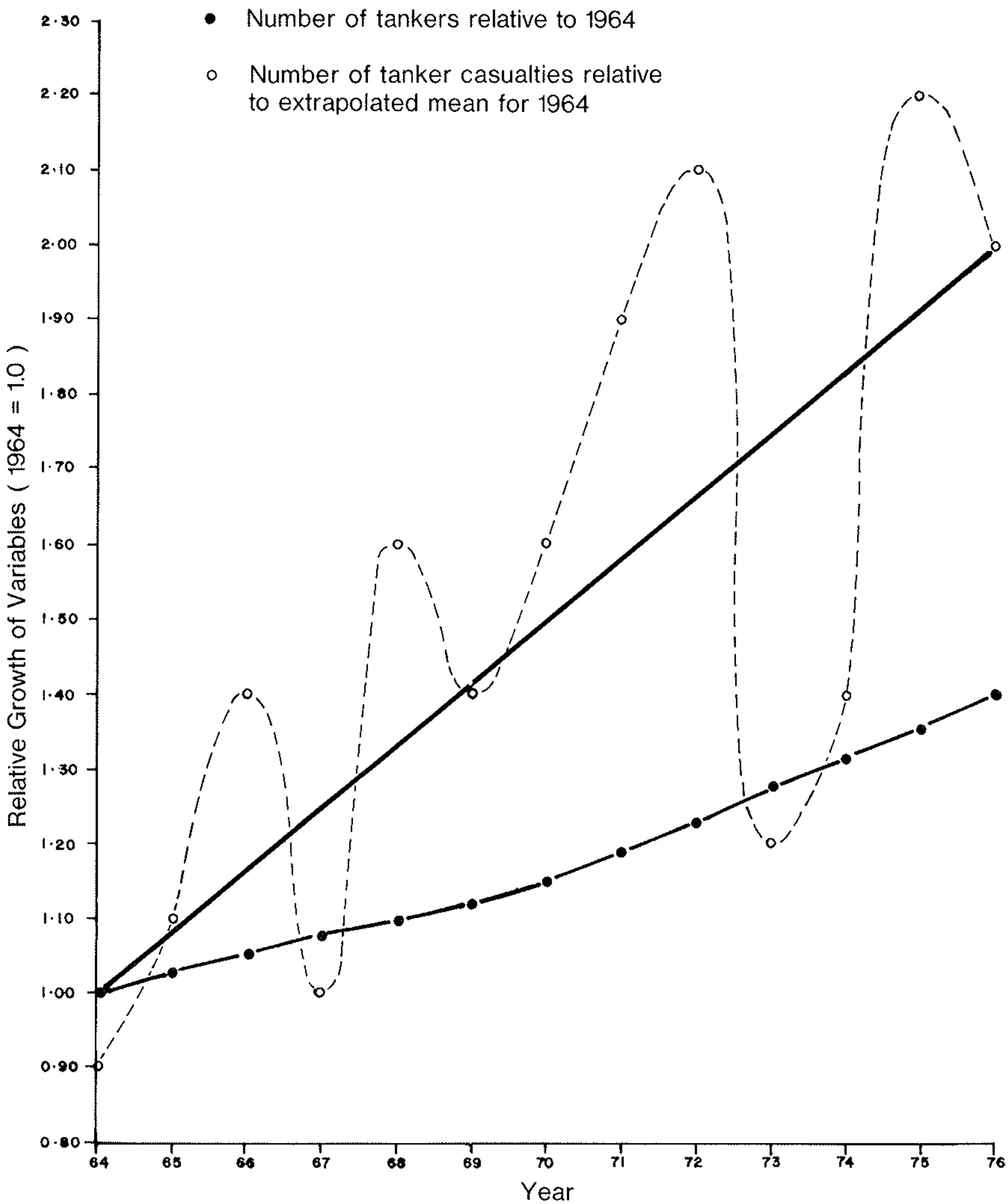


Fig.3 - Relative Tanker Losses and Relative Number of Tankers in Operation

Source: "Tanker Advisory Centre, Summary of Tanker Casualties" 1977

It is not clear why tanker casualties should have increased proportionately much more rapidly than the size of the tanker fleet, but it was to prevent the continuation of this trend (which itself would result in the accidental introduction of something like 3/4 of a million tons of oil in sensitive areas by 1984) that the TSPP conference addressed this problem as well. An analysis of tanker accidents shows that although part of these can be related to defective equipment many of them are related to inadequate inspections, the absence of back-up systems and human error. It was precisely to overcome this deficiency that the TSPP conference focused its attention on these areas. It was agreed at this conference (February 1978) that all tankers over 10,000 dwt should be fitted with back-up radar systems and steering systems as well as alternative and automatic power supplies for the steering and radar systems in the event of the failure of the main systems. In addition, the conference agreed to develop collision avoidance aids for tankers similar to those used for aircraft. These aids would have audible warnings to help wake up sleepy crews which might not be aware of looming disaster. The frequency of inspections for older ships will also be increased.

Only time will tell whether these measures, designed to prevent pollution from either intentional or accidental situations, will bear fruit. I believe that a dramatic step has been taken in favour of the marine environment and the next decade will tell whether these measures have been as effective as those who negotiated them hoped they would be.

DEVELOPING A DISPERSANT SPRAYING CAPABILITY

Submitted by: Dr. S.D. Gill
Marine Emergencies Office
Canadian Coast Guard
Ministry of Transport
7th Floor, Tower A, Place de Ville
Ottawa, Ontario
K1A 0N7

Phone: (613) 996-3852

One of the problems in maintaining a national inventory of marine emergency countermeasures equipment is the constant struggle to upgrade existing holdings as newer hardware becomes available in the marketplace. In the Canadian Coast Guard Emergency (CCGE) organisation, this problem can be typified by attempts to keep abreast of the improvements in oil spill dispersant technology. In 1971, CCGE purchased 40 sets of offshore dispersant spraying gear similar to the hardware illustrated in the 1972 IMCO Manual on Oil Pollution. As improvements in dispersant toxicity and efficiency were made, it became necessary to replace the existing stocks of conventional dispersant in accordance with DFE's list of 'approved dispersants'. With the advent of the new concentrated dispersant formulations, it meant that the original spraying equipment mentioned above, must be modified with metering units that would enable the pumps to spray the conventional dispersant or dilutions of the new concentrates. This programme of retrofitting the offshore spraying gear should be completed this year. In order to establish an immediate supply of dispersant to those high risk areas, orders were placed for two tank trucks that will be used as mobile storage facilities, enabling 4,000 gallons of concentrate to be stationed on the East and West Coast. While this is not an inexhaustable supply, it represents sufficient dispersant to treat a 180 ton slick while allowing time to requisition supplementary dispersant from the manufacturers. Should this project progress well this year, it is planned to purchase more of these units for the other Coast Guard regions.

While the offshore spraying gear was primarily designed for use aboard tugs, it was soon recognized that in many incidents the first vessel of convenience would be a CCG vessel. With considerable beam and freeboard, it became necessary for the original equipment to be modified in order to be suitable for the CCG buoy tenders. Consequently, André Leduc, Regional Manager Emergency Operations, Laurentian Region, undertook to have a stanchion fabricated, that when bolted to the bulwark, cleared the vessel's rubbing strake, allowing the height of the spray boom to be adjusted. Using such a fundamental modification, spraying equipment can be fitted aboard almost any vessel of convenience, including those of the CCG fleet, positioned appropriately forward to avoid interference from the bow wave.

To supplement the offshore spraying gear, field personnel last year took receipt of smaller, but more versatile, inshore spraying units that can be fitted to CCGE workboats or used in shoreline restoration.

When it appeared that hovercraft would play a more significant role in the CCG search & rescue and navaids programme, work was begun on adapting the versatile inshore spraying gear for use aboard the CCG Voyageur cargo carrying hovercraft. This approach of dispersant application has a number of advantages that may make it the only practical method of applying oil spill dispersants in the unlikely event of an oil well blowout in the Beaufort Sea.

As the new low toxic dispersant concentrates gained prominence, the idea of aerial application of dispersants, first used by the South African government in 1968 during the Esso Essen and World Glory incidents, became quite fashionable. Although this cause has been taken up by a number of different agencies, work in the CCGE organization has been towards adapting coast guard's existing resources to this technique.

While the principle components of the dispersant programme are in place, much remains to be done in improving the efficiency of our existing hardware. In an attempt to provide better dispersant shipboard handling of dispersants, CCGE has purchased a number of Sealdrums. These containers will be put into trial service this year and promise to be quite flexible. They may be used as temporary storage containers and can be fork-lifted, dragged or rolled behind a vehicle. They may also be used as roll-on fluid air freight containers.

With a coastline as extensive as Canada's, it is difficult to obtain a sufficient supply of hardware in all areas of high risk. However, by integrating countermeasures equipment with the Canadian Coast Guard fleet and air systems, it is hoped that existing equipment can be brought to bear within the largest possible area.

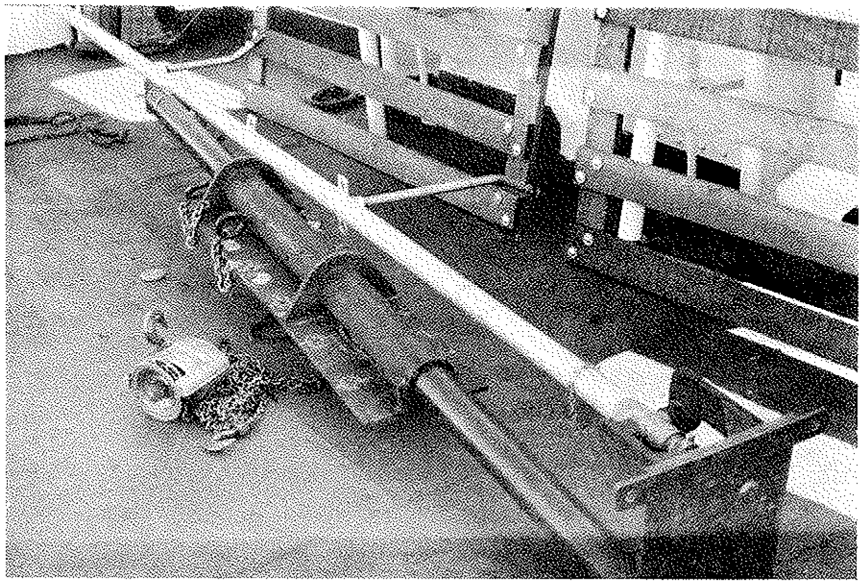


Figure 1. Adjustable stanchion laid out on vessel's well-deck.

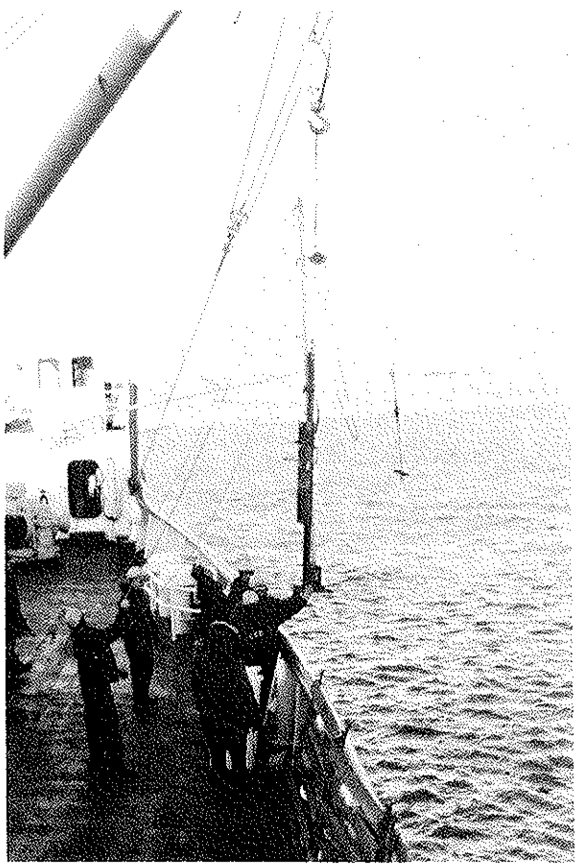


Figure 2. Stanchion being secured to vessel's bulwark.

Figure 3. Starboard side view of offshore spray boom with stanchion modification.

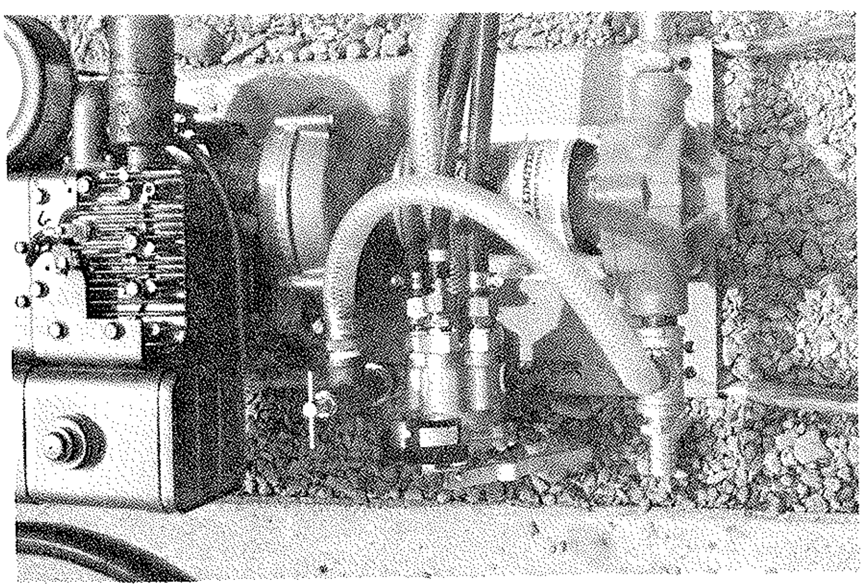


Figure 4. Inshore spraying unit showing 7-way control valve.

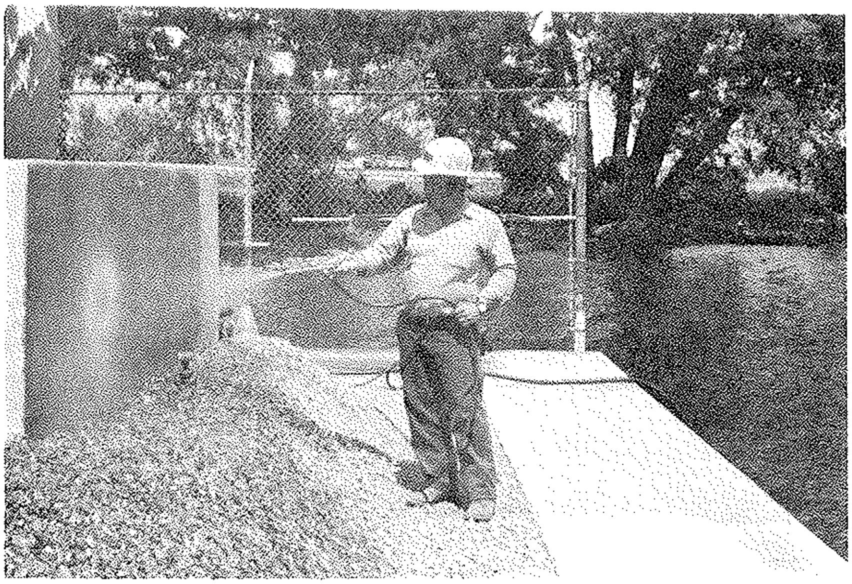


Figure 5. Inshore spraying unit may be used for shoreline restoration.

Figure 6. Canadian Coast Guard Voyageur hovercraft.

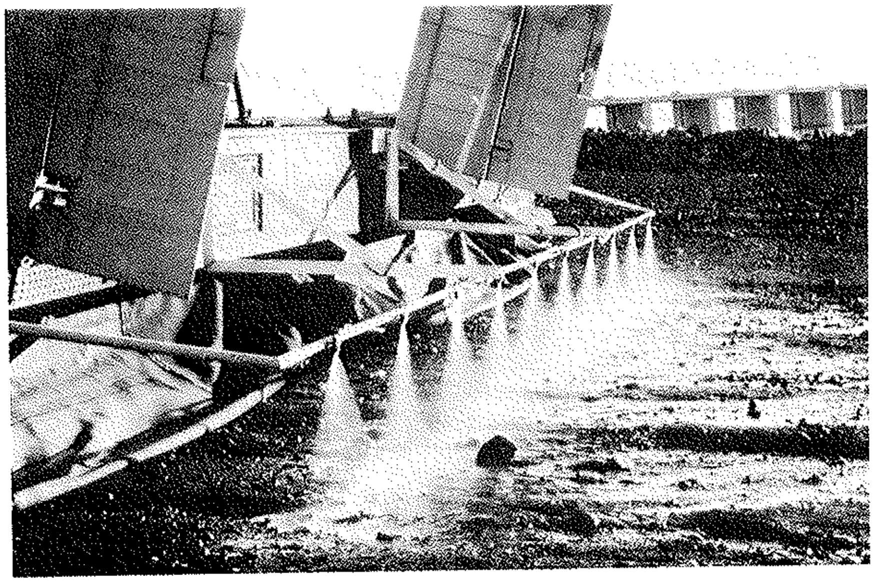


Figure 7. Voyageur fitted with dispersant spraying gear.

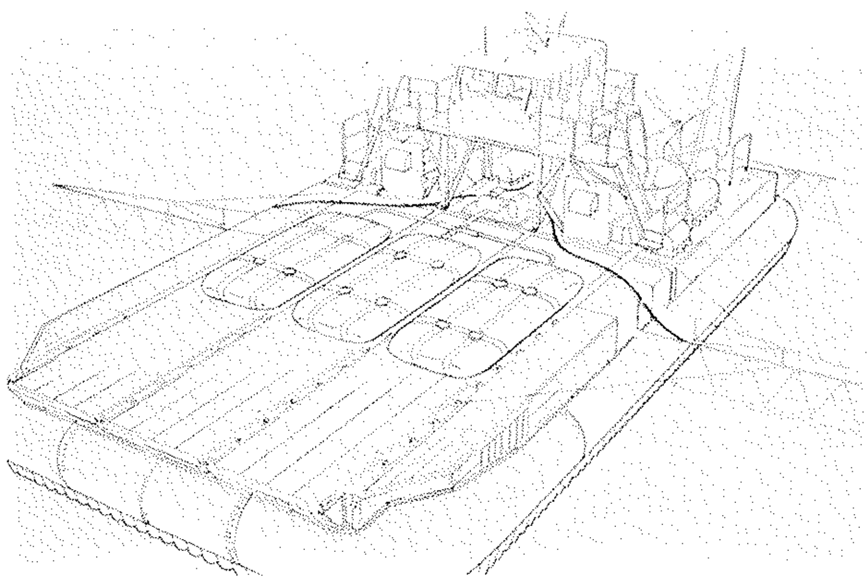


Figure 8. Illustration of Voyageur dispersant hardware.

A STUDY OF PETROLEUM HYDROCARBONS FOUND IN THE SEDIMENTS OF LONG COVE, SEARSPORT, MAINE

Submitted by: Mr. Marc Guerin
Director, Division of Oil Conveyance Services
Department of Environmental Protection
State of Maine
State House
Augusta, Maine 04333

Phone: (207) 289-2591

Editors note: The following is an executive summary of this study. A full report is available from Mr. Guerin.

On 16 March 1971 an underground pipe in the Air Force tank farm at Searsport, Maine burst. At least 5000 gallons of JP-4 and #2 fuel oil were lost. The oil flowed through a system of ditches and culverts into Long Cove Searsport, where it contaminated the clam and worm flats. In August, 1972 about 55% of the clam population present in Long Cove in 1971 had been killed. At the same time that clam mortalities were occurring, worm dealers in the Searsport area began to experience unusually high mortalities when shipping worms from Long Cove.

In the Summer of 1976 DEP contracted with the Bigelow Laboratory, Bowdoin College, Maritec Inc., and The Smithsonion Institution to carry out a biological, chemical and histopathological study in Long Cove. The objectives of this study were to determine the size and condition of the clam population in Long Cove as well as to determine the present distribution of petroleum residues in sediments and in clam and worm tissues in Long Cove. Estimates were made of the degree of damage still occurring in Long Cove as a result of the 1971 oil spill as well as estimates of the degree of recovery which has occurred since 1971.

Interviews with worm dealers established that problems with shipping worms from Long Cove have ceased. The report was backed up by experimental evidence which showed that worms from Long Cove were at least as resistant to drying as worms from Wiscasset, hence they should ship as well as the Wiscasset worms.

Results of analyses for petroleum hydrocarbon content of sediments showed that the west shore of Long Cove still contains appreciable amounts of material similar to what was spilled in 1971. The east shore contains some more recently spilled petroleum residues, and very little material from the 1971 spill. Samples taken from the subtidal regions of Long Cove showed that no large reservoir of material from the 1971 spill was contained in subtidal sediments. Samples at various places in Long Cove showed evidence of more recent petroleum contaminations. A search of DEP records has shown that many small oil spills have occurred in Long Cove since 1971. However, the bulk of the petroleum material in Long Cove can be ascribed to petroleum from the 1971 spill remaining in the sediments on the west shore of Long Cove.

The most striking change in the clam population of Long Cove between 1971 and 1976 has been the dramatic reduction in the standing crop of clams. In 1971 there were 14,162 bushels of clams in Long Cove; they inhabited 83 acres of flat. In August 1976 there were 1,931 bushels of clams inhabiting 17.9 acres of flat. Thus 65 acres of flat that once held clams no longer do so; where clams do occur population densities are 1/2 to 1/3 what they were in 1971. These differences appear to be caused by a failure of recruitment (setting of young clams) in many areas of Long Cove which has been caused by the presence of oil in the sediments. The presence or absence of clams in Long Cove correlates very well with the presence or absence of heavy oil contamination.

In areas where clams survived there has been recruitments, however, growth has been much reduced. The reduction in growth has been caused by oil residues in the animals' tissues. In addition to reduced growth clams from Long Cove show many histopathological anomalies typical of stressed clams. At the same time clams from the oiled western shore of Long Cove show a high incidence of neoplastic growths (tumors) particularly in the gonads.

It is clear from the results of the study that oil in sediments as well as in animal tissues is having a drastic effect on the clam population at Long Cove. There have been 17 oil spills at Long Cove since 1971. However, the 1971 spill vastly overshadows the amounts of subsequent spills. The rate of oil release since 1971 is probably similar to what it was before 1971. It seems clear that the clam population in 1971 was able to tolerate this rate of release. In the absence of large amounts of oil, sediments can recover fairly readily from minor oil spills. However the heavy oiling by the 1971 spill seems to have reduced or eliminated the recovery potential of sediments in a number of locations in Long Cove.

OFFSHORE DRILLING IN THE LABRADOR SEA - ONE VIEWPOINT

Labrador Resources Advisory Council
P.O. Box 430
Happy Valley, Labrador

Phone: (709) 896-5091

Editor's note: The following article was abstracted and reprinted with permission from a larger article published in November 1977 by the LRAC entitled "As If People Mattered-Resource Issues in Labrador". Copies are available at the above-noted address.

By far the most massive environmental concern and potentially the greatest hazard to the fishing economy and lifestyle of coastal Labrador is oil and gas exploration in the Labrador Sea.

We find it ironic that the risks of drilling in the Beaufort Sea in the Arctic have attracted wide attention while the same activity in the Labrador Sea - in many ways a more hostile environment - is conducted under much less stringent regulations without notice. The concerns in the Arctic are legitimate but we want the Canadian public to contemplate the prospect of an oil blowout gushing unchecked off Labrador all winter, while its contents are swept south on a strong current along some of the most spectacular and productive coastline in Canada.

To date the major operators in petroleum exploration off Labrador have been Eastcan and British Petroleum. Eastcan, a consortium of seven companies and the government of France, has taken the lead so far. Eastcan has leased more than 25 million acres from the federal government and has spent about $100 million in exploration up to this year, when drilling was halted.

The halt in exploration, after three out of eleven wells struck substantial flows of gas, appears to us to have orchestrated for its political effect in the province, adding to pressure for Newfoundland to back down in its dispute with Ottawa about jurisdiction over offshore resources.

Newfoundland's position has been that its claim to jurisdiction is both different and legally much stronger than the claims of other Atlantic provinces, which have already settled with Ottawa. The province also insists that it needs jurisdiction in order to control the pace of development and moderate its effect on the provincial economy. Though we marvel at an almost bankrupt province standing up to both the federal government and the oil industry, we believe Newfoundland's position shows wisdom and courage in the face of considerable temptation, and we fully support the province in this stand.

After Eastcan, the next largest operator has been British Petroleum. Other companies with interests off Labrador have been Imperial, Texaco, Shell, Gulf and Aquitaine. They have spent about $250 million on exploration here since 1966, of which the province estimates that 5% has entered the provincial economy.

Eastcan's remarkable score of three strikes in eleven wildcat wells has raised the odds on a commercial field. The costs of exploration and development in the Labrador Sea are so high that a field would have to be massive to be viable, but the chance of locating a commercial field is thought to be better than 70%. Estimates of the time needed to develop the technology to get offshore wells into production range upward from six years after commercial quantities are established.

The most spectacular environmental threat in this activity is probably that of a blowout, the eruption of oil or gas from a drilling operation on the sea floor. Very sophisticated precautions may reduce the risk of this happening, but the possible effects on the marine environment are so frightening that few dispute the need to reduce the risk to nearly zero. The only way to control a blowout if it occurs is to drill a relief well down to the same formation and pump down a mixture that will seal the leak. This cannot be done in less than several weeks, at best.

The Labrador Sea is known in the drilling business as "Iceberg Alley", a reference to icebergs drifting south on the Labrador Current. While these pose an obvious hazard to drilling or production platforms in their path, the destructive power of pack ice swept down by the same current is even more awesome. In fact pack ice and the mountainous waves of fall and winter storms reduce the drilling season to three months a year, so that if a blowout in late season was followed by violent storms it could blow unchecked for nine months, with untold consequences to the Atlantic coast.

As the nearest neighbors of drilling activity in this setting, we believe we have a right to expect safeguards unmatched elsewhere.

In fact, however, the regulations which govern oil exploration off Labrador are relatively lax. Companies are operating under federal permits issued in 1962, when the world was far less conscious of the risks of this work. On its part, the province lacks the personnel to do more than scan the drilling programs of the companies, and readily admits that even if it wins its jurisdictional dispute with Ottawa it will expect the federal government to take the lead in environmental protection offshore.

Federal leadership in this field is absurdly divided. North of 60 degrees latitude, drilling is under the control of Department of Indian and Northern Affairs, which has at least some sensitivity to the concerns of native and environmental groups. South of 50 degrees the principle authority is the federal Department of Energy Mines and Resources (EMR), which in our view tends to share the orientation of the industry it is supposed to regulate.

In neither area is there vigorous leadership from Environment Canada, which appears to have lost a bureaucratic power struggle for control over offshore drilling. This could be tragic, especially since Environment Canada includes the federal Department of Fisheries, with its considerable expertise and its newfound enthusiasm for the potential of the Atlantic inshore fishery.

In any case, offshore drilling in the Arctic is conducted under regulations far more stringent than those in force here, and is subject to processes of environmental assessment and public consultation almost totally absent in Labrador.

There is no good reason for this more relaxed approach in Labrador. The coast of the Beaufort Sea, where northern offshore drilling first aroused public alarm, has few settlements and its marine life does not support a commercial fishery, though of course it is important for its own sake and for the subsistence of native groups in the area. Nor does the Beaufort pose the risks of the Labrador Sea in terms of storms, drift ice and icebergs. Yet more than 30 environmental studies have been done there at a cost of $12 million, and no drilling was permitted until an environmental impact assessment was complete. The same is true in the eastern Arctic, where drilling is being delayed until the completion of an extensive program of environmental research. Inuit communities are being involved in planning and evaluating this research.

Virtually none of this has been done in Labrador, where drilling has been underway since 1971. In fact the only serious environmental research prompted by the risks of offshore drilling came about as a spin-off from exploration planned in the eastern Arctic, when it was seen that oil from any spills or blowouts off Baffin Island would drift south on the Labrador Current.

Thus Labrador is getting a trickle of the research money allocated to the Eastern Arctic Marine Environment Study (EAMES). This will be spent largely in northern Labrador, beyond the prime range of interest for companies now active here. We know of no work being done on the effects of drilling and seismic activity on the cod stocks which spawn on the Hamilton Banks, where several of Eastcan's wells have alrady been drilled, or on the consequences of an oil spill or blowout in this crucial area. The Hamilton Bank is the nursery of a cod resource which supports nearly half the fishing communities in Newfoundland and Labrador.

Companies directly involved in drilling off Labrador have been done almost no environmental research, at least not as most of us use that term. The work they have done has been mostly studies of factors which affect the technical business of drilling, and while we recognize the value of this, it is no substitute for baseline studies of the environment or research into the tactics of coping with spills and other hazards in that setting.

Nor has there been much environmental work by EMR, which takes the approach that since its job is to prevent spills there is little point in studying their consequences. We have had trouble getting the minister of the department, Alistair Gillespie, even to see the point of pulling together existing data on the biology of the Labrador Sea, let alone conducting the thorough environmental impact assessments which are a prior condition of drilling farther north. We believe this demonstrates either an ignorance of what is at stake or a reckless disregard for the risks involved.

The federal Minister of Fisheries and Environment, whose fisheries staff know what is at stake, has agreed with us on the need to pull together existing information on the Labrador Sea. If nothing else this may mean that Labrador's meagre portion of the EAMES budget can be directed toward gaps in existing knowledge. Yet there is no guarantee that this exercise, vital though it is, will have any influence on the attitude of EMR or the behavior of oil companies, both of which seem content to congratulate themselves on the absence of any serious accidents so far.

THE FLOW STRUCTURE OF AN UNDERWATER OIL BLOWOUT

Submitted by: Dr. D.E. Thornton
Environmental Emergency Branch
c/o Environmental Protection Service (Northwest Region)
10th Floor
Imperial Oil Building
10025 Jasper Avenue
Edmonton, Alberta.
T5J 2X9

Phone: (403) 425-5128

INTRODUCTION

In order to discuss the fate of oil from a subsea oilwell blowout, and hence to appreciate the likely oil distribution facing cleanup crews, it is necessary to understand the behaviour of the blowout fluids as they emerge from the sea floor and rise through the water column.

To quantify this discussion, the oil flowrate and location of the scenario considered here is taken to be a hypothetical blowout in a report recently published by the Newfoundland Mines and Energy Department[1]. The site coordinates are 57°30'N; 60°00'W, the approximate location of the Snorri Well. The water depth in this area is approximately 200 m. Light, sweet crude oil (40° API gravity) is assumed to flow at a rate of 2400 m^3/day (15,000 bbl/day) accompanied by natural gas at a rate, normalised to atmospheric pressure, of 360,000 m^3/day (20 MMcfd). This oil to gas ratio, incidentally, of 1 to 150 is the same value that is frequently used in similar analyses of oilwell blowouts for the Beaufort Sea. The blowout fluids are assumed to issue freely from a circular opening at the sea floor (the pipe exit) of diameter 15 cms. This is not an unreasonable assumption, as long as the fluids do not escape outside the well casing and crater the surrounding earth, since any obstruction in the well bore would soon be cut away by sand and grit entrained with the fluids.

The flow resulting from a subsea blowout may be roughly divided into two main parts based on the driving forces: a jet region where the initial momentum of the emergent fluids dominates, and a plume region where the buoyancy of the escaping gas is the driving mechanism. It is also convenient to consider separately the upper portion of the buoyant plume where the flow impinges on the water surface.

[1] A report prepared by NORDCO Ltd. for the Department of Mines and Energy, Newfoundland, entitled, "Physical Environmental Baseline Study with Application to the Prediction of Oilspill Movement and Oilspill Countermeasures Techniques for the Drilling Area off Newfoundland and Labrador".

THE JET REGION

A schematic representation of the flow resulting from a subsea blowout, taken from Mundheim and Fannelop (1976), is shown in Figure 1. The flow near the point of release has the character of a jet which, as it spreads, entrains water and loses its initial velocity.

The only applicable analysis of submerged jets with large, turbulent flows seems to be that of Abramovich (1963). His work indicates that the velocity decay of an essentially gaseous jet emerging from a pipe will be very rapid (roughly inversely proportional to the square of the distance from the pipe exit). In this subject case, the velocities should be only a few metres per second at a vertical distance less than 10 m from the pipe exit. This rapid decay is a consequence of thesignificantdifference in densities between the bulk of the jet fluid (by volume, 7 parts gas and 1 part oil at 200 m depth) and the water.

Since buoyancy forces become dominant within the order of 10 m from the sea floor, little accuracy is lost, from the point of view of an observer on the surface, by neglecting the initial momentum of the blowout fluids for depths greater than about 100 m. For most purposes, it suffices to consider only the buoyant plume solution corresponding to a buoyant point source located at, or close to (see Figure 1), the sea floor.

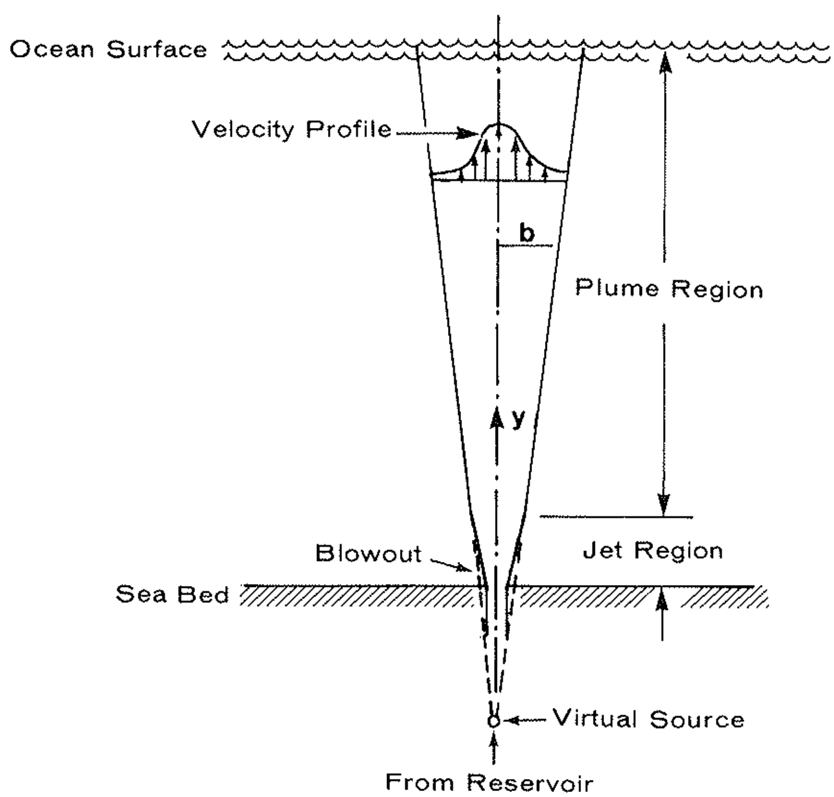


Fig.1- Schematic representation of underwater structure,jet and plume.
(Taken from Mundheim and Fannnelop,1976)

The jet solution is of interest, however, in establishing forces on objects intended to intercept or block the flow, and in calculating inflow velocities along the bottom to evaluate the possibility of sea bed erosion or danger to divers. According to Mundheim and Fannelop (1976), using a method by Taylor (1958), water velocities of the order of 1 m/s or more occur only in the immediate lateral vicinity of the jet (within 2 - 3 m, depending on flow rate). Velocities of less than 0.25 m/s can be expected at distances exceeding 10 m laterally from the jet axis.

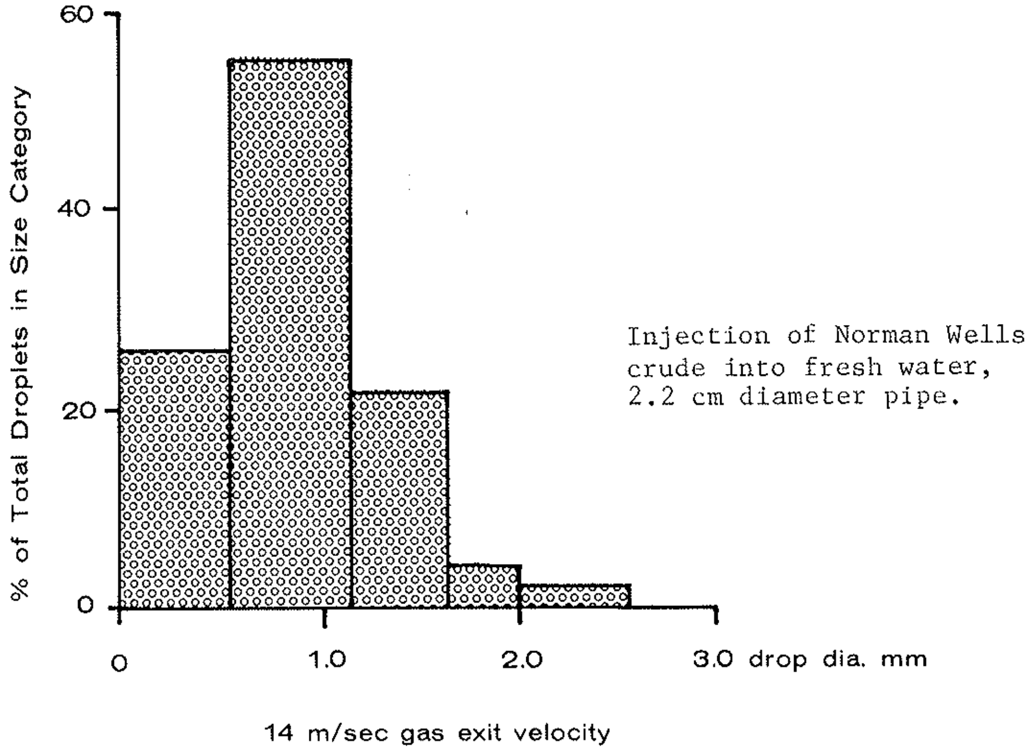
Another reason, however, for interest in the region near the pipe exit, is that the break-up of the blowout fluids as they enter the water column, to a significant extent, may determine the eventual fate of the oil. For example, the energy dissipation near the sea floor could cause, conceivably, the formation of stable emulsions. To examine this possibility, Topham (1975) injected mixtures of oil and gas under water through a common pipe exit.

Topham used two crude oils: Norman Wells crude, which was known not to form stable emulsions, and Swan Hills crude, which was thought likely to form stable water-in-oil emulsions. In the experiments, two gas superficial velocities, 1.9 and 14 m/s, were used. (The superficial velocity is that which the fluid would have if it occupied the pipe alone.) The oil superficial velocity of 0.25 m/s was based on expected flowrates from a hypothetical blowout in the Beaufort Sea. With this oil velocity the two gas flow rates used by Topham were expected to result in two different flow regimes within the pipe. "Slug" flow was predicted for the low gas velocity (with alternate sections of oil and gas emerging) and "annular" flow was expected for the higher gas velocity (with oil flowing up the sides of the pipe and gas up the centre). If the two expected flow regimes did stabilize in the experiments, the difference in flow did not obviously cause a variation in the fate of the emergent oil.

The bursting action of oil-covered gas bubbles near the pipe exit broke the oil into fine droplets. In general, the higher gas flow velocity produced smaller oil droplet sizes, as did larger pipe diameters. (Topham used 0.64, 2.2, 7.6 and 14.7 cm). The decreasing oil droplet size was associated with the increasing violence of the bubble release from the pipe, as might be expected. The major portion of the oil was contained in droplets with diameters in a range of 0.05 to 1 mm. Two droplet size distributions obtained by Topham are reproduced in Figure 2. Stable emulsions did not form with either crude oil.

For the subject hypothetical blowout, the superficial gas and oil velocities are about 18 m/s and 2.4 m/s, respectively. Despite the order of magnitude increase in the oil superficial velocities compared to Topham's experiments, the flows within the pipe are predicted to be of the annular type with, perhaps, some small oil droplets entrained within the central core of gas. There is little reason to suspect that the average oil droplet size will be very different from the 0.5 - 1 mm range noted above (Topham, private communication). Oil droplets of this size have terminal velocities between 5 and 7 cm/s and, if they escape from the main plume of bubbles and entrained water, they will rise to the surface within 40 - 60 min.

Topham's work indicated that a small proportion, of the order of 1%, of the oil was shattered into small drops of less than 50 micrometers diameter. The terminal velocity in this case is 0.5 mm/s or less. If these droplets escaped



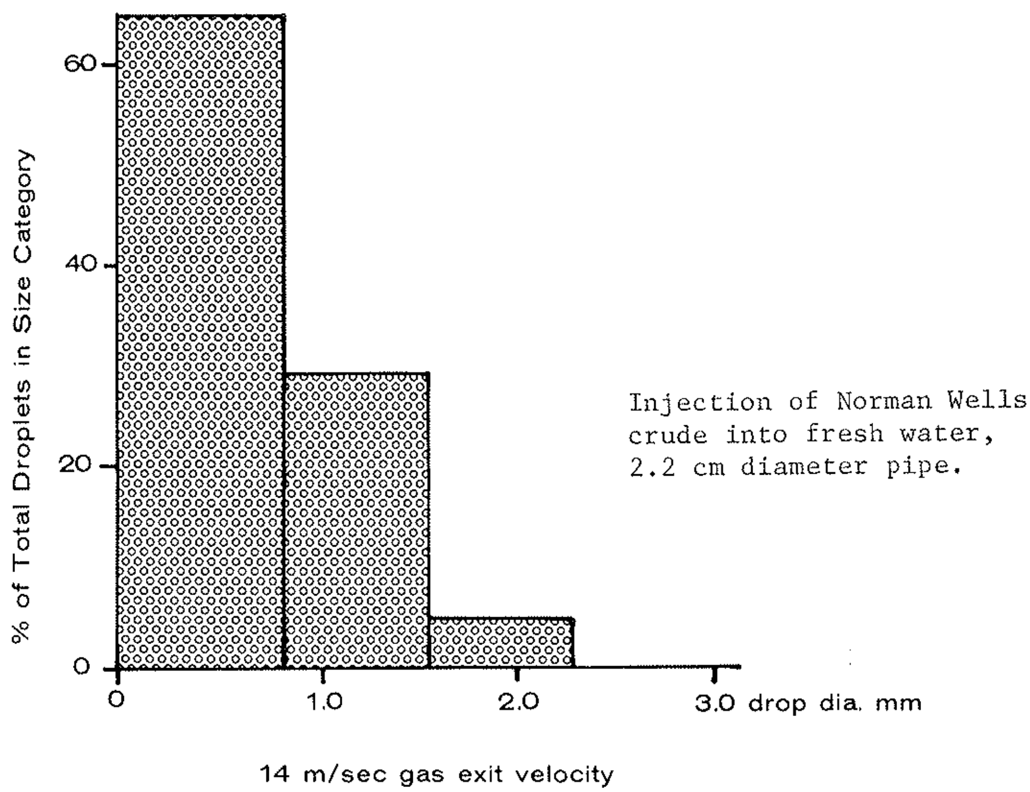


Fig.2 - Oil Droplet Size Distributions.(Taken from Topham,1976)

from the main plume it would be of the order of days and many kilometres from the blowout site before they approached the surface; if at all.

THE PLUME REGION:

(a) Theoretical Considerations

The plume region is the part of the vertical flow structure between approximately 10 - 20 m from the sea bed and the sea surface. In this region, buoyancy is the driving mechanism as gas bubbles formed at the pipe exit expand, slowly at first and then much more rapidly as they approach the surface. The gas bubbles rising through the water column entrain water and create an upward current or water plume which in turn entrains the more slowly rising oil droplets. Beyond a certain limiting size, large, expanding gas bubbles break-up. Observations from bubble curtains (line sources) (Mundheim and Fannelop, 1976), point sources (Topham, 1975) and theoretical considerations (Levich, 1962) indicate that the maximum diameter is in the range 1 - 3 cm. (Single bubbles in this size range would have terminal velocities of 0.3 to 0.6 m/s, and if separated from the plume would rise the 200 m to the surface in about 5 to 10 minutes.)

Morton, Taylor and Turner (1956) provide a method for the analysis of buoyant plumes based on an analogy with heat-driven plumes. Ditmars and Cederwall (1974) have modified this approach to include the effect of increasing buoyancy with height caused by gas expansion (which they take to be isothermal). The modified theory also takes into account the natural rise velocity of the gas bubbles relative to the induced plume velocity.

A schematic representation of the bubble plume model, taken from Ditmars and Cederwall, is included in Figure 3. In an analogy with single phase buoyant plume theory (e.g. thermally driven plumes), the lateral distributions of vertical velocity and density difference are taken to be similar at all heights (gaussian), and the rate of water entrainment is characterised by an entrainment constant. The entrainment constant must be determined empirically.

Using the expressions of Ditmars and Cederwall, Nordco (1977) calculated the predicted plume width and average vertical water velocity with height for the subject Snorri blowout, and these are reproduced in Figure 4. (In this figure, the plume radius is defined to be 2 times the standard deviation of the lateral distribution of the vertical velocity.) As may be noted from the figure, an essentially conical plume is predicted. (This is usual for buoyant plume theories.)

The theory, then, predicts an average plume velocity over most of the water column of just over 1 m/s; so oil droplets entrained in the flow would surface in about 3 minutes. Moreover, at about 40 m depth, just below the region where the flow defects from the water surface, the approximate width of the essentially conical plume is predicted to be 30 m.

(b) Experimental Evidence

Although the agreement between the theory derived from an analogy with thermal plumes and small-scale bubble plume experiments is satisfactory, experimental

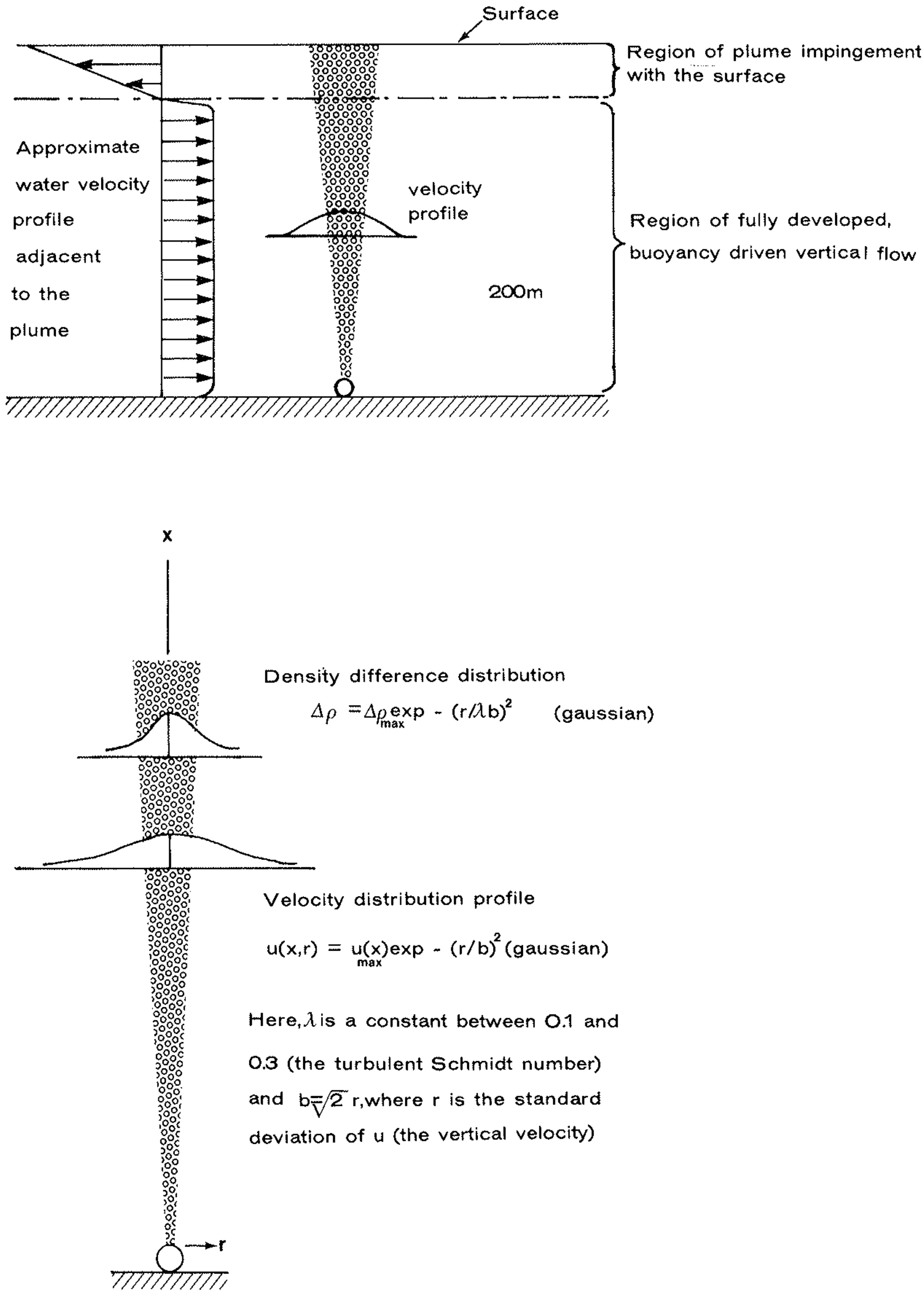


Fig.3 - Schematic Representation of Bubble Plumes
(after Ditmars and Cederwall,1974)

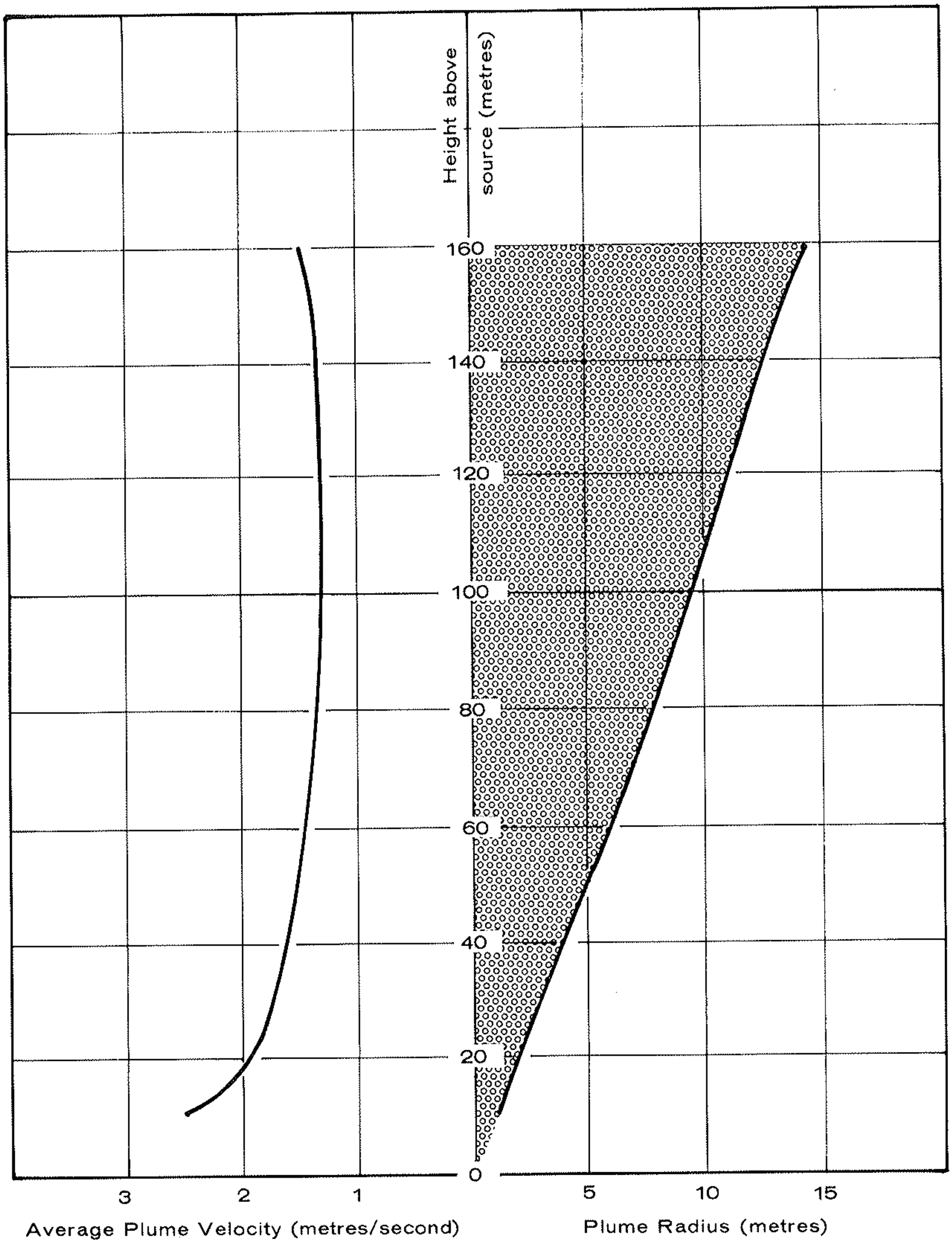


Fig.4 - Average Plume Velocity
(after Nordco 1977)

Plume Profile
(after Nordco 1977)

work with large-scale air bubble plumes in water depths of 23 and 60 m by (1975) has indicated some discrepancies with simple theoretical predictions his experiments, the rising gas bubbles entrained the surrounding water to for... a rising plume which was initially conical in shape, but became cylindrical above a certain height. Specifically, the plumes in 60 m of water became cylindrical about 23 m vertically from the source. In these experiments, gas flows of 3.7 to 40 m^3/min were used; which should be compared to a rate of 250 m^3/min (and depth of 200 m) for the hypothetical Snorri blowout.

Measured radial profiles of vertical velocity were not similar along the cylindrical portion of the plumes; thereby violating one of the assumptions embodied in the usual plume theories. According to Topham (1978), this feature of air-bubble plumes may be caused by the local turbulence created by the bubbles themselves modifying the eddies generated by the large-scale shear associated with the plume as a whole.

In terms of the final disposition of the oil, the formation of a cylindrical plume over part of the water column is not of great significance for the current water depth; although, of course, in deeper waters it would have considerable ramification for the size of the plume near the surface. For the subject case we will take the width of the bubble plume near the surface to be 30 m, as estimated by NORDCO. This may be slightly high, based on Topham's experimental work, but this possibility does not radically alter the overall scenario.

THE NEAR-SURFACE REGION

In Topham's experiment the general pattern of the interaction of the plume with the water surface was consistent; although the overall scale increased with increasing airflow rate and with source depth. The main features of the interaction were a central boil area on the surface where the bubbles left the water, surrounded by an outwardly directed radial surface current.

A ring of waves concentric with the plume centre marked a change in direction of the radial surface currents. The near-surface flow inside the wave ring took the form of radially expanding torroidal vortices which came to a halt at the wave-ring radius, where the flow turned downwards in a complex mixing region. This downward mixing entrained the inward-directed flows outside the wave ring.

For the moment, we will consider the data obtained by Topham in 60 m of water using a gas flowrate of 26 m^3/min. The vertical velocity profiles at a variety of radial positions is shown in Figure 5.

Oil drops of diameter 1 mm have a natural rise velocity of the order of 5 cm/sec and if they were swept outwards from the plume at a depth of 3 m (approximately the maximum outward radial current depth in Topham's experiments), they would rise to the surface at a radial distance of about 20 m -- within the wave ring (of radius 32 m in Topham's experiment). The oil would be swept out to the wave ring by the 0.5m/s surface current and tend to collect there because of the containing effect of the inwardly directed current of about 0.2 m/s outside the wave ring. However, once the oil thickness exceeded about 1-2 cm, the potential head associated with the oil would overcome the velocity head of the containing

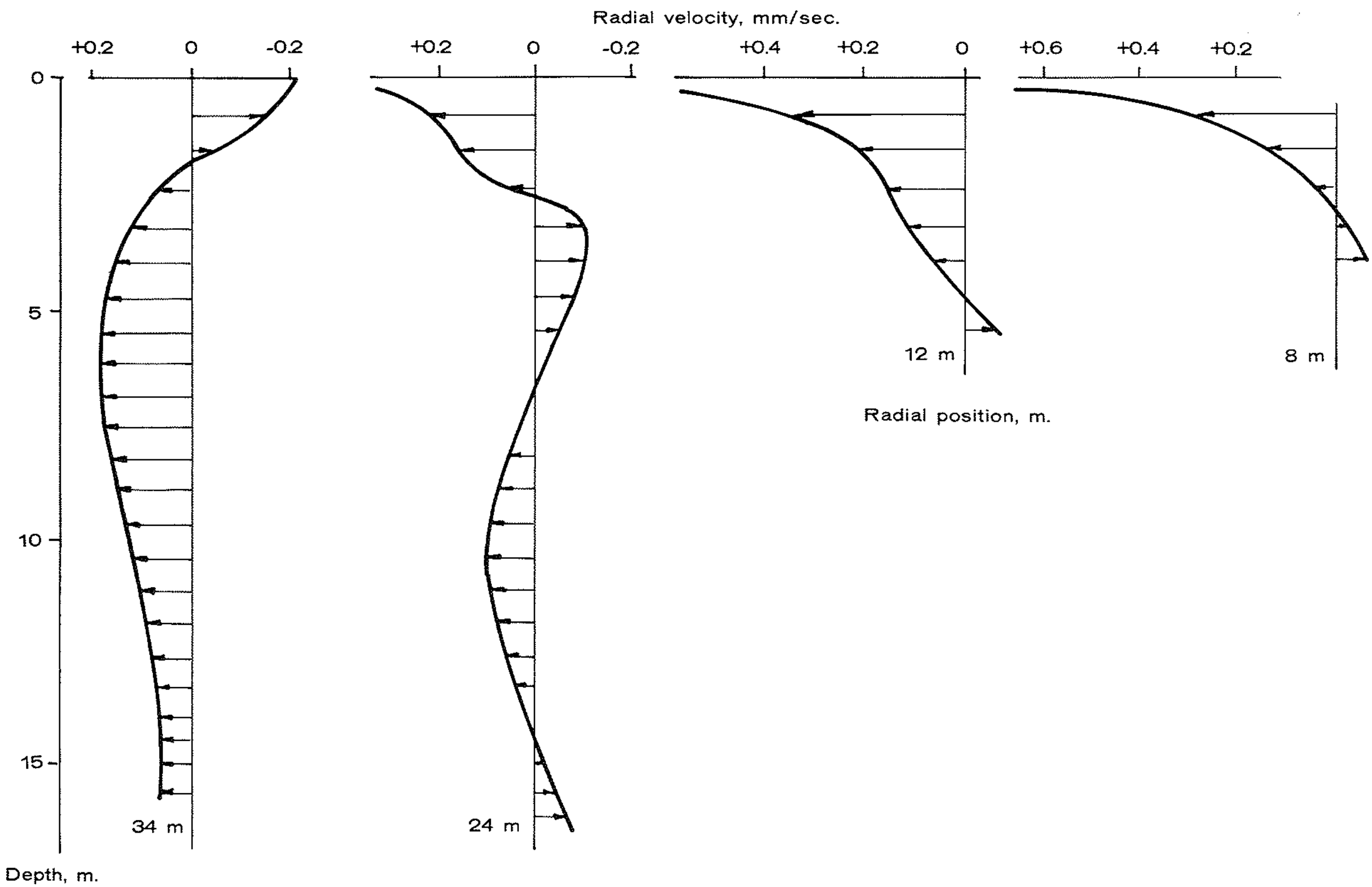


Fig.5 - Radial velocity profiles of induced currents, source depth 60 m, airflow rate 25.1 m^3/min.
(Reproduced from Topham,1975)

current and oil would begin to escape. Moreover, even before this situation could be attained, local surface currents, if greater than about 0.2 m/s, would cause leakage from the "downstream" side of the wave ring. In the Labrador Sea, surface currents are typically of the order of 0.3 to 0.4 m/s. Of course, wave action and winds would also tend to cause leakage from the wave ring.

Smaller oil drops, with lower natural rise velocities, could well reach the wave ring before surfacing and become entrained in the downward mixing current below the wave ring and eventually surface outside. Some might be carried back towards the wave ring by the inward radial currents, but, more likely, the movement of the majority of the oil surfacing outside the wave ring would be dominated by residual surface currents and winds.

The proportion of oil which might surface quickly is dependent upon the distribution of oil droplet sizes near the surface and the detailed nature of the turbulent currents in the region. Despite the simple discussion above for the rise of a 1 mm diameter oil droplet to the surface, the turbulence associated with the expanding toroidal vortices may be sufficient to carry even droplets of this size out to the wave-ring radius where down-mixing currents extended 10-15 m downwards in Topham's experiments and were of the same order of magnitude as the natural rise velocity of the droplet. If so, even the larger oil droplets may escape the immediate vicinity of the plume before surfacing.

Moreover, the spacial and size distribution of oil droplets in the boil area itself is uncertain. It is possible, for instance, that the "scrubbing" action of gas bubbles during their ascent in the plume (2-3 min. in 180 m depth) could cause their coalescence with many of the slower-moving oil droplets. If so, from simple interfacial considerations, it is likely that most of the gas bubbles might have an oily skin. The thickness of the skin is uncertain. For illustration, although this extreme is unlikely, if all the oil were associated with bubbles of diameter about 1 cm, the oil skin on each bubble would average about 10 micrometres in thickness. The water flow around the bubbles could distort the bulk of the skin into a pendular oil droplet beneath the bubble, or even strip some of the oil away.

The detailed behaviour of an oily gas bubble breaking the water surface in the boil area of the plume is unknown. It seems probable that some oil would tend to flash over the water surface to form a surface slick, but it also seems likely that oil droplets, probably considerably smaller in diameter than 1 mm, would be thrust down a few metres into the water column as the gas bubble breaks the surface.

It is difficult, then, even based on Topham's experimental scale, to assess the fraction of oil droplets which would likely surface within the wave ring and quickly form a fairly coherent slick; or, equivalently, to estimate the proportion which would escape under the influence of near-surface currents and probably become more quickly dispersed. This difficulty is compounded further in the case of the hypothetical Snorri blowout, where the blowout fluid volumes are increased by a factor of ten.

Topham developed an empirical relationship for the wave ring radius as a function of gas flow rate and water depth. Although it is strictly valid only for the range of parameters in his experiment, he extrapolated to water depths of 180 m by assuming a virtual origin at a depth of 60 m. This procedure was adopted since the relative bubble volume increase is very rapid above this point and near-surface currents are mainly dictated by the upper part of the plume column. Nordco (1978) utilised the same approach, despite the order of magnitude increase in gasflow rate, and estimated a wave ring radius of approximately 90 m for the hypothetical Snorri blowout. Whether or not the other features of the near-surface flow (e.g. currents, etc.) would scale in the same ratio of approximately 1:3 (32m:90m) is unknown.

Whatever the detailed nature of the near-surface region, it seems likely that a significant proportion of the oil will be entrained by currents and carried outside the wave ring. Oil droplets with diameters between 0.1 and 1 mm have natural rise velocities in the range of about 0.1 to 5 cm/s. If these droplets were carried beyond the wave ring at depths of about 10 - 20 m, they would surface 200 m to 5 km "downstream" from the blowout plume in a residual current of about 0.3 m/s. By the time (0.2 - 5 hours) these particles surface, if they did at all, considerable lateral spreading could have occurred. The magnitude of the areal spreading is uncertain due to the lack of data regarding turbulent diffusion under moving pack ice. However, based on an empirical relationship for the spreading of dyes in open water (Okubo, 1971), the suspension of finely divided oil droplets escaping from the plume would spread laterally from the diameter of the wave ring (180 m) to about 500 m in about 5 hours.

OTHER CONSIDERATIONS

1. The above discussion assumes a uniform ambient water column with no cross-currents or waves present. Consideration of these factors leads to a considerable increase in complexity. Furthermore, the paucity of experimental data means that the value of such an extended analysis is dubious. The following points, however, are noted:

   a) The effect of stratification may be significant, especially for greater depths. Cederwall (1975) provides the equations for a stably stratified fluid, but these are for incompressible fluids and require numerical solution. McDougall (1975) has confirmed that in a stabely stratified environment, fluid may shed from the sides of the plume as it rises. This mean that oil droplets may be released from the plume to be carried by deep water currents over considerable distances before surfacing.

   b) Shuto (1971) has analyzed the effect of cross streams and waves on plume dilution. These studies may not be directly applicable to the gaseous plumes considered above; however, the general results are probably valid here. It is found that since the length of the plume is longer and its cross-sectional shape is altered by the cross current, the rate of entrainment of water and thus the dilution are increased.

   For the hypothetical Snorri blowout, with an average cross current of about 0.3 m/s, the upper portion of the plume could be displaced perhaps 40 m laterally from the source below. This corresponds to a plume leaning at approximately 10° to the vertical.

2. Topham (1977) has recently confirmed the formation of gas hydrates during a discharge of simulated natural gas in water depths of 325 to 650 m. These solids are compounds of gaseous hydrocarbons and water, which are thermodynamically stable at high pressures and low temperatures. Since hydrates have a specific gravity close to 1 (0.92 - 0.96), if the gas from an underwater blowout is converted into this solid form the buoyancy forces will be effectively eliminated and a water plume will not form. Topham concluded from his underwater discharges that the minimum water depth for hydrate formation in 7°C water appeared to be about 300 m. This is close to the temperature and pressure expected from thermodynamical laboratory work. A reduction of water temperature would decrease the minimum water depth for hydrate formation. However, it is likely that hydrate formation would play little or no role at the subject depth of 200 m.

3. Since the bubble velocities are of the order of 1-2 m/sec, and the diameter of the boil area is expected to be about 30 m, the volume occupied by gas in the near surface portion of the plume is only about 1%. Hence, the danger to surface vessels from loss of buoyancy, or stability, is negligable. (Though, of course, the fire danger associated with the emergent gas would be considerable.)

4. The behaviour of a blowout plume beneath a flat, continuous ice sheet is not expected to be significantly different to the open water case discussed above. Gas would collect at the ice-water boundary and thereby create a gas-water interface similar in nature to the open water case. Of course, in reality some gas would tend to escape through cracks in the ice sheet and between floes. In this case, it is probable that the slightly increased surface drag caused by the ice could somewhat decrease the wave ring radius and the relatively protected environment could slightly reduce the areal dispersion of the oil.

CONCLUSION

In view of the uncertainty concerning the detailed behaviour of oil in the near-surface region, a somewhat arbitrary decision will be made regarding the ultimate disposition of the oil. For discussion purposes related to the interaction of the oil and the ice, it is assumed that 50% of the oil (comprising the droplets with the larger diameters) would surface within a wave ring of radius 90 m and would evenly "paint" the surface in this region. At an oil flowrate from the well of 1.7 m^3/min, and an ice velocity of 0.3 m/s, the oil would be distributed inside the wave ring at an average thickness of about 0.25 mm.

The remaining 50% of the oil, in the form of a finely divided suspension of small droplets less than 1 mm in diameter, would be carried beyond the wave ring by near-surface currents. Based on simple arguments related to their natural rise velocities, these would surface of the order of a kilometre away "downstream" from the blowout. Because of areal diffusion and the random component of the velocity of the ice sheet, when this oil surfaces, if it would at all, it would be unlikely to collect in (average) thickness much over a micrometre.

TABULAR SUMMARY

Water Depth

190-200m (Jet Region)
- emergent fluids 7 parts gas and 1 part oil with velocities >1m/s.
- bursting gas bubbles near the exit
- oil shattered into small drops about 1 mm and less in diameter

190-0.20m (Plume Region)
- buoyancy (gas bubble) driven water plume rising at about 1m/s
- gas bubbles expanding and breaking into bubbles of maximum size about 1 cm
- oil drops of size about 1 mm and less in diameter entrained in the vertical water plume
- an unknown fraction of the oil coating the surface of the gas bubbles

0.20m-200m - (Near Surface Region)
- gas escapes in a boil area about 30 m in diameter
- radially outward surface currents averaging about 0.5 m/s extend to a radius of approximately 90 m (wave ring radius)
- radially inward surface currents beyond the wave ring radius
- 50% of the oil (0.9 m^3/s) surfaces within the wave ring, which would "paint" a band of oil 180 m wide, 0.25 mm average thickness under ice moving at a velocity of 0.3 m/s.
- 50% of the oil escapes beyond the wave ring and surfaces 200 m to 5 km "downstream" of the blowout site over an area up to 0.5 km wide.

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SPILL TECHNOLOGY NEWSLETTER

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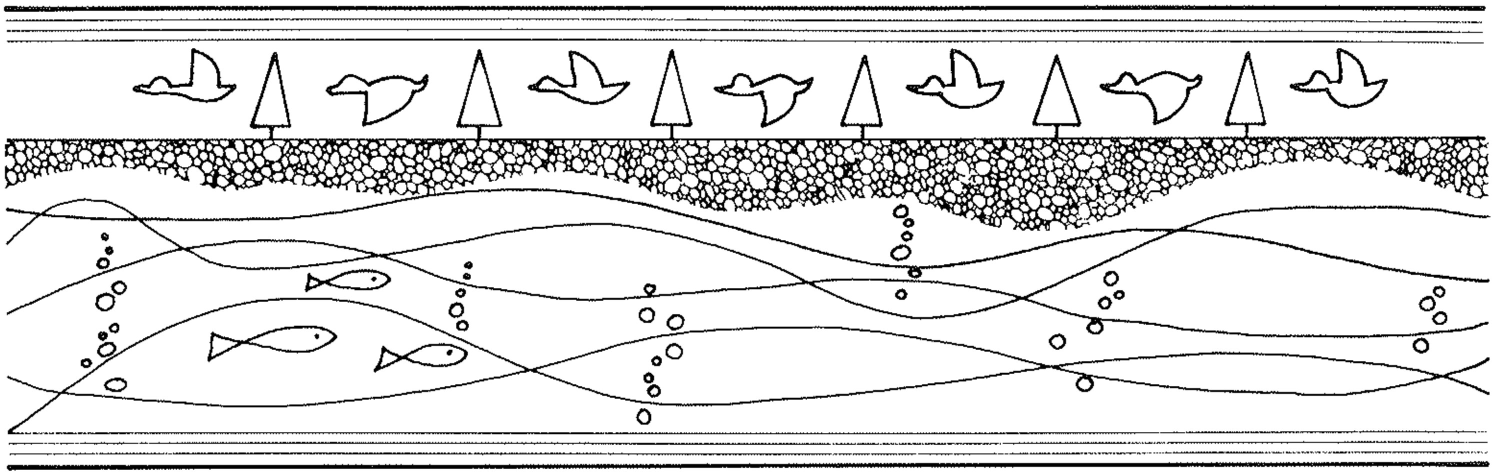

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Spill Technology Newsletter

EDITORS

Dr. S.L. Ross & Mr. M. Fingas

Research and Development Division
Environmental Emergency Branch
Environmental Impact Control Directorate
Environmental Protection Service
Department of Fisheries and The Environment
Ottawa, Ontario
K1A 1C8

Phone: (819) 997-3921

The Spill Technology Newsletter was started with modest intentions in 1976 to provide a forum in Canada for the exchange of information on oil spill countermeasures and other related matters. The interest in it was such that we now have almost 2,000 subscribers in Canada and around the world.

To broaden the scope of this newsletter, and to provide more information on industry and foreign activities in the field of oil spill control and prevention, readers are encouraged to submit articles on their work and views in this area.

INTRODUCTION

As usual we have in this issue an interesting combination of articles on oil spills ranging in subject matter from the effects of oil spills on phytoplankton and arctic marine species to the development of a boom to deal with oil in ice-infested rivers.

Of particular interest and topicality is an article describing some ecological observations of the AMOCO CADIZ spill that recently took place off France. Two other articles from Canadian government and industry observers at the spill site are in preparation and will hopefully be presented in the next STN issue. These will concentrate on the practical aspects of the massive clean-up operation that is still underway.

UPCOMING CONFERENCES

- The organizing committee for the fourth International Association for Hydraulic Research Conference on Ice Problems is inviting papers for a symposium to be held in Lulea, Sweden, August 7-12, 1978. Papers are invited on any of the four topics: (a) ice in estuaries and harbors, (b) thermal regime of ice covered waters, (c) mechanics of broken ice masses, and (d) ice forces on structures. For further information contact: Information office, FACK. S-95185, Lulea, Sweden.

- The 'Offshore North Sea 1978 Technology Conference and Exhibition' will be held in Stavanger, Norway, September 5-8, 1978. Two themes will be presented: 'safe technology for hostile waters' and 'Norwegian oil scene - a pattern is developing'.

- The Centre for Ocean Management Studies of the University of Rhode Island in cooperation with NOAA will be sponsoring a conference on 'Formulating Marine Policy: Limitations to Rational decision Making'. The conference will be held at the University of Rhode Island's Bay Campus in Narragansett, Rhode Island, June 19-21. For further information contact:

  Center for Ocean Management Studies,
  University of Rhode Island,
  Kingston, Rhode Island, 02881
  or call 401-789-1374.

REPORTS AND PUBLICATIONS

- "The Arctic Coastal Zone Management Newsletter" is published monthly as part of the Arctic Coastal Zone Management Program in Alaska. To obtain this document write:

  Arctic Coastal Zone Management Newsletter
  323 East Fireweed Lane,
  Anchorage, Alaska, 99503.

- The International Institute for Applied Systems Analysis has published a report by D.W. Fisher entitled "A Decision Analysis of the Oil Blowout at Bravo Platform". This and other publications may be obtained from the Publication Department, International Institute for Applied Systems Analysis, A-2361, Laxenburg, Austria (Tel: 02236/7521 Ext: 401). Orders should be accompanied by a check payable to IIASA Publication Department or evidence of bank transfer to: Creditanslalt Bankverein, 1010 Vienna, Scholtengasse 6, Account Number 23-76788. Unfortunately, the editors of this newsletter were unable to ascertain the exact price of this particular publication.

- The following reports are available from the U.S. Department of Commerce, National Technical Information Service, Springfield, Virginia, 22161; telephone (703) 321-8543. Most reports are also available on Microfiche at $2.25 (U.S.) each. Canadian buyers add $2.50 to each paper copy and $1.50 for each microfiche report.

  "Oil Persistence in Tundra and Its Impact on the Belowground Ecosystem. Progress Report, June 1, 1976 - March 1, 1977". D.K. Miller. Virginia Polytechnic, Blacksprurg. 153 p. ORO/4940-2.

  "Gulf Underwater Flare Experiment (GUFEX): Effects of Hydrocarbons on Phytoplankton". J.M. Brooks, G.A. Fryxell, et al. Texas A & M University, College Station. 33 p. PB-276 482/7SL.

  "Input of Low-Molecular-Weight Hydrocarbons from Petroleum Operations Into the Gulf of Mexico". J.M. Brooks, B.B. Bernard, et al. Texas A & M University, College Station. 14 p. PB-276 488/4SL.

  "Biodeterioration of Oil Spills (A Bibliography with Abstracts)". E.A. Harrison. NTIS, Springfield, Virginia. January, 1978. 123 p. NTIS/PS-78/0043/6SL.

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  "Oil Spill and Oil Pollution Reports". P. Melvin, H. Ehrenspeck and P. Norden. California University, Santa Barbara. November, 1977. 389 p. PB-276 691/3SL.

"Performance Testing of Spill Control Devices on Floatable Hazardous Materials". W.E. McCracken and S.H. Schwartz. Mason Co. Inc., Leonardo, new Jersey. November 1977. 152 p. PB-276 581/6SL.

"A Field Manual For Breaking Emulsions in Navy Bilge Collection and Treatment Systems". R.C. Little and D. Taylor. Naval Research Lab, Washington, D.C. December 1977. 11 p. AD-A049 450/0SL.

"Theoretical Study to Determine The Sea State Limit for The Survival of Oil Slicks on the Ocean". P.P.K. Raj. Arthur D. Little Inc., Cambridge, Massachusetts. June 1977. 275 p. AD-A049 794/1SL.

"Development of a Spilled Oil Recovery Separator for Use as Part of an Oil Spill Removal Device". A. Harvey, W. Mack, et al. Foster-Miller Associates, Inc., Waltham, Massachusetts. October 1977. 105 p. AD-A049 711/5SL.

"M/V ELIAS Explosion and Fire at Fort Mifflin, Pa., on 9 April 1974 with Loss of Life". Coast Guard, Washington, D.C. September 1977. 43 p. AD-A049 845/1SL.

"SS SANSINENA (Liberian); Explosion and Fire in Los Angeles Harbor, California on 17 December 1976 with Loss of Life". Coast Guard, Washington, D.C. November 1977. 54 p. AD-A049 805/5SL.

"Assessment and Significance of Sediment-Associated Oil and Grease in Aquatic Environments". L.H. Disalvo, H.E. Guard and N.D. Hirsh. Naval Biosciences Lab., Oakland, California. November 1977. 154 p. AD-A050 044/7SL.

"The Biological Effect of Oil Spills (A Bibliography with Abstracts)". E.A. Harrison. NTIS, Springfield, Virginia. March 1978. 247 p. NTIS/PS-78/0193/9SL.

"Biodeterioration of Membrane Separators for Use in an Oil Pollution Prevention System". M.E. May and R.A. Neihof. Naval Research Lab., Washington, D.C. December 1977. 59 p. AD-A050 121/3SL.

"Towed Planing Sled for Delivery of Oil Pollution Control Equipment, Addendum 1. Improved Version". R.S. Ward. Naval Coastal Systems Lab., Panama City, Florida. August 1977. 30 p. AD-A050 150/2SL.

"Offshore Pipelines (A Bibliography with Abstracts)". G.E. Habercom. NTIS, Springfield, Virginia. March 1978. 126 p. NTIS/PS-78/0179/8SL.

"Environmental Management of a Ship Channel-Harbour Complex". M.W. Reavis and R.W. Hann. Texas A & M University, College Station. November 1977. 146 p. PB-278 145/8SL.

"Effects of Sub-Lethal Oil Levels on the Reproduction of a Copepod, 'Nitocra Affinis'". J.F. Ustach. North Carolina State University, Raleigh. November 1977. 22 p. PB-278 129/2SL.

"Modeling Methods for Predicting Oil Spill Movement". R.J. Rath and B.H. Francis. Oceanographic Institute of Washington, Seattle. March 1977. 106 p. PB-277 669/8SL.

BRIEF NOTES

▶ The article entitled "The Flow Structure Of An Underwater Oil Blowout" which appeared in the January - February Newsletter (Volume 3.1) was extracted from the report "An Oilspill Scenario For The Labrador Sea" prepared by C-CORE as part of the Arctic Marine Oilspill Program (AMOP). Copies of the entire report should be available shortly in the AMOP report series. The extensive use of results from Nordco and other research groups in preparing the article is acknowledged.

▶ The 'New Products' section in the last issue of this Newsletter illustrated Vikoma's Oceanpak and implied that the vessel is part of the system. The system is actually a module that may be placed on the deck of an appropriate vessel.

▶ ANNOUNCING--A COMPENDIUM ON PRODUCTS FOR OIL SPILL CONTROL AND CLEANUP

In recent years, enormous increases in the scale of worldwide oil operations, and the enactment of strict environmental legislation have helped to spur the development of a broad range of products and materials designed for the detection, control, and cleanup of oil spills in the aquatic environment. In a research project sponsored by the U.S. Environmental Protection Agency, members of Marine Science Institute, University of California are presently compiling a compendium on such products and equipment. Scheduled for publication in early 1979, the compendium will provide a source of standardized and concise product information for those in industry and government concerned with oil spill control.

Information sheets on four major categories of products will be included in the compendium: 1) equipment for detecting and monitoring oil pollutants on or in water; 2) floating booms and other spill containment barriers; 3) skimmers and multipurpose vessels for spill cleanup; and 4) chemically or physically active oil spill treating agents, such as sorbents, sinking agents, gelling agents, collecting agents, biodegradation aids, combustion aids, and beach sealing agents. Dispersants are specifically excluded from this compilation as they will be reviewed elsewhere.

Domestic and foreign manufacturers are asked to provide a list of their relevant products, general product information, and the name of a contact person to Helmut Ehrenspeck, Marine Science Institute, UCSB, Santa Barbara, CA 93106. Information provided will be compiled into standardized data sheets, and the data sheets will be submitted to the companies for additional information or data verification and approval prior to publication.

PRELIMINARY REPORT - BEDFORD INSTITUTE OF OCEANOGRAPHY SCIENTIFIC VISIT TO "AMOCO CADIZ" SPILL SITE

Submitted by: J.H. Vandermeulen, D.E. Buckley, E.M. Levy, B.F.N. Long, P. McLaren and P.G. Wells
Bedford Institute of Oceanography
Dartmouth, Nova Scotia
B2Y 4A2

Because of the ecological and coastal similarities of the Britanny coastline to the Canadian maritime region, a group of six Bedford Institute of Oceanography (B.I.O.) scientists, representing a wide range of scientific expertise and with extensive oil spill experience, visited the North Brittany coast for first-hand surveys of ecological damage assessment and to establish scientific contact with French counterparts for further long-term studies.

HISTORICAL

The Liberian-registered supertanker "Amoco Cadiz", carrying 220,000 tons (68,000,000 Imperial Gallons) of light Arabian and Iranian crude oil, drifted aground March 16, 1978, on the rocks of Portsall, 7.5 km off the northwest coast of Brittany, France. Approximately 14,400,000 gallons were spilled during the initial grounding, and a combination of strong westerly winds and westerly shore currents drove the resulting slick along the north coast of Brittany. With further release of crude oil from the stranded tanker, a 20 km wide slick moved easterly toward the Bay of Morlaix and the English Channel Islands, oiling extensive stretches of shoreline in the process (see attached map).

Eventually the wreck was bombed because of fear that the remaining cargo of crude oil could not be taken off the wreck by pumping and would thereby present a continuous unknown contamination problem for the North Breton fisheries and tourist industries. In the end she was holed with depth charges, releasing the remainder of her cargo.

B.I.O. RESPONSE

Immediately after news of the grounding reached B.I.O., Dr. R. Trites established telephone contact with the Centre Océanologique de Bretagne (C.O.B.) laboratory at Brest, in an attempt to gather information on scientific activities regarding immediate and long-term spill behavior and impact. A B.I.O. committee consisting of Mr. D. Buckley (Atlantic Geoscience Center), Dr. D. Nettleship (Canadian Wildlife Service) and Dr. J. Vandermeulen (Marine Ecology Laboratory) together with Mr. B. Nicholls (Director General's Office, Atlantic) met to monitor spill news relayed by an Environmental Protection Service (EPS) observer*, and to assess French and other scientific activities emerging following the spill. Telephone contact was also made with United States and United Kingdom colleagues to evaluate international scientific volunteer participation.

* Two Canadian site observers, one from Environmental Protection Service and one from Transport Canada, were on the scene immediately after the grounding of the "Amoco Cadiz".

At the specific invitation of M. Lucien Laubier, director of C.O.B., the group* left B.I.O. on April 6 for C.O.B. and returned from France on April 16, with actual field work carried out from April 8 to 14. The visit was delayed until 3 1/2 weeks after the grounding of the tanker, primarily so as not to get underfoot of French clean-up activities.

FRENCH CLEAN-UP OPERATIONS

The spill has presented clean-up problems both offshore and onshore since the body of the spill did not all come onto land, with a large but undetermined amount continuing to remain free at sea.

French offshore efforts were limited largely to dispersant spraying in waters over 50 m depth, although some small amounts of oil were picked up. Generally, offshore activities were limited to following the spill movements and to observations.

Shoreline clean-up has been extensive, awesome and nearly miraculous with large numbers of soldiers, local citizenry and volunteers carrying out an essentially manual clean-up operation. Except for some local dispersant use (e.g. near Roscoff and near Lilia), all clean-up was done by a combination of manual pick-up and mechanical pumping. The residue was trucked to inland storage depots (dug-outs) for further handling. On sandy beaches trenching was frequently used to aid in collecting stranded oil. The use of heavy equipment was limited, apparently largely on the advice of the French scientific community (coordinated through M. Laubier of C.O.B.). The apparent absence of heavy earth-moving equipment such as road-graders in Brittany may have been another factor.

FRENCH SCIENTIFIC EFFORT

Effort in this area has been from various government and university sources (see attached), and has been coordinated through the office of M. Laubier, director of C.O.B. at Brest. There exists presently little established French expertise committed to oil spill research, despite frequent tanker accidents including oiling of that particular coastline in 1967 during the "Torrey Canyon" disaster.

Generally the scientific attitude to date has been to continue the established research programs in fisheries and intertidal studies, such as the long-term work carried out at Roscoff, incorporating "Amoco Cadiz" - related observations when relevant. There appeared to be no immediate redirection of funds or effort specifically to study problems related to oil pollution. However, a large number of environmental samples (fish, etc.) were collected, in advance of the

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* Mr. D. Buckley (AGC/GSC) - geochemistry
Dr. E. Levy (AOL) - chemical oceanography
Dr. B.N. Long (AGC/GSC associate) - geomorphology
Dr. P. McLaren (AGC/GSC) - sedimentology
Dr. J.H. Vandermeulen (MEL) - environmental biology/physiology
Dr. P.G. Wells (EPS) - environmental toxicology

slick, by the Institut Scientifique et Technique des Pêches et Sciences de la Mer (ISTPM), Nantes. Also intertidal benthos were collected by students and faculty of the University of Bretagne Occidentale. These various samples will be analyzed for baseline hydrocarbon concentrations at the University of Brest, and are to serve as a baseline file for the spill.

Three short scientific cruises were carried out from C.O.B. to track the offshore movement of the oil, to measure the concentration of aromatic fractions in the water column "downstream" from the wreck and the chemical/biological consumption of dissolved oxygen, and to carry out some assessment of the impact of the oil on pelagic organisms. There are also plans at C.O.B. to carry out an integrated study of oiled estuarine environments, and to do some physiological studies on marine organisms.

FOREIGN SCIENTIFIC INVOLVEMENT

This included several United States groups, and to a much lesser extent other European interests, primarily British. The United States NOAA organization had representatives of its Spilled Oil Research (SOR) team on site within days of the spill, and by team rotation has kept and plans to keep continuous representation in the area for possibly up to several months. NOAA interests consisted mainly of spill trajectory work, a beach survey and weathering effects on oil chemistry. They have run a well-financed site program, including interpreters and repeated helicopter and fixed-wing overflights - all part of NOAA's $25 million oil spill research program. Aside from their own interests they have also acted in an advisory capacity to the French navy in spill trajectory and have provided some clean-up advice.

The United States Environmental Protection Agency has had several of its people of the scene, principally interested in spill clean-up, but also carrying out some basic measurements of hydrocarbon concentration in tissue. In addition there have been visits by a number of independent groups and individuals.

British effort consisted of observers and dispersant experts on offshore vessels in the event of movement of the slick into British waters or threatening British shoreline. Although direct involvement by the British has been small, scientific interest has been significant.

B.I.O. GROUP VISIT - GENERAL SCHEDULE

Our visit, because of the limited time available, was primarily of a reconnaissance nature. Following an intensive three-day shoreline survey covering circa 250 km, however, the group split up for more detailed re-examination of 32 specific sites. Over 300 samples (sediment, water, fauna) were taken for later analysis at B.I.O.

The three-day general survey aimed at a multi-disciplinary evaluation of spill behavior in different coastal environments and of impact on related biota. Where possible, unoiled control sites were included, although these were extremely rare. Besides the beach environments, three tidal estuaries and a heavily oiled saltmarsh were studied with environmental samples collected from each. In addition, group members participated in two fixed-wing overflights of the entire north shore of Brittany for an aerial survey of both shoreline and offshore oil distribution.

During the second half of the visit specific areas were revisited, in some cases several times, for more detailed study. In these we were accompanied by staff from both C.O.B. and the Marine Biology Laboratory at Roscoff, and a number of coastal and biological projects were initiated, both within the B.I.O. group and with French colleagues.

Circa 550 lb of scientific collecting gear, including sampling and coring equipment, disposable clothing and waders (as well as a small amount of analytical grade solvent) were carried as extra baggage to allow flexibility and independence in the field.

OIL CHEMISTRY OBSERVATIONS

During the days immediately following the release of oil from the "Amoco Cadiz", the most noticeable component of the weathering process was the evaporation of volatile substances (there were numerous reports of nausea amongst people exposed to the vapors). Even during the visit of the B.I.O. group, circa four weeks after the spill, the odor of crude oil combined with decaying marine fauna and flora created a disagreeable stench in some localities and several complained of nausea and headaches.

Soluble aromatic compounds were observed by French scientists in the water column in the region extending from the wreck to the Baie de Saint-Brieuc and offshore. Concentrations of oil in the water decreased with distance from the wreck, but interestingly, a corresponding decrease in oxygen-undersaturation was also observed. This suggests that the chemical/biological oxygen demand of the oil was having a significant impact on the concentration of dissolved oxygen. It also implies possible biological repercussions.

On the shoreline, the oil was present as "chocolate mousse" and in several places, where pools of oil had accumulated and remained undisturbed, there was evidence that the water-in-oil emulsion was separating into a layer of free black oil overlying the emulsion. The surface of the oil layer was crusty and dry, suggesting that further weathering in these pools of such stranded oil, if left undisturbed, would proceed much more slowly because of this protective layer.

On many beaches oil had become buried in the sand, both through natural processes and clean-up operations. It is expected that under these conditions the oil will weather very slowly and that its impact on the environment will be greatly prolonged. In some localities the emulsion had mixed with the sand and formed potato-size lumps which were more dense than seawater.

COASTAL OBSERVATIONS

Three main geomorphological environments are found along the Brittany Coast; sandy beaches with rock headlands and dune or rock back-shore areas, macrotidal estuaries, and salt marshes. By far, the combined beach and rocky shoreline is the most common, and is the area of most concern as a recreational resource.

Most oil observed on the surface of sandy beaches was in the form of "chocolate mousse" and was distributed in continuous layers on freshly oiled beaches or in the form of "blobs" and strand lines on most of the beaches that had been partially cleaned or re-oiled. Oil was also found buried in layers of "chocolate mousse" at depths up to 60 cms. These layers represented a considerable potential for recontamination of intertidal areas at later stages in the cycle of changing beach profiles. This oil burial process was one of the interests of the B.I.O. group, and further studies are planned on later visits to the area. Rocky headlands or cobble-strewn shorelines retained oil most commonly in association with dead or dying marine macro-vegetation.

Estuarine inlets were most heavily oiled at the upper limit of the high water zone; this being the area of the vegetated fringe above the intertidal mud banks. The oil in the fringe was slowly released during lower tides with a continuous film often flowing over the smooth mud surfaces. Virtually no direct penetration of oil could be observed into the black reduced muds below the thin oxidized layer at the surface except by way of the openings of living, burrowing organisms.

The salt marshes retained the highest concentration of oil per square meter of surface area. Thick deposits were trapped in the grasses and small high tide creeks. As is the case with the estuaries, this oil is constantly draining through the creeks and mud banks, with little physical penetration into the subsurface muds.

French clean-up techniques were for the most part labour-intensive, manual, and not massively destructive of the natural environment. In some cases, however, the necessary traffic, trenching and removal of materials will have some long-term detrimental effects.

BIOLOGICAL/ECOLOGICAL OBSERVAITONS

Necessarily the biological survey was restricted to macroscopic organisms of the intertidal areas, although some impressions were formed of offshore toxicity through observations on stranded sublittoral organisms. Generally in all marine environments visited, oiling was accompanied by large to massive mortality of animal life, however, with some notable exceptions.

In rocky areas most molluscs (marine snails in particular) and shore crabs were wiped out, and tide pools were devoid of life. Throughout the rocky intertidal areas, however, many limpets were found alive, and apparently in reasonable shape, possibly protected by the algal foliage covering the shore boulders and rocks. Very few small limpets could be found, however, in most places.

The lower-energy beach environments such as sand or mudflats also were hit hard, with large mortality observed in the crustacea and pelecypods. The exceptions were the burrowing annelids, large numbers of which appeared to have survived the initial three weeks following the tanker spills. Their survival was also observed in a heavily oiled saltmarsh, where in the marsh drainage channels both annelids and some small fishes were found alive. However, in the main body of the marsh mortality was extensive, if not total. Occasionally small knots of moribund annelids were observed in minute depressions of trapped marshwater.

In the oiled tidal estuarine systems mortality was significantly lower, and many areas appeared normal. Even here, however, recently dead bivalves were seen floating in tidal channels several kilometers inland, and many dead crabs were present amongst the vegetation in the high water areas.

The general preliminary impression was that heavy mortality in those macroscopic intertidal organisms normally exposed to the environment, such as the crustacea, and therefore vulnerably exposed to oiling. Burrowing organisms in sub-tidal sandflats or marsh drainage channels appeared less affected. Burrowing organisms in estuarine mudflats, such as soft-shell clams and annelids, also survived remarkably well, possibly due to the apparent lack of penetration of oil into the mud substrate, at least during this initial post-spill phase.

No direct observations were made of offshore or sublittoral impact. However, a large number of dead Echinodardium and dead and moribund bivalves (Cardium, Venus, and two species of razor clams) were found washed up on a sandy beach near St. Michel, indicating a considerable toxicity of oiled seawater in the sublittoral environment, below the surface slick.

No fish kills were observed during our visit.

There was a large bird kill associated with the spill, although only estimates of numbers are presently available. Most of the deaths occurred in the diving birds, with the largest mortality observed in cormorants.

Unlike normally, very few foraging birds were observed along the coast, although on the last day of the visit some shorebirds (sandpipers?) were observed on the sandflats in Portsall Harbor. A few gulls were seen feeding in a tidal river several km inland.

FRANCE-CANADA CORRESPONDENCE & COLLABORATION

Both collaboration on a "lab-to-lab" level as well as between individual scientists was established during the visit, and it is anticipated that some long-term studies will be carried out on a collaborative basis.

A number of studies were initiated, including studies of weathering and bio-availability of stranded oil in high energy shore environments, chronic impact of oiling in estuarine mudflats, shoreline processes involving oiling and weathering, and relationship between tissue hydrocarbon loads and weathering on surface slicks.

Contact was established not only with C.O.B., but also with the Marine Fisheries Laboratory at Roscoff (part of the University of Paris) with the view toward future collaborative activities relating to spill impact.

Two members of the B.I.O. group, Drs. Long and Vandermeulen, are planning to revisit the area in June of 1978 at the invitation of the directors of C.O.B. and the Roscoff Laboratory, in order to continue follow-up observations on beach changes, weathering of stranded oil and biological impact.

FRENCH SCIENTIFIC EFFORT

Centre Océanologique de Bretagne (C.O.B.), Brest
- marine geology, marine biology, marine chemistry

Institut Géographique National (I.G.N.), Paris
- remote sensing

Institut Scientifique et Technique des Pêches et Sciences de la Mer (I.S.T.P.M.), Nantes
- fish control

Société d'Etude de la Protection de la Nature en Bretagne (S.E.P.N.B.)
- bird (cleaning stations)

Service Hydrographique et Océanographique de la Marine, Brest (Navy), (S.H.O.M.)
- weather analysis

Université de Bretagne Occidentale, Brest
- marine biology (both at Brest and at the Roscoff Laboratory)
- birds

Université de Haute Bretagne, Rennes
- marine biology (east of Roscoff)

Université de Paris through their Station Marine de Roscoff
- marine biology (Roscoff area)

Location of the AMOCO CADIZ Spill

AN ICE-OIL BOOM - FROM TSANG'S FOLLY TO TSANG'S BOOM

Submitted by:

Dr. G. Tsang
Hydraulics Research Division
Canada Centre for Inland Waters
P.O. Box 5050
Burlington, Ontario
L7R 4A6

Phone: (416) 637-4735

and

N. Vanderkooy, Manager
Environmental Emergency Branch
Environmental Protection Service
Ontario Region
135 St. Clair Avenue West
Toronto, Ontario
M4V 1P5

Phone: (416) 966-5840

The title of this newsletter reflects neither egoism nor resentment, but the usual progression from skepticism to rejoicing in the business of research and development; the boom was so referred to during its development.

When oil is spilled in rivers with drifting ice floes, the conventional containment booms and recovery apparatus have great difficulty in performing their functions. The ice floes will rip the conventional booms apart and jam the intakes of the recovery machinery. In fact, even the operation of small crafts in a fast current with drifting ice floes not an easy task. The small vessels can capsize easily when rammed by large ice floes.

The presence of ice floes in rivers during winter months is not uncommon and is not necessarily confined to spring breakup months. Statistical analysis of the ice conditions in Detroit and St. Clair rivers showed that the most likely form of ice in the two rivers is ice floes. An aerial survey made in the winter of 1974 showed that most ice floes were less than the tennis court size. However, occasionally large floes spanning up to half the river's width would drift down.

To contain and recover oil in an ice infested river, an ice free area has to be created first where conventional clean up gear may be employed. Such an area is obtained if a barrier can be set up which while permitting the oil slick to pass through, will bar ice floes from entering the area.

In a study on how to contain and recover spilled oil on the Detroit and St. Clair rivers in winter should such an oil spill occur, Tsang (1975) proposed the use of perforated boom at an angle to the flow. While the slick should have little difficulty in passing through the boom through the openings provided, the ice floes would be guided by the boom and deflected to one side.

The above study was conducted for "Operation Preparedness, Oil Spills on St. Clair and Detroit Rivers", an international joint program between Canada and the United States to investigate countermeasures in case of an oil spill in the two rivers.

Initially, it was proposed to anchor the boom by its two ends, very much the same way as the anchoring of conventional canvas booms or ice booms. Parallel theoretical studies and laboratory experiments were carried out at the Canada Centre for Inland Waters (CCIW) at Burlington, Ontario.

As a consequence of participating in a field exercise to evaluate conventional booms under summer conditions (Vanderkooy et al, 1976), the difficulty and danger of anchoring a boom by its two ends under winter conditions became readily apparent. It would be very desirable if an ice-oil boom could be developed which needs only to be anchored at one end, preferably to the shore.

Inspired by the ruddering principle and the use of glance booms in the lumber industry, the concept of developing a finned, perforated boom was conceived. To describe the concept briefly, the conceived boom is to consist of a sturdy boom body and a number of short fins or rudders (see Figures). The angle between the boom and the fins is adjustable. The upstream end of the boom is tied to the shore. When the fins are closed, the boom aligns is in the direction of the flow. As the fins are gradually opened, the impinging of the current on the fins will bring the boom gradually into the flow. The out-swung boom prevents the ice floes entering the area behind it and thus creates the desirable ice free area. Openings are provided to the boom for the oil slick to pass through. By making the openings in the direction of the flow, the oil slick encounters little resistance. After passing through the boom, the oil may be contained and recovered by conventional methods in the ice free area.

Further theoretical and laboratory work were conducted at CCIW along the above line, out of which the design of a prototype boom was produced.

The U.S. Coast Guard was interested in the concept and funded the construction of the prototype boom in 1976. The project of constructing and testing the prototype boom was coordinated by Cmdr. C.R. Corbett of the 9th U.S. Coast Guard district, Captain C. Beckett of the Canadian Coast Guard and N. Vanderkooy of the Environmental Protection Service, Environment Canada.

Six sections of the prototype boom were constructed. Each boom section measured 2' wide x 1' high x 20' long and was made of timber. A 50 percent opening was provided for the middle six inches of the boom in the form of four openings of equal size (see Figure 1). The openings were at 45° to the longitudinal direction of the boom. Two fins, measured 1' x 8', were attached to each boom section. A 2' gap was allowed between the fin and the boom (see Figures) to reduce turbulence. Eye rings were provided to the ends of the sections and the boom sections were connected by shackles. The construction was completed in 1977.

The field testing of the boom was carried out during 21-22 March 1978 at Amherstburg, Ontario at the Canadian Coast Guard Base. The participating agencies included the U.S. Coast Guard, The Canadian Coast Guard (through Captain J. Bennett), Environmental Protection Service and Canada Centre for Inland Waters. The U.S. Corps of Engineers also provided survey supports.

With the help of a mobile crane, the fins could be fitted to a boom section and the assembled section could be placed from land to water and connected to other sections in water in about 15-20 minutes. With the help of a tug boat, another half an hour was needed to shackle the fins to a cable. The assembling was done in the bay of the Canadian Coast Guard Base and the assembled boom was towed into the Detroit River by tug and tied to one of the bollards on the dock. The surface current at the test site was a little more than 2 ft/sec. (1.2 knots).

The Tsang boom performed well during the test. The boom to current angle responded well to the adjustment of the angle between the fins and the boom. The maximum angle attained between the boom and the current was about 40° and that happened when the fin angle was about 115°.

The boom deflected ice floes nicely. For ice floes as large as 50' x 50' (and 1' thick), such as the one shown in Figure 1, they were deflected smoothly to the outer current with the boom yielding only 3° - 4°. Once the ice floe had passed, the fins would push the boom further into the current again.

When a large ice field covering almost the entire river surface arrived, such as in the case shown in Figure 2, the boom would yield completely by swinging into the direction of the flow and by so doing avoiding the excessive stress which otherwise would have been produced. As soon as the ice field passed, the boom would swing back into the current to perform its function once again.

The force generated by the current on the 120 foot long boom was moderate. The boom could be dragged under working conditions by two strong men and the manipulation of the fins could be handled by two men of average strength.

The boom was very stable, even when hit by a fair sized floe, as exemplified by the two rather relaxed workers working on the boom as shown in Figure 1.

To test the ability of the boom to oil slicks, plastic chips were released upstream from the boom as shown in Figure 3 to simulate oil. By visual estimation more than 95 percent of the simulated oil passed through the openings. Should the boom be longer, a higher percentage could pass through the boom. Some oil simulant was caught between ice floes and could not flow through the boom even had the boom been longer. It is seen from Figure 3 that some ice chips and slush ice also managed to pass through the boom. However, they should pose little problem to clean up operations since they were not in concentrated masses.

Although it is seen from the figures that wood wedges were hammered in between the boom sections to make the boom a rigid barrier, in the field test, the boom was first tested as a flexible boom with the sections just hinged together. The field test showed that such a flexible boom deformed excessively when hit by ice floes of relatively large size. Such an excessive deformation, of course, was not acceptable. Since the deformation could be eliminated and the boom as a whole performed much better when wedges were used to make the boom a rigid one, the subsequent tests were made on the rigid boom only.

After flowing through the openings, the surface current was deflected by the fins. A shoreward surface current thus was created behind the boom as can be seen from the streaklines of the oil simulant in Figure 3. This surface current transported the oil simulant to the shore and the plastic chips were seen piling against the shore. Such a diversion of the oil slick by the boom to the shore, of course, is very desirable because it diverts the oil to where the recovery apparatus is logically located.

To sum up, the field test showed that the Tsang boom served its purpose very well and should find wide application in oil containment and recovery in ice infested waters. As a matter of fact, it may also be employed under summer conditions to deflect the oil to the recovery site and/or to serve as a protector of recovery equipment from floating debris. The boom can be made less expensive and its deployment can be made less time-consuming by improving the engineering design.

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FIG.1 DEFLECTION OF ICE FLOE BY BOOM

FIG. 2 YIELD OF BOOM UNDER HEAVY ICE

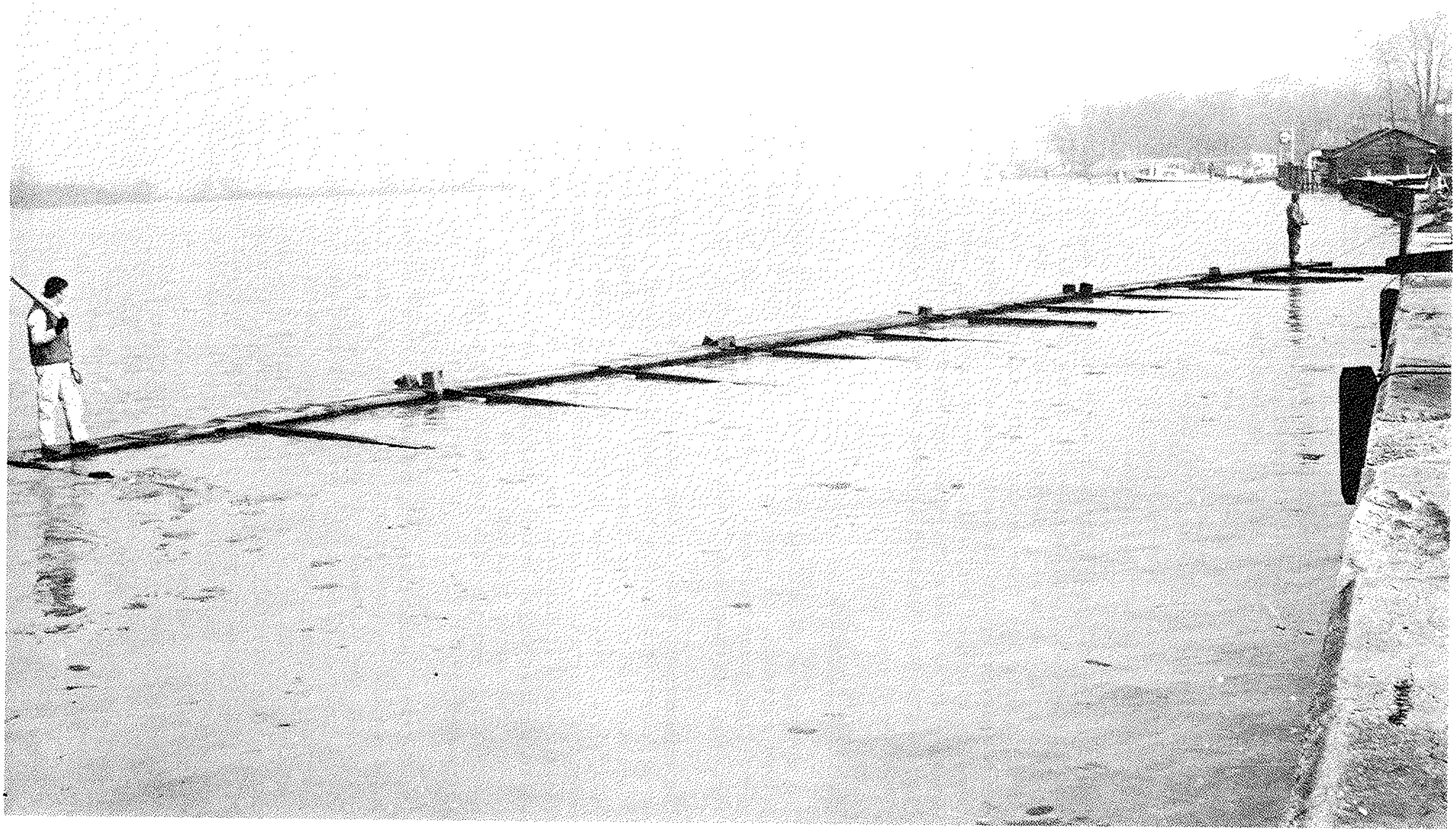

FIG.3 PASSING OF OIL SIMULANT THROUGH BOOM

A PREDICTIVE OIL SPILL SURFACE DRIFT MODEL FOR THE LABRADOR SEA

Submitted by: Christopher J. Noll
NORDCO Limited
St. John's, Newfoundland
A1B 3T2

Phone: (709) 745-2401

INTRODUCTION

A predictive oil spill surface drift computer model has been applied to the Labrador Sea in order to predict paths of spills originating from drilling locations in the area. Surface trajectories are determined for a one (1) month period. Only ice free periods are considered due to the limited knowledge of ice movements in the Labrador Sea and the effect of ice/oil interaction. Six to ten-year averaged wind data from surrounding coastal weather stations are employed to evaluate the wind and wave-induced currents. Available current data from charts and research cruises are used to determine the prevailing ocean currents.

OCEANOGRAPHIC DATA

The surface drift of oil spills is primarily caused by three processes: 1) wind-driven currents, 2) wave-driven currents and 3) other currents such as tidal and prevailing ocean currents. These currents can be determined by analyzing available oceanographic data for the Labrador Sea area.

The predominant flow in the Labrador Sea is the Labrador Current which is made up of water from Baffin Bay (Canadian Current), Hudson Strait and the West Greenland Current (see Figure 1). Part of the current breaks off and enters the Gulf of St. Lawrence through the Strait of Belle Isle. The remainder continues down the northeast coast of Newfoundland to the northeastern corner of the Grand Banks. Here it divides, one branch going southwest around the Avalon Peninsula while another major branch continues southward along the eastern edge of the Banks. The major portion of the Labrador Currents travels eastward and eventually combines with the Gulf Stream to form the North Atlantic Current (Dinsmore, 1972).

The current velocities are a combination of three currents structures superimposed on each other. They are: 1) base translatory currents, 2) rotary currents, and 3) random currents. Base translatory currents average between 26 and 36 cm/sec. The rotary and random currents normally take the form of eddies less than 30 km in diameter. Seasonal variations in velocities have been compiled for the pilot charts. There is a slight increase in current velocities during the late fall and winter months. It should be noted that the available data are for the general area only, and are not site specific. The majority of the data have been collected during the summer with sparse measurements made during other seasons.

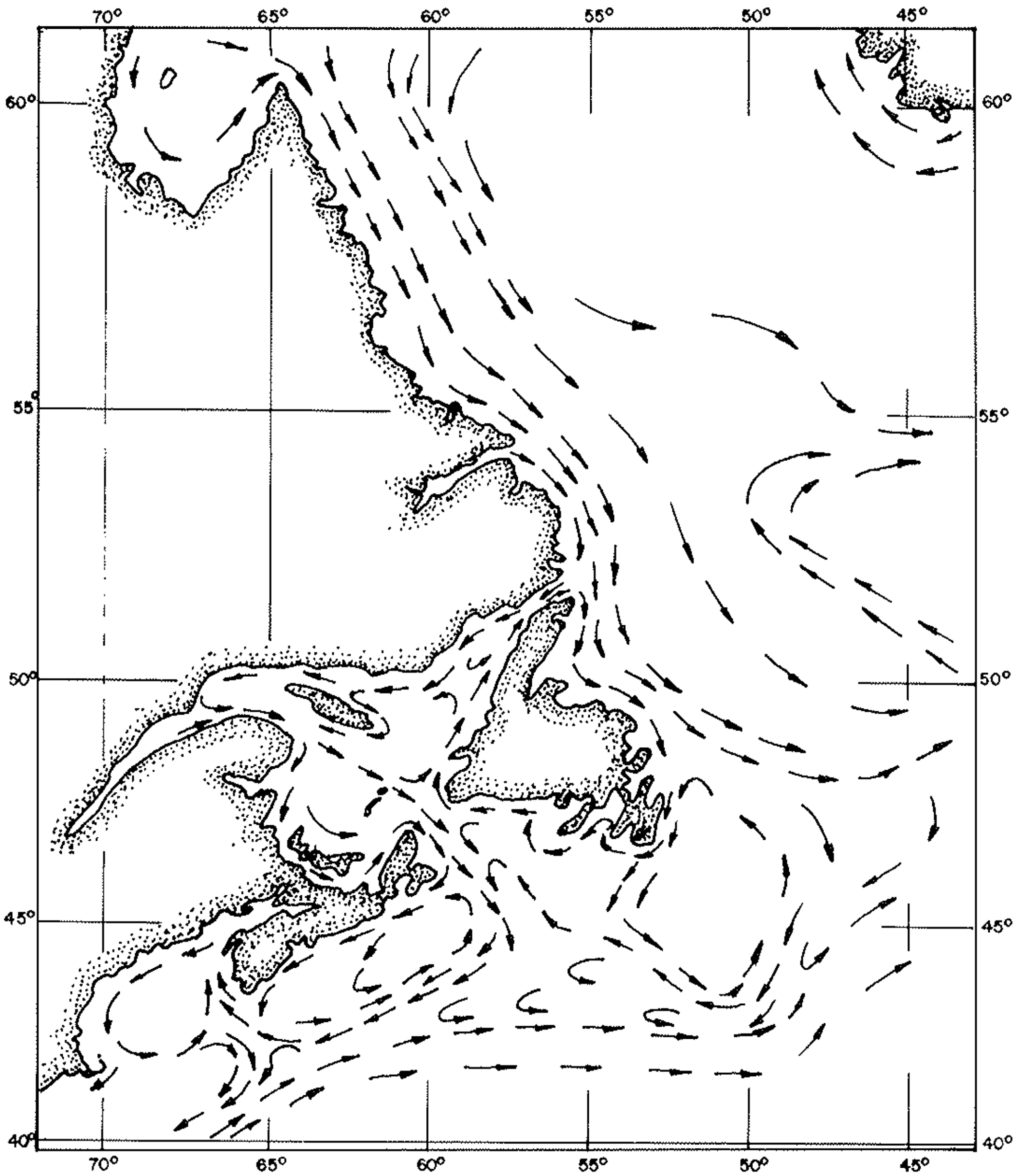

Fig.1 - General Circulation of the Labrador Sea and Grand Banks

(After Dinsmore, 1972)

METEOROLOGICAL DATA

Coastal weather stations have bene collecting basic meteorological data for more than 30 years, and it is wind data from these stations that are used to predict oil movement on the water surface. Although these stations are typically several hundred kilometers away from the blowout sites, (Figure 2), it is felt that the coastal data are more reliable than ships' data because of the latter's coverage of a large area and the probable bias towards fair weather conditions.

Data from Coastal stations show an overall predominance of northwest to southwest winds. However, regional variations do occur. Data from the northernmost stations show frequent southwesterly to westnorthwesterly winds during the winter and northwesterly to northeasterly winds in the summer. The southern Labrador coast experiences frequent southerly to southwesterly winds year round with secondary northerly and westerly winds. During the summer months calm winds occur up to 20% of the time. Data from the southermost stations reveal westerly and southwesterly winds during the winter and summer respectively. Often, during the spring, there is a fairly strong northerly wind. Calm periods occur only about 4% of the time. Wind speed averages range from 8.6 knots in the summer to 21.0 knots in the winter. Stronger winds occur off Newfoundland in comparison with those off Labrador.

Wind speed data from coastal stations are probably not representative of offshore conditions because of the difference in frictional effects of the land and on air movement. However, it appears that in comparison with ships' data, the wind directions for the two cases may be essentially similar and this latter factor is of obvious importance when attempting to predict the direction of oil movement.

MODEL DESCRIPTION

The oil spill drift prediction computer model is designed to predict surface drift only while ignoring factors such as spreading, evaporation and dispersion, which affect the concentration of the oil but not its drift. The direction of the spill's surface movement is independent of volume losses incurred during the drifting process.

As previously mentioned, the surface drift is a combination of wind-driven, wave-driven, tidal and prevailing currents. The resultant drift is the vectoral addition of these currents.

Even though several investigators (Schwartzberg, 1970; Reisbig, 1973; Smith, 1974) have shown that wave effects are coupled to wind effects in a complicated manner and are not simply additive, Wu (1975) has found that there is a relatively constant percent drift which is about 3.5 percent of the wind velocity. Coriolis forces which might be expected to cause a deflection of the oil drift will be ignored due to their inconclusive effect on actual oil spills. For example, during the Torrey Canyon spill, the oil was observed to drift in the direction of the wind. It can be inferred from the incident that Coriolis forces had little, if any, effect on the oil drift.

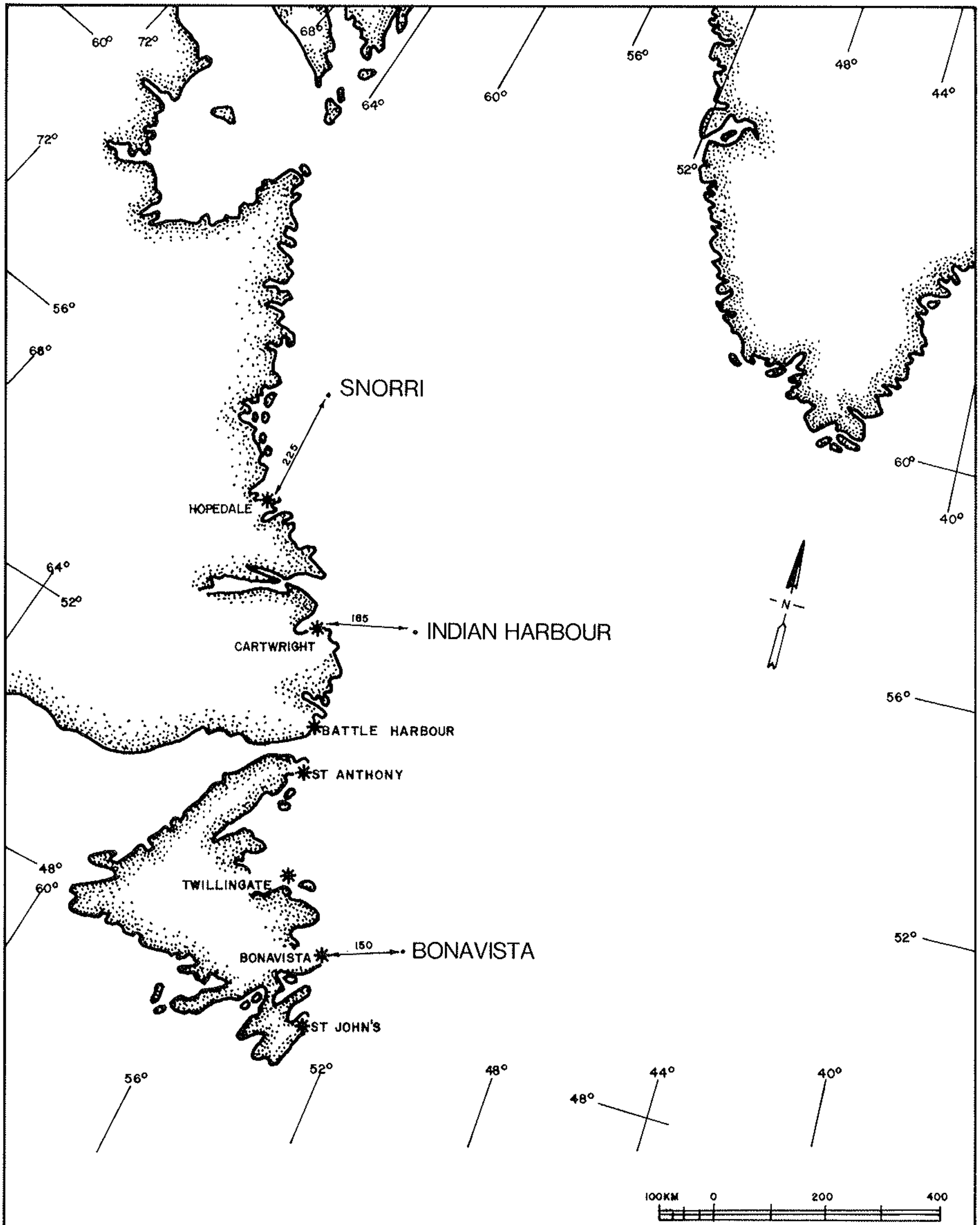

Fig.2 - Distance and Locations of Spill Sites from Climatic Stations

(Distance in Kilometers)

The surface drift caused by the prevailing ocean currents is simply equal to the magnitude and direction of the current itself. The effects of tides and their associated tidal currents have been ignored in the model due to their insignificance at distances well offshore. Such currents will not affect the overall trajectory of an oil slick. Instead the effect will probably be to produce periodic fluctuations that would be insignificant compared to the overall oil movement. However, if the oil movement were to be predicted on a day-to-day basis, as would be the case during cleanup operations, the effect of such currents could not be ignored. In this case, long term predictions are of interest and thus, tidal effects are considered to be negligible.

Averaged wind data are employed to evaluate the wind and wave-driven currents. The prevailing wind speed and direction are chosen by a random number generator in conjunction with the wind data. The resulting current is then determined by applying the 3.5 percent rule. This current is subsequently added vectorially to the ocean current to yield the total surface drift.

Wind data from eight coastal stations (see Figure 2) are used to aid in the oil spills surface drift prediction. Data from the coastal stations nearest the slick at any one time are used to determine the wind and wave-driven current. As the slick moves, the model continuously checks for the nearest coastal station and employs data from that station.

The current structure of the study area has been discussed previously. Such a general treatment does not lend itself well to application in a computer model as the currents in relatively small section of the study area are required. In order to apply the model, the area was discretized, and currents obtained from the Pilot Charts were applied to the resulting grid system. The resulting current scheme contains 30 different current areas. The monthly magnitudes of the current in each of these areas are recorded and used in the model in conjunction with wind speeds to determine the slick trajectory.

The model simulates oil spill drift for one (1) month at three selected sites as listed in Table 1. Prediction are made for July and November to represent the beginning and the end of the drilling season. These months also represent summer and near-winter wind conditions. Five probable paths are plotted for each case using 6-hour time steps. (See Figure 3 to 8). After each time step, the model assess the current and wind data for the position of the slick and modifies the trajectory accordingly. In all cases, the five paths are sufficient to give a reliable prediction of the slicks drift.

In all cases, the oil slick is displaced farther east in November than July. This is due to the frequent and strong westerly winds in November as compared to the more frequent southerly or northerly winds occuring during July. The northernmost site (Snorri) appears to be the most critical with respect to coastline and fishing grounds contamination, particularly in July. At one point, the slick comes within 50 miles of the Labrador coastline (Figure 3). A deviation of the wind from the averaged wind data could easily cause the oil to contact the coastline at this point. The slick's path also crosses some of the prime fishing areas in the Labrador Sea. The Indian Harbour site doesn't pose any problem in these respects. The slick stays well off the coast and is not near any fishing banks. However, the southernmost site (Bonavista) poses a

TABLE 1

Sites of Hypothetical Blowouts

	Site	Time of Year	Duration (Days)
1.	Snorri 57°30'N 60°00'W	July 1st November 1st	30 30
2.	Indian Harbour 54°20'N 54°25'W	July 1st November 1st	30 30
3.	Bonavista 49°10'N 51°15'W	July 1st November 1st	30 30

OIL SPILL DRIFT PREDICTION

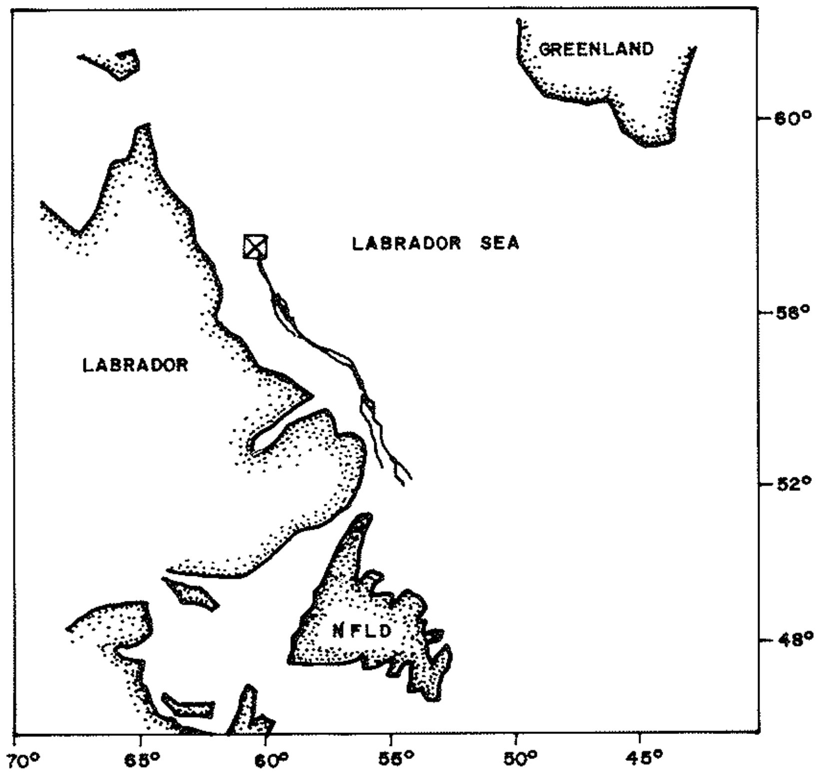

Fig.3 - SNORRI SITE, July 1 - Aug 1

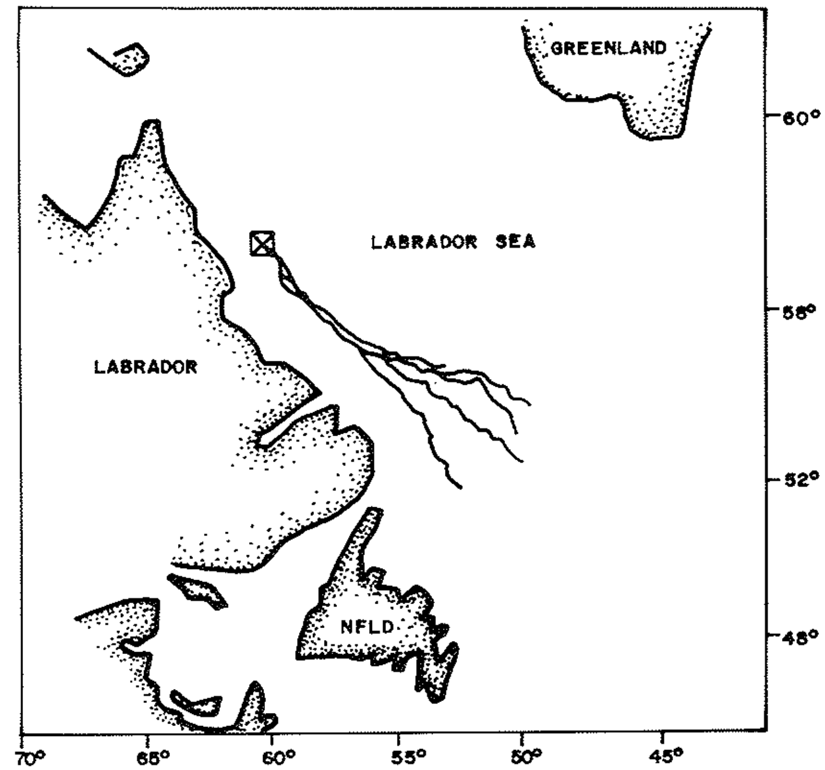

Fig.4 - SNORRI SITE, Nov 1 - Dec 1

OIL SPILL DRIFT PREDICTION

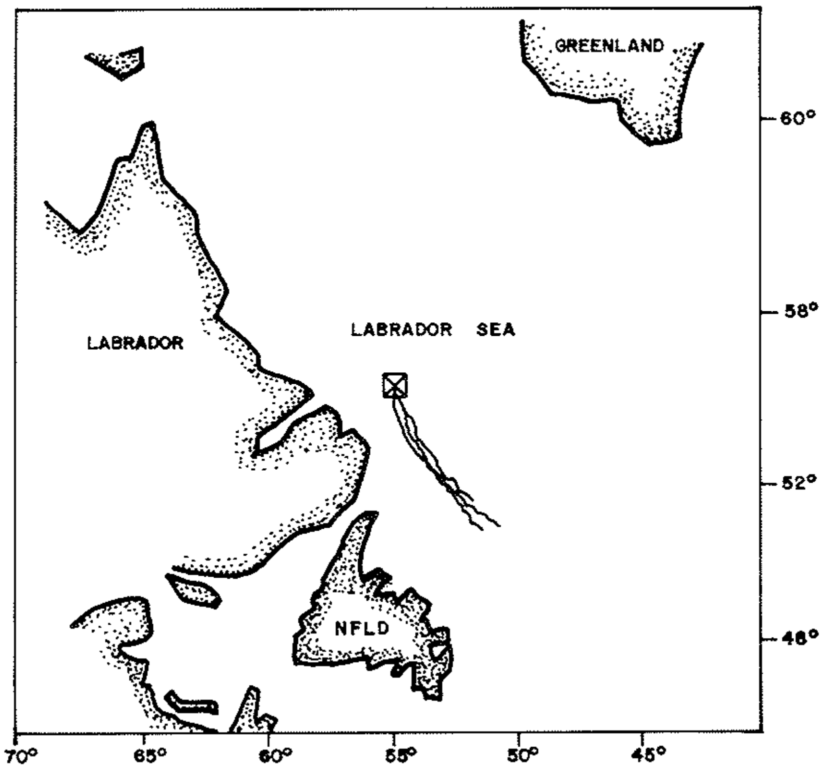

Fig.5 - INDIAN HARBOUR SITE, July 1 - Aug 1

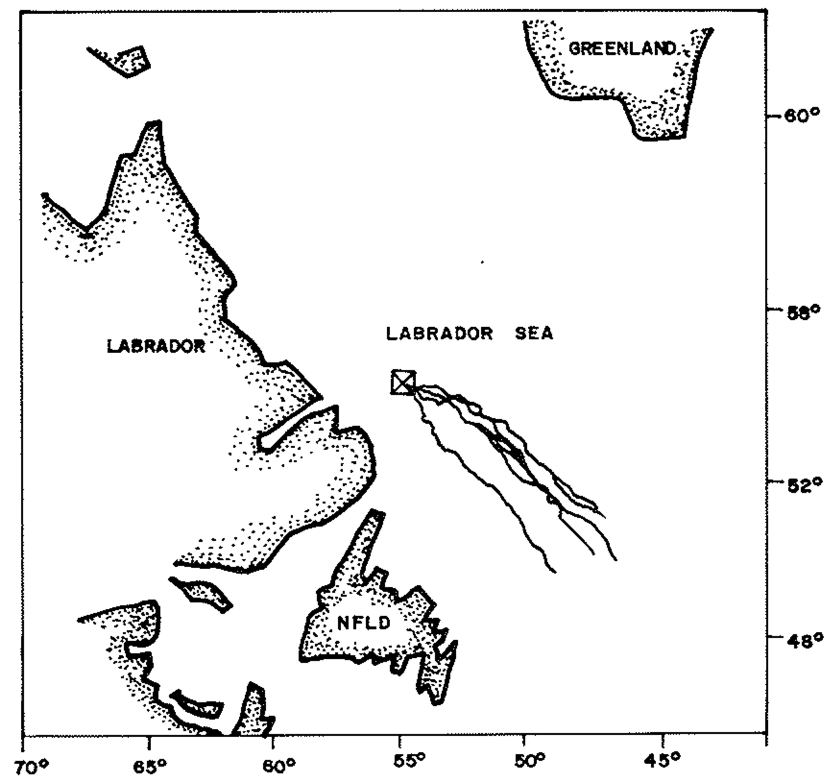

Fig.6 - INDIAN HARBOUR SITE, Nov 1 - Dec 1

OIL SPILL DRIFT PREDICTION

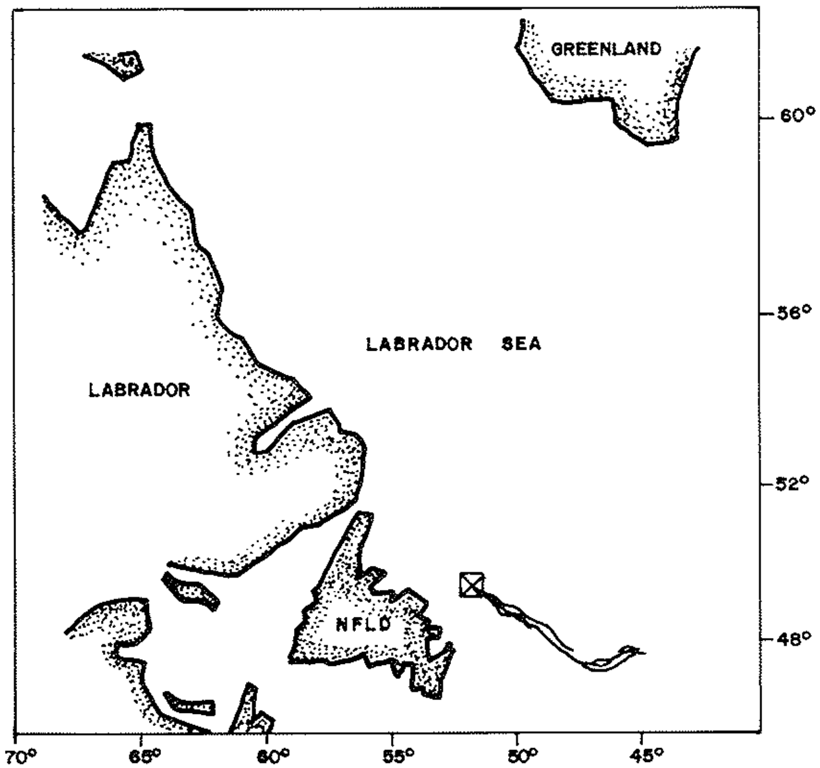

Fig.7 - BONAVISTA SITE, July 1 - Aug 1

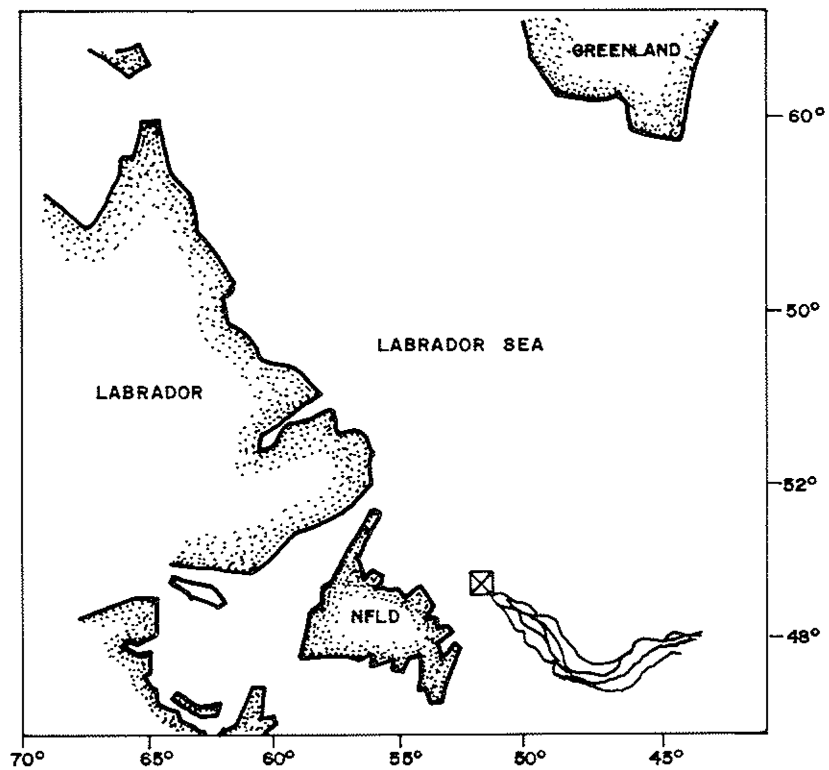

Fig.8 - BONAVISTA SITE, Nov 1 - Dec 1

danger to the northeastern section of the Grand Banks. The oil drifts across this section of the banks before entering the North Atlantic Current and turning northeastward. At all sites, there is considerably more scatter in November due to the stronger winds. This suggests that the slick could affect a larger area at this time of year.

The trajectories presented in this paper represent the most likely path of an oil spill during a particular month of the year. Deviations of the winds and currents which are used as input for this model are likely to occur at the time of an actual spill, thus affecting the spill's path. However, the results of the model are reliable enough to be used as a basis for selecting optimum storage locations of spill clean-up equipment as well as determining the possible danger to coastlines and other ecologically sensitive areas for selected drilling sites.

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RESPONSE TO SPILLS IN ONTARIO

Submitted by: Peter G. Belling
Contingency Planning Officer
Ontario Ministry of the Environment
Toronto, Ontario (Canada)

Phone: (416) 965-2537

Summary

Industry in Ontario, as elsewhere in Canada, is now legally obligated to report and clean-up all accidental discharges of contaminants which could potentially damage the natural environment. Government policy has been to prosecute only when difficulty is encountered by the regulatory agencies in obtaining cooperation from the responsible party for effective and efficient countermeasures. Private enterprise has responded well to this policy and has developed spill contingency plan which serve their individual as well as their collective needs, and established seemingly adequate mechanisms and facilities to deal with the clean-up of spilled materials. Government agencies at the municipal, provincial and federal level have found it necessary to develop spill contingency plans only for 1) incidents requiring resources beyond the capability of the responsible party, 2) incidents where the responsible party refuses to respond, and 3) mystery spills or spills where the responsible party cannot be determined.

The Ontario Government Response

Contaminants have been released to the natural environment ever since the first volcano erupted during the creation of time, and the evolution of all living things has been and continues to be molded by our ever-changing surroundings. In his quest for ever more and newer things, man has concocted and continues to create materials which the present equilbrium of the environment finds difficult to assimilate. The unnecessary discharge of harmful pollutants has received significant attention by the scientific community and the legislators for a number of years. The need to control accidental releases of contaminants has received attention only recently. Spills generally involve large quantities of pure hazardous chemicals or solutions containing extremely high concentrations of harmful substances when compared with "normal discharges" from process facilities or treatment systems. Governments at various levels are now forcing those in charge and owners of contaminants to accept the responsibility to contain and clean-up spilled contaminants and to restore affected areas. To reduce the burden on the environment imposed by spilled contaminants, legislation at the federal and provincial level is now in place which prohibits the discharge of contaminants to the natural environment of Ontario and forces those who experience spills to report these immediately to stipulated regulatory agencies.

The reporting of the involuntary release of contaminants to the natural environment, or spill incidents, has been mandatory in Ontario since 1970, and has recently been made mandatory throughout Canada. In Ontario, some fifteen statutes at the provincial and federal level deal with the subject of accidental releases of harmful products in one form or another. The regulatory bodies which administer these statutes have encouraged those with a potential to experience spills to develop adequate contingency plans and to create satisfactory mechanisms for prompt and effective countermeasures which do not rely on government assistance. In this fashion, government spill contingency plans restrict the involvement of tax-funded spill countermeasures operations to a minimum.

Perhaps the most all-encompassing statute dealing with the release of contaminants in Ontario for non-marine activities is the Environmental Protection Act administered by the Ontario Ministry of the Environment which makes it an offence to release into the natural environment a contaminant which:

"Section 14. - (1) (a) causes or is likely to cause impairment of the quality of the natural environment for any use that can be made of it;
(b) causes or is likely to cause injury or damage to property or to plant or animal life;
(c) causes or is likely to cause harm or material discomfort to any person;
(d) adversely affects or is likely to adversely affect the health of any person;
(e) impairs or is likely to impair the safety of any person; or
(f) renders or is likely to render any property or plant or animal life unfit for use by man. 1972, c. 106, s. 3."

Prosecution under the above in situations involving the accidental release of pollutants has been restricted to a few incidents where difficulty has been encountered in having the party experiencing the spill effect prompt and effective countermeasures. Industry* has thus been encouraged in an indirect manner to develop effective spill contingency plans and to establish an adequate countermeasures response mechanism.

Ontario has a population of about 8 million and in all probability experiences about the same frequency of spills in proportion to its population and industrial activity as other parts of Canada or similar areas of the United States. Federal and provincial regulatory agencies investigate an average of 900 spill incidents annually. Municipal entities deal with an additional estimated 200 spills. The involvement of the federal and provincial agencies in Ontario is as follows:

- Canadian Coast Guard: approximately 80 marine-related spill incidents primarily on the Great Lakes

- Department of Fisheries and Environment: approximately 50 spill incidents involving facilities or property under strict federal jurisdiction

* the term "industry" is used loosely, recognizing that it is not always industry in the traditional sense which may be responsible for all spills.

- Ontario Ministry of Consumer and Commercial Relations - Energy Safety Branch: approximately 150 incidents dealing with potential safety hazards of petroleum products at commercial and retail gasoline and fuel oil facilities

- Ontario Ministry of the Environment: approximately 620 incidents of various spilled materials which affect the natural environment.

The manner which regulatory bodies have approached the subject of spills of contaminants has resulted in the evolution of distinctly recognizable levels of countermeasures response capabilities. Figure I attempts to illustrate the interrelation of the present spill response mechanisms available in Ontario. Each step in this diagram represents a separate mechanism available in a naturally escalating response. As a general statement each step or level of response or each level of jurisdiction, as the case may be, has the flexibility to draw on the collective response capability of all preceding levels. Contingency plans of regulatory agencies to the right of Feature "B" on the diagram also have provisions to draw on resources available through subsequent response levels to their respective right.

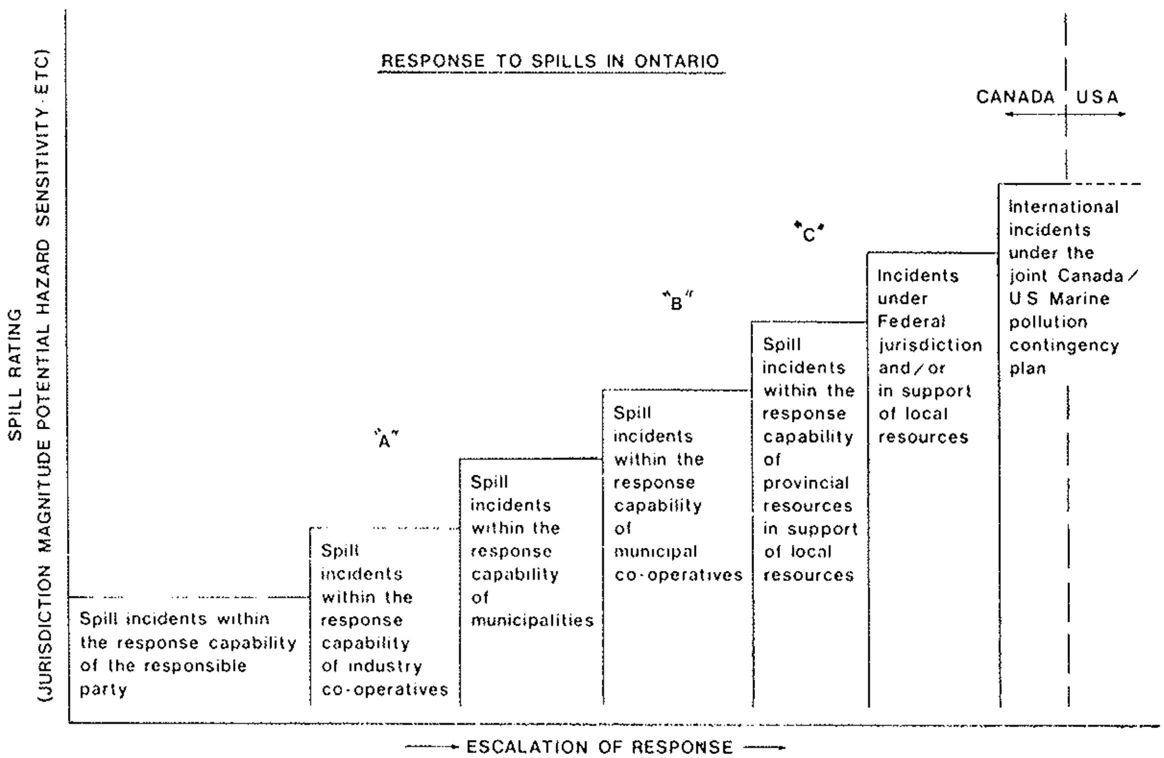

FIGURE 1

Feature "A" of Figure I identifies the very significant response capability of two distinct types of industry cooperatives which have emerged. The petroleum industry through the Ontario Petroleum Association has developed 18 oil spill cooperatives in Ontario. These "co-ops" have purchased and made available significant equipment and supplies for the countermeasures of petroleum spills. Four additional localized cooperatives have also emerged comprised of neighbouring industries. Two excellent examples are the Hamilton Spill Control Group comprised of 18 members including such diverse interests as steel mills, refineries, oil pipeline companies, as well as a car assembly plant, and the Lambton Industrial Society comprised of 17 members in the petro-chemical sector.

The second type of industry co-operative identified under Feature "A" was developed by the Canadian Chemical Producers Association and consists of the availability of immediate advice to those at the scene of a transportation emergency involving chemicals through what is known as the Transportation Emergency Assistance Plan (TEAP).

Provincial and federal legislation may hold a municipal entity responsible to clean-up spills discharged to the natural environment through a municipally owned collection system. Municipalities have thus been encouraged to include a municipal response mechanism for spills in their contingency plans for peacetime emergencies.

Feature "B" of the diagram identifies the increased response capability available which has recently emerged in some parts of Ontario through what could best be termed municipal cooperatives. These "co-operatives" are comprised of the collective response capability of certain, usually large, contiguous municipal entities.

Feature "C" represents the response capability through the development of the Province of Ontario Contingency Plan for Spills of Oil and Other Hazardous Materials. This plan is administered by the Ontario Ministry of the Environment and by agreement draws on the expertise and resources of seven provincial agencies as well as two federal agencies including the Canadian Coast Guard.

The Canadian Coast Guard has stockpiled considerable quantities of oil spill countermeasures equipment with a replacement value of approximately $3 million. Under mandate of the Canada Shipping Act, the Coast Guard responds, aside from providing assistance under the aforementioned provincial plan, to all marine related pollution incidents with the aid of an appropriate contingency plan.

Canada is represented on the Joint Canada-United States Marine Pollution Contingency Plan for Spills of Oil and Other Noxious Substances by the Canadian Coast Guard with participation of the federal Department of Fisheries and Environment and the Ontario Ministry of the Environment. Through the availability of the aforementioned provincial spill contingency plan identified as Feature "C" in Figure I, the Ministry of the Environment can draw also on all agencies who co-signed the provincial plan and all available resources to the left of Feature "C" for any international incident if required.

The costs of any countermeasures response undertaken by any municipal entity or any provincial or federal regulatory agency is borne by those who had control of the pollutant immediately prior to its release to the natural environment. Maritime law and very recent amendments to federal environmental legislation make the owner of the contaminant also liable for any cost incurred by the regulatory agency. Parallel provincial legislation is pending.

It must be emphasized that industry has responded well during the last few years in developing spill contingency plans and countermeasures mechanisms which satisfy their requirements. Most spill incidents are now taken care of by the responsible party quickly and efficiently and seldom require the direct involvement of regulatory agencies.

Government contingency plans have been developed to augment the response required to major spills or those of catastrophic proportions, to provide a response mechanism for mystery spills, and to rare incidents where the responsible parties default. Strict surveillance by regulatory bodies over spill clean-up efforts, more stringent legislation, and cooperation of industry helped to decrease the probable need to invoke government contingency plans.

ACUTE LETHAL TOXICITY OF COREXIT 9527/PURDHOE BAY CRUDE OIL MIXTURES TO SELECTED ARCTIC INVERTEBRATES

Submitted by: A. Sekerah & M. Foy
L.G.L. Ltd.
Toronto, Ontario.

Introduction

As part of the Arctic Marine Oilspill Program, Prudhoe Bay crude oil and Prudhoe Bay crude oil/Corexit 9527 dispersant mixtures were tested for acute lethal toxicity on four arctic marine invertebrates--*Onisimus litoralis, Boeckosimus edwardsi, Anonyx nugax and Calanus hyperboreus*. Due to the difficulties in transporting to and maintaining Arctic animals in southern laboratories, the work was performed in Resolute, N.W.T. in December 1977 and January 1978.

Materials and Methods

Animals were exposed to the crude oil and oil/dispersant mixtures in a water 'accommodated' form, prepared in a similar manner to those of Percy and Mullin (1975). Oil was added to filtered (0.67) seawater taken from the sites of animal collection; when oil/corexit mixtures were prepared, Corexit was added in a volume of 1/10 that of oil. Generally, 3 concentrations of oil-water or oil/Corexit-water were prepared for each bioassay. The mixtures were shaken on a reciprocating shaker for 0.5 h and transferred to separatory funnels where they were allowed to stand undisturbed for 210 min. The lower oil-water or oil/Corexit-water fraction was withdrawn and distributed evenly into 3 replicate jars. The volume in each jar was approximately 440 ml.

Five *(A. nugax)* or 10 *(O. litoralis, B. edwardsi and C. hyperboreus)* individuals of the test species were added to each replicate jar; 5 control replicates of filtered seawater were prepared for each bioassay. Time of addition of animals to test mixtures was labelled as 0 h. Ninety-six hour biossays were run in standard refrigerators at mean temperatures from 0° to 3.5°C; every 24 h, dead animals were removed and the remainder transferred to freshly prepared mixtures. 'Death' was determined as lack of appendage movement in response to touch. Mixtures were not aerated nor were animals fed during the bioassays.

Hydrocarbon concentrations in experimental mixtures were measured using fluorescence spectroscopy at time of animal addition (0 h) and after 24 h of exposure. Hydrocarbons were extracted with spectro-grade hexane; the solutions were diluted and relative fluorescence was determined. This reading was applied to a calibration curve, prepared from dilutions of Prudhoe Bay crude in hexane, and hydrocarbon concentrations determined. Exposure concentration was determined as a mean of all measurements at 0 h and at 24 h, for each added concentration of oil.

As a control, Corexit 9527 was tested for toxicity, in concentrations up to the maximum used in oil/Corexit mixtures, on *O. litoralis and B. edwardsi*. Toxicity of a reference toxicant (sodium lauryl sulphate) was determined on *O. litoralis, B. edwardsi and A. nugax*.

Ninety-six hour LC50s based on the measured exposure concentrations and mean mortalities of all replicates were determined using the simplified probit analysis of Litchfield and Wilcoxon (1949) or a computerized probit analysis (Davies 1971). Where number of partial mortalities was too few for such determinations, the 96 h LC50 is simply reported as a range (concentrations at which less than and more than 50% mortality was observed).

Results and Discussion

Measured concentrations of hydrocarbons in the experimental mixtures for all added concentrations of oil and oil/Corexit are summarized in Table S1.

TABLE S1

Measured Concentrations of Prudhoe Bay Crude Hydrocarbons in Oil-Water and Oil/Corexit 9527 - Water Mixtures Used in 96 h Bioassays for Various Concentrations of Added Oil.

Added Oil (ppm)	Measured Oil (ppm)					
	Oil-Water Mixtures			Oil/Corexit-Water Mixtures		
	0 h[1]	24 h[1]	$\bar{X}$[2]	0 h[1]	0 h[1]	$\bar{X}$[2]
50	24.4	14.6	19.5	25.6	22.1	23.9
100	41.1	22.9	32.0	67.3	59.6	63.5
200	61.4	20.7	41.1	123.7	128.0	125.9
400	61.3	23.8	42.6	220.2	205.8	213.0
800	68.3	20.4	47.4	447.4	261.6	354.5

[1] Mean of all measurements for that time period and added oil concentration.
[2] Mean of all 0 h and 24 h measurements for that added oil concentration.

Measured hydrocarbons in oil-water mixtures essentially reached 'saturation' at added oil concentrations of 200 ppm. By adding Corexit to the mixtures, measured concentrations of hydrocarbons increased throughout the range of added oil concentrations. Dispersions were more stable in oil/Corexit-water mixtures than in oil-water mixtures. Hydrocarbon concentrations in oil/Corexit-water mixtures at 24 h were similar to those at 0 h (except for 800 ppm added oil). In the oil-water mixtures hydrocarbon concentrations in the water column decreased by between 40 and 70 percent within 24 h; most of the oil was lost in the formation of a surface 'slick'.

On the basis of amount of oil added, greater mortality was observed in the Corexit-dispersed oil-water mixtures. This was not thought to be attributable to the toxicity of Corexit since no mortalities were observed in Corexit concentrations up to the maximum used in oil/Corexit mixtures in tests on two species. However, the increase in mortality was not proportionate to the increase of measured hydrocarbons in the water column, resulting in higher 96 h LC50s for the oil/Corexit water mixtures than for the oil-water mixtures than for the oil-water mixtures (Table S2). It is speculated that a greater proportion of non-toxic hydrocarbons were dispersed in the water column by using Corexit.

TABLE S2

Median Lethal Concentrations (96 h LC50) of Prudhoe Bay Crude Oil, Corexit 9527, Prudhoe Bay Crude Oil/Corexit 9527 and Sodium Lauryl Sulphate (SLS) on Four Arctic Invertegrates.

Species	96 h LC50 (ppm)			
	Oil[1]	Corexit	Oil/Corexit[1]	SLS
Onisimus litoralis	49 (44-55)[2]	>70	24-213	4-40
Boeckosimus edwardsi	44 (43-45)	>80	64-213	>40
Anonyx nugax	38 (32-43)	-	64-213	26 (20-32)
Calanus hyperboreus	73 (51-103)	-	196 (161-238)	-

[1] Values quoted are measured concentrations of hydrocarbons.
[2] Parenthetical figures represent 95% confidence limits.

All species tested demonstrated sensitivities to the toxicant mixtures of the same order of magnitude. However, consistent differences in sensitivities could be seen in the various species. *A. nugax* appeared to be the most sensitive species while the copepod, *C. hyperboreus* was the most resistant. The small amphipods, *O. litoralis* and *B. edwardsi* were intermediate in sensitivity.

The possibility of mortality subsequent to exposure to the toxicants was not investigated in this study. However, observations on the condition of animals after 96 h, especially in high toxicant concentrations, would indicate that survival would have been unlikely had these animals then been placed in toxicant-free seawater. In addition, sublethal effects, such as behavioural modification, might further have reduced their chances of survival after exposur to oil in a natural situation.

Comparison of results with other studies is difficult due to lack of standardized methods of dosing the animals and measuring hydrocarbons, and the use of different oils and test animals. Results were most comparable with those of Percy and Mullin (1975) who used similar methods, one of the same (organisms *(Calanus hyperboreus)* and one closely related organism *(Boeckosimus affinis)* but different oils. The toxicity of Norman Wells crude oil on *B. affinis* (96 h LC5 of 32 ppm), calculated by us from their results) was similar to the toxicity of Prudhoe Bay crude oil on *Anonyx nugax* (96 h LC50 of 38 ppm) found in this study. *Calanus hyperboreus* was found to be surprisingly resistant to acute toxicity of oils in both studies.

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6 h LC50s Based on Measured Hydrocarbon Concentrations

Test Organism	Prudhoe Bay Crude	Corexit 9527	Prudhoe Bay Crude/ Corexit 9527	SLS[1]
Onisimus litoralis 7 to 13 mm length 1 year old	49 (44-55)[2]	> 70	24-213	4-40
Boeckosimus edwardsi 6 to 15 mm length 1 year old?	44 (43-45)	> 80	64-213	40
Anonyx nugax 23 to 42 mm length 3 size classes	38 (32-43)	-	64-213	26(20-32)
Calanus hyperboreus mostly copepodite stages IV to VI (adult)	73 (51-103)	-	196 (161-238)	-

[1] Sodium Lauryl Sulphate.
[2] Parenthetical figures represent 95% confidence limits.

Summary Sheet

Toxicants	: Prudhoe Bay Crude, Oil, Corexit 9527, Prudhoe Bay Crude/Corexit 9527 mixtures (10:1, by volume), Sodium lauryl sulphate.
Test Species	: Arctic amphipods *(Onisimus litoralis, Boeckosimus edwardsi, Anonyx nugax)* and Arctic copepod *(Calanus hyperboreus)*.
Oil Mixtures	: Oil-water dispersions, prepared by mixing with reciprocating shaker, settling and using water accommodated fraction.
Bioassay Technique	: 96 h static bioassay; animals transferred every 24 h to fresly prepared solutions; no aeration or feeding; 50 to 10 animals per 440 ml toxicant mixture.
Analytical Methods	: Measurement of hydrocarbons in bioassay mixtures using fluorescence spectroscopy; exposure concentration determined as mean of measurements at 0 h and 24 h.
Measured Effect	: Death as determined by lack of movement of limbs; no postexposure observation.
Experimental Conditions:	Mean temperatures between -0.2 and 3.4°C; large temperature fluctuations may have produced additional stress; significant temperature differences between some experiments may influence relative sensitivities. Dissolved oxygen >5.0 ppm in all experiments. Salinities from 29.1 to 34.6°/°°.

EVAPORATION RATES OF COMPLEX HYDROCARBON MIXTURES UNDER ENVIRONMENTAL CONDITIONS

by: J.S. Nadeau
Environmental Protection Department
Imperial Oil Limited

and

D. Mackay
Department of Chemical Engineering and Applied Chemistry
University of Toronto

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Introduction

When hydrocarbon mixtures, such as crude oils or petroleum products are accidently spilled on water, land, or ice surfaces, they are subject to a number of physical, chemical and biological processes collectively termed weathering. One of the most significant weathering processes is evaporation. Evaporation is often responsible for the loss of a considerable fraction of the oil mass spilled. It may lead to increases in oil density and viscosity and high evaporation rates may cause explosive conditions.

The objective here is to provide a relatively simple method of calculating evaporation rates of spills of various hydrocarbon mixtures, such as gasolines, diesel fuels, and crude oils. Other weathering processes, for example, dissolution, microbial degradation, chemical oxidation, dispersion, emulsification and polymerisation are not considered here, since they are either slower or may only become important later in a spill history. A calculation procedure is provided in the form of equations and charts which enable the evaporation rate of a given product to be calculated from the knowledge of the product volatility, the wind speed, temperature and the spill thickness. A simplified background explanation is also presented.

The amount of hydrocarbon mixture evaporated from a spill is controlled by five factors.

1. First is the mass transfer coefficient K, which has units of metres/second (m/s) and is a measure of the rate at which hydrocarbon vapour at the spill surface is carried away by wind into the atmosphere. The mass transfer coefficient is primarily dependent on wind speed. Higher wind speeds lead to higher values of K. A chart relating K to wind speed is provided in Figure 1. For convenience, the chart is given in units of miles/hour, metres/second and kilometres/hour. Ambient wind speeds can be obtained from a local weather office or can be estimated.

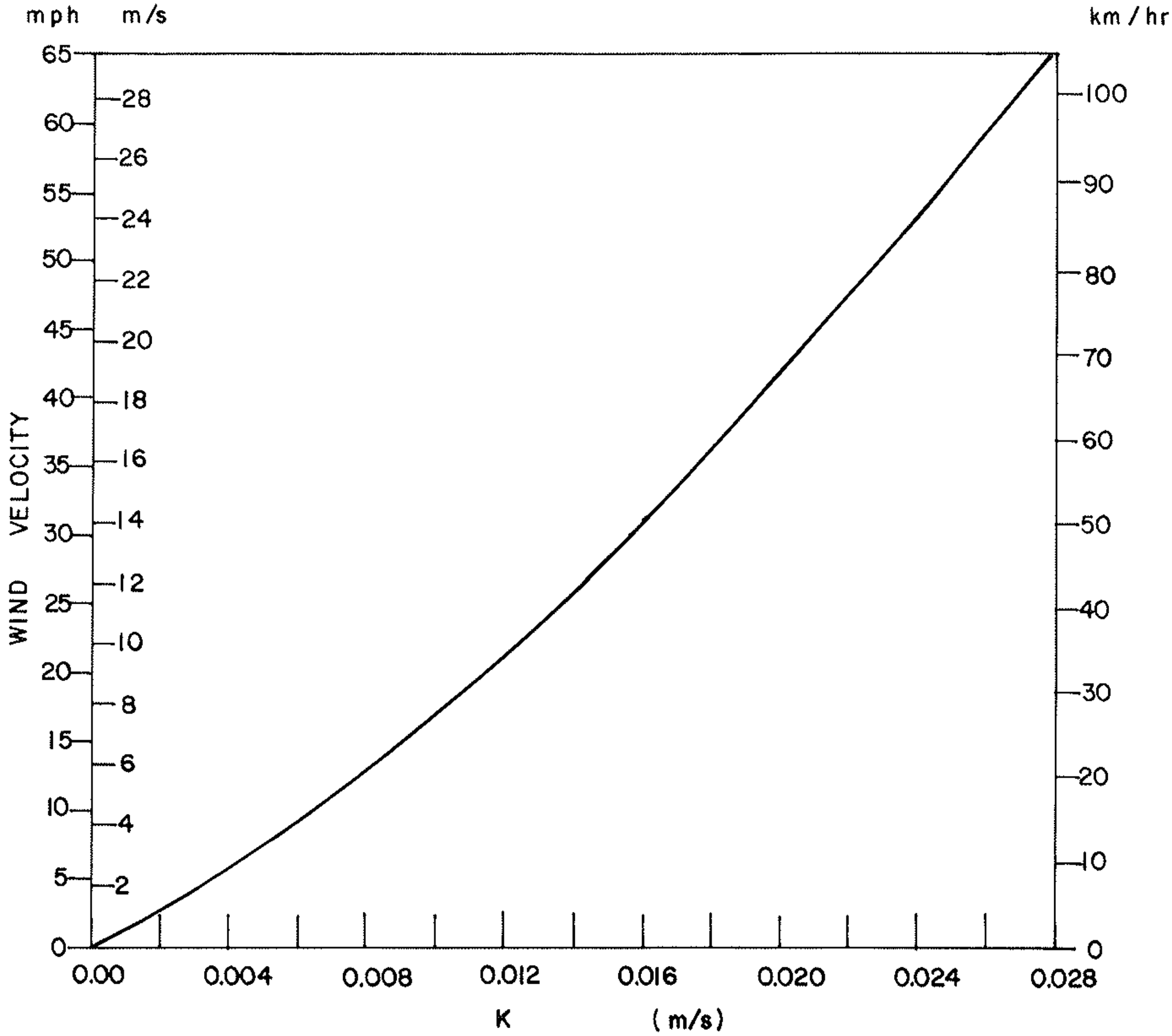

Fig.1 - Determination of the mass transfer coefficient K from the wind velocity

2. The evaporation rate depends on the area of the spill exposed to the atmosphere. The larger the area exposed, the faster will be the evaporation rate per unit mass of oil, thus the faster will the oil compositions change. The effect of area is taken into account by calculating an area factor A, which has the units of square metres per kilogram of spill material.

   This area factor A may be calculated in one of two ways depending upon which parameters are known or can be most easily estimated.

$$A = \frac{1}{\text{(spill thickness)(fuel density)}} = \frac{1}{(\text{m})(\text{kg/m}^3)} = \frac{\text{m}^2}{\text{kg}}$$

   A graph has been provided for the conversion of API gravities to kilogram per cubic metre density units (Figure 2).

$$\text{or} \quad A = \frac{\text{(spill area)}}{\text{(spill volume)(fuel density)}} = \frac{\text{m}^2}{(\text{m}^3)(\text{kg/m}^3)} = \frac{\text{m}^2}{\text{kg}}$$

3. The third factor is the time of exposure of the oil to the environment. This is calculated as the quantity t (seconds).

4. Another parameter which affects the evaporation process is temperature. High temperatures lead to high vapour pressures and thus to high evaporation rates. It is thus necessary to estimate the temperature of the evaporating hydrocarbon mixture surface. Generally, this can be assumed to be the local air temperature, however, in certain cases this may not be appropriate.

   (a) When the hydrocarbon is spilled on ice, or a cold solid surface, or on water, it will be close in temperature to the underlying material, thus it may be best to use the ice, land, or water temperature.

   (b) If the hydrocarbon is evaporating very quickly, it will cool through the "wet bulb" effect, thus it may tend to be colder than the environment. This is likely only to occur with gasoline spills.

   (c) If an oil lying on a surface is subject to an intense solar radiation, for example, at noon in summer, it may become very hot, indeed much hotter than the air or ground surface due to the adsorption of solar energy.

   Thus for the last two cases, it is desirable to measure the hydrocarbon temperature at the evaporating surface; however, if this is not possible, some estimate can be made taking into account the factors described above.

5. Finally, the evaporation rate is dependent on the nature of the hydrocarbon mixture. Obviously low boiling distillates, such as gasoline will evaporate much more quickly than diesel fuel or kerosene.

The last two effects, temperature and product volatility are taken into account by plotting curves containing these quantities in charts, for example, Figure 3, from which the evaporation rate of gasoline at various temperatures, ranging

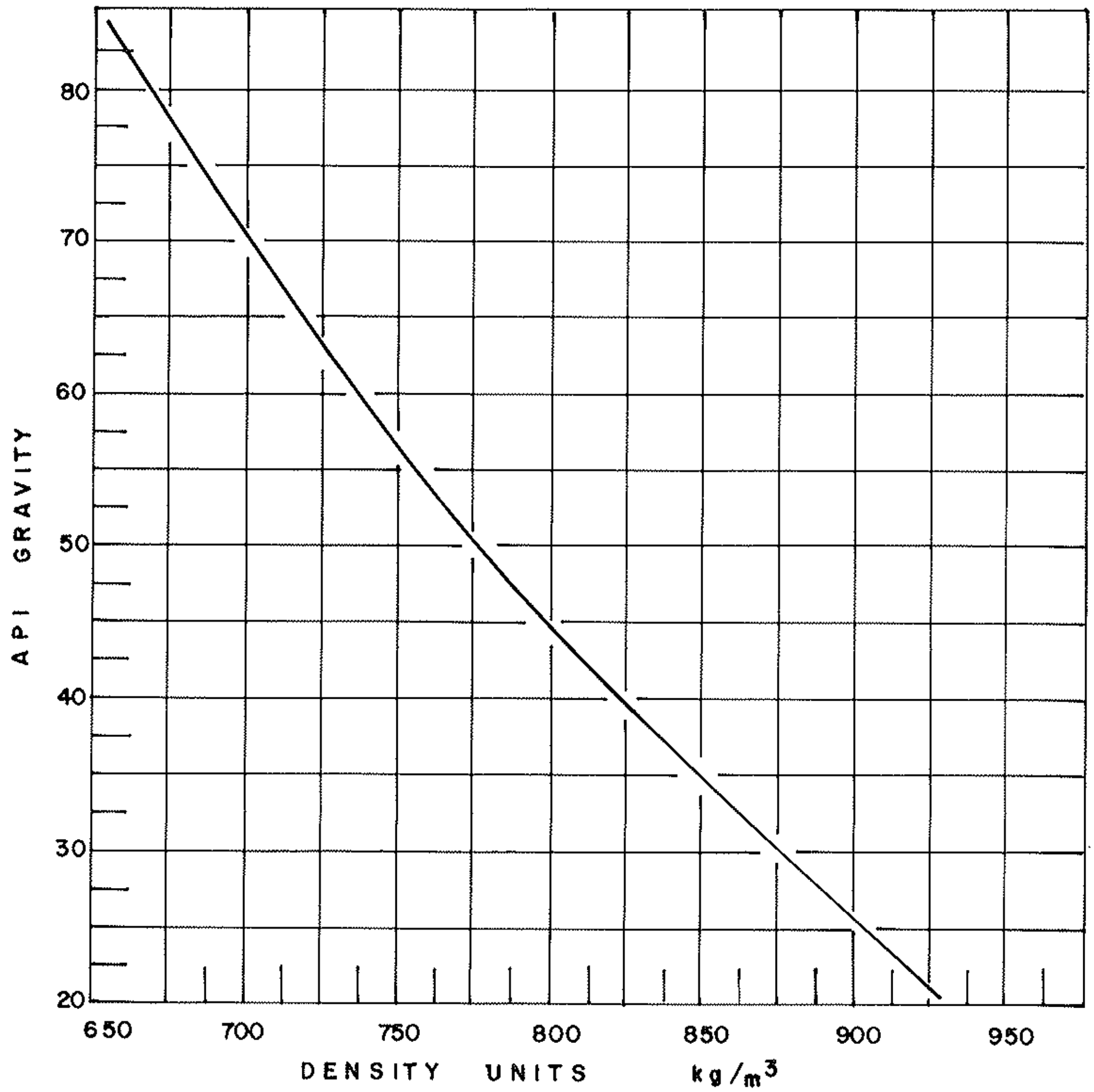

Fig.2 - Conversion of API gravities to conventional density units

from -30°C to 30°C can be obtained. The fraction of spill material remaining at various values of temperature, time, A, and K can be obtained by a calculation procedure described later.

Specimen Calculation

An estimated 1,000 barrels of winter diesel fuel (API=40) have been spilled on a lake in early spring. A thin slick covers an area approximately 300 m long by 600 m wide. The ambient air temperature is 15°C, but the water temperature is only 5°C. The prevailing wind is approximately 30 mph. The on-scene-commander wants to know what percentage of the diesel fuel will remain unevaporated after 24 hours and 48 hours.

Procedure:

1. From Figure 1, a wind speed of 30 mph corresponds to a mass transfer coefficient K of 0.0155 m/s.

2. The next step is to calculate the area A. Since the volume of the spill and the area are known, the second calculation procedure will be used. Since 1 barrel of fuel corresponds to 0.158 m^3, from Table II, then 1,000 barrels correspond to a volume of 158 m^3. The fuel density with the appropriate units kg/m^3 is obtained from Figure 2. The fuel with API gravity=40 corresponds to a density of 825 kg/m^3.

   The spill area will be approximately 300 x 600 = 180,000 m^2, and the A term can now be calculated as follows:

$$A = \frac{\text{(spill area)}}{\text{(spill volume)(fuel density)}} = \frac{180{,}000\ m^2}{(158\ m^3)(825\ kg/m^3)} = 1.38\ \frac{m^2}{kg}$$

   This spill is 0.88 mm (0.88 x 10^{-3}) thick, thus A could be calculated as 1/(thickness x density) = 1/(0.88 x 10^{-3} x 825) = 1.38 m^2/kg. A thicker spill, say 8.8 mm, would have smaller A value of 0.138 m^2/kg.

3. Times of interest are 24 hours which equals 24 x 60 x 60 = 86,400 s and 48 hours (172,800 s).

4. Next the respective KAt values may be calculated

$$KAt = (0.0155\ \frac{m}{s})(1.38\ m^2/kg)(86{,}400s) = 1848\ m^3/kg \text{ at 24 hours}$$

   and

$$KAt = (0.0155\ \frac{m}{s})(1.38\ m^2/kg)(172{,}800s) = 3696\ m^3/kg \text{ at 48 hours}$$

5. The next step is to estimate the temperature of the fuel. Although the air is warmer than the water, the fuel temperature is most likely at, or close to, the water temperature of 5°C.

6. Finally, the percent of fuel remaining after the times of interest may be obtained from Figure 5 which is for a winter diesel fuel. The KAt value of 1850 at a temperature of 5°C corresponds to a fraction of fuel remaining of 60%. Similarly, for a KAt value of 3700 corresponding to 48 hours, the percent of diesel fuel remaining is 52% at the same temperature.

Experimental

Evaporation rates of the various hydrocarbon mixtures were investigated in an experimental wind tunnel under controlled conditions. The specifications of the various fuel samples used as the basis for the computer model are summarized in Table I.

Table I
Fuel Specifications

Fuel Type	API Gravity	IBP	FBP
Summer gasoline	64.6	94°F	368°F
Winter gasoline	63.8	76	346
Winter diesel	41.8	338	548
Summer diesel	38.5	341	647
Light crude	40.0	-	-
Medium crude	35.0	-	-
Turbo jet fuel (A-1)	44.4	334	470
No. 2 heating oil	32.6	308	658

It was found that the evaporation rates of the light and medium crude oils were identical so only one graph was required for both types of oil (Figure 7).

The simple calculation procedure described in this work assumes that the spill has a constant area (i.e. it is not spreading). This, of course, may not be true, however, it may be reasonably close to the truth in situations where oil or other products are contained by booms, harbour walls or by ice. If the spill has experienced an increase in the area during the evaporation time, the best procedure is to assume an average area. It is possible to undertake a more complex calculation to include the effect of changing area. However, this is not discussed here.

If a product is spilled on land and a significant fraction of the product is absorbed or soaked into the soil, then the product under the soil surface will not generally be exposed to evaporation at the same rate. The calculation procedures described in the text, strictly speaking, apply only to pools of spill product on a solid surface or a liquid surface.

The computer model also assumes that the wind, speed, temperature, and spill thickness are constant over the time of interest. If the meteorological conditions and slick characteristics are changing quite rapidly but are monitored quite closely, then it would be advantageous to select shorter time intervals and determine the fraction of fuel remaining after each time interval using the average wind speed, temperature and spill thickness conditions within each selected interval.

It should be noted that the graphs do not extend below a KAt value of 1.0. This corresponds approximately to an evaporation time of 15 minutes for a 1 cm deep spill or 1.5 minutes for a 1 mm deep spill. Evaporation times shorter than this are of little practical interest in cleanup operations. Volatile fuels such as gasoline, however, evaporate to a considerable extent even in these short times.

Discussion

The following graphs provide data for predicting evaporation rates of summer and winter gasolines, summer and winter diesel fuels, light and medium crude oils, a turbo fuel (Type A-1), and a No. 2 heating oil. These graphs show the mass fraction of fuel remaining at the spill after various times for certain wind speeds, spill areas, and ambient temperatures. Knowledge of evaporation rates is helpful in assessing fire or explosion hazards, biological effects, and legal identification of a particular product.

These evaporation curves have been generated from a computer model based on the evaporation of representative component groupings for each different type of fuel. Results from the model have been tested in an experimental wind tunnel and evaporation studies of selected fuel samples under environmental conditions confirmed the results. The model assumes that Raoult's Law and the Antoine vapour pressure-temperature relationships are applicable for these hydrocarbon mixtures.

The inputs required by the computer are the initial composition of the mixture, respective molecular weights, Antoine constants, ambient temperatures, the prevailing wind speed, spill volume and spill area. Once the intial composition is known, subsequent compositions are computed.

Any combination of K, A and t giving the same numerical KAt value will correspond to the same mass fraction of a particular fuel remaining at a particular temperature. The KAt parameter is the appropriate thermodynamic quantity describing the total volume of hydrocarbon vapour (at its ambient vapour pressure) evaporated under isothermal conditions per unit mass of fuel (i.e. m^3/kg).

Table II
Conversion Factors

1 sq. ft.	= 0.0929 m^2
1 sq. yd.	= 0.836 m^2
°C	= 5/9(°F-32)
1 lb.	= 0.454 kg
1 day	= 86,400 s
1 m	= 39.4 in. = 3.28 ft.
1 barrel	= 0.158 m^3
1 US gal	= 0.003785 m^3
1 Imp gal	= 0.00455 m^3
1 cu. ft.	= 0.17811 barrels
1 cu. ft.	= 0.02832 m^3

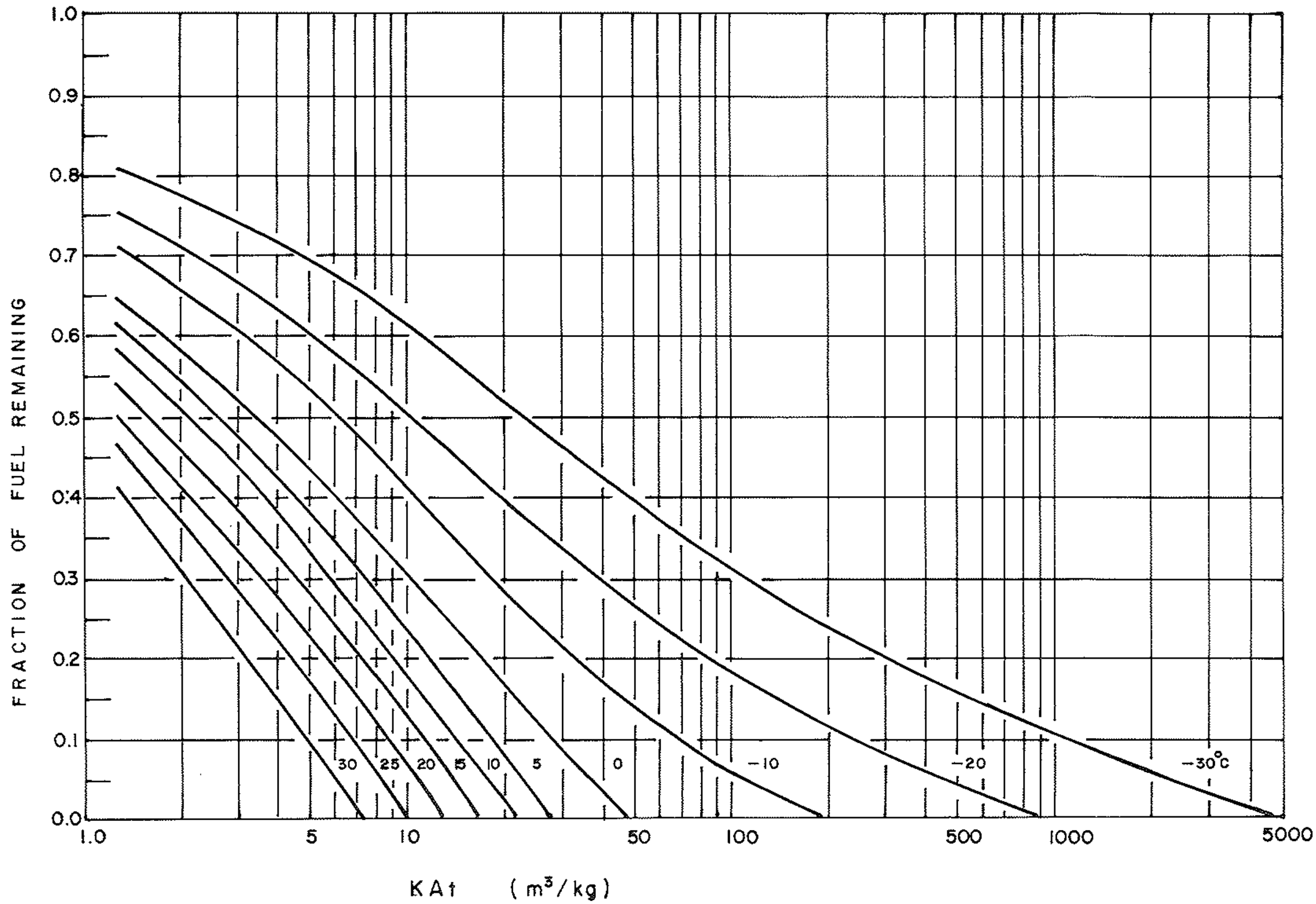

Fig.3 - Evaporation curves for summer gasoline

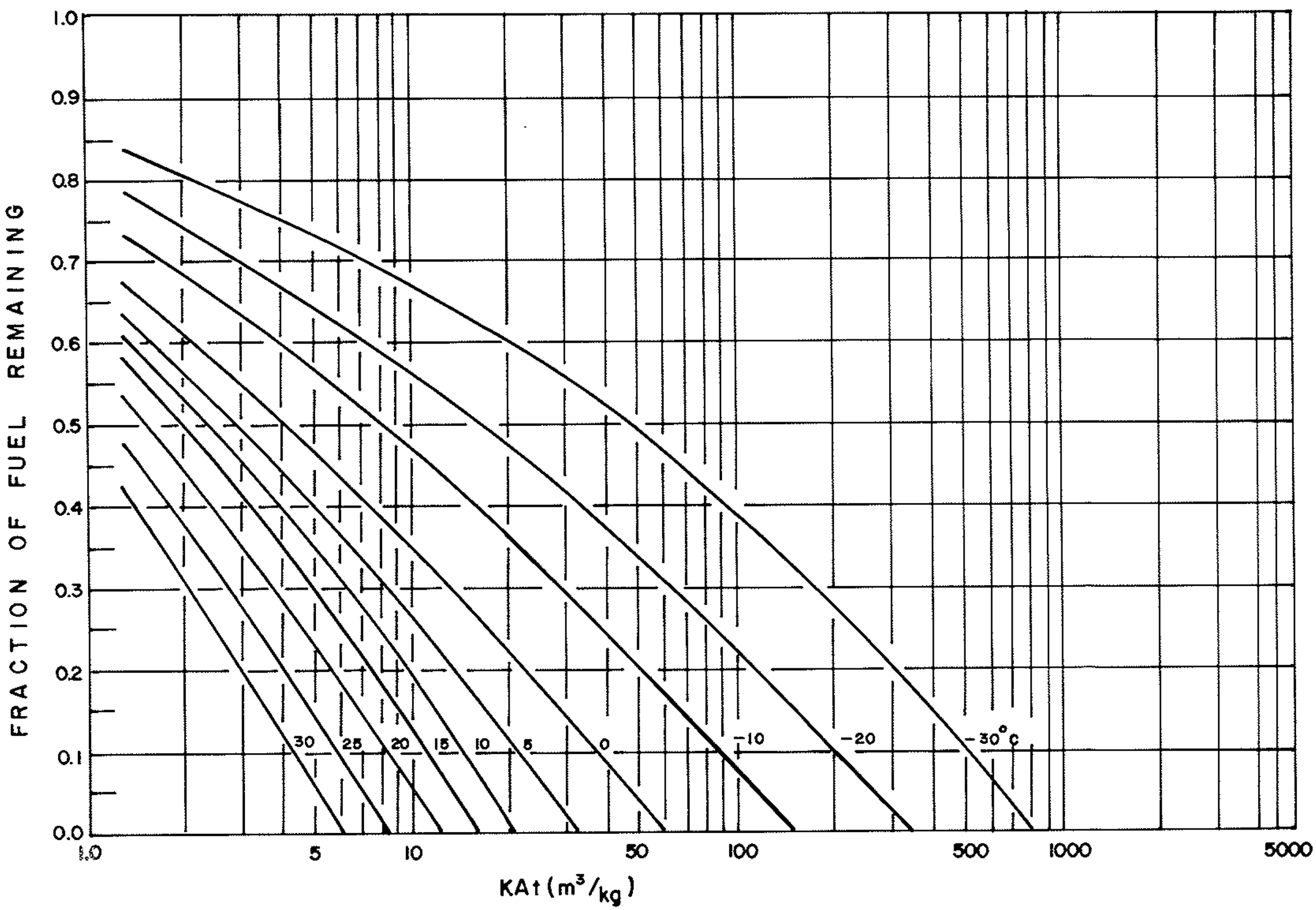

Fig.4 - Evaporation curves for winter gasoline

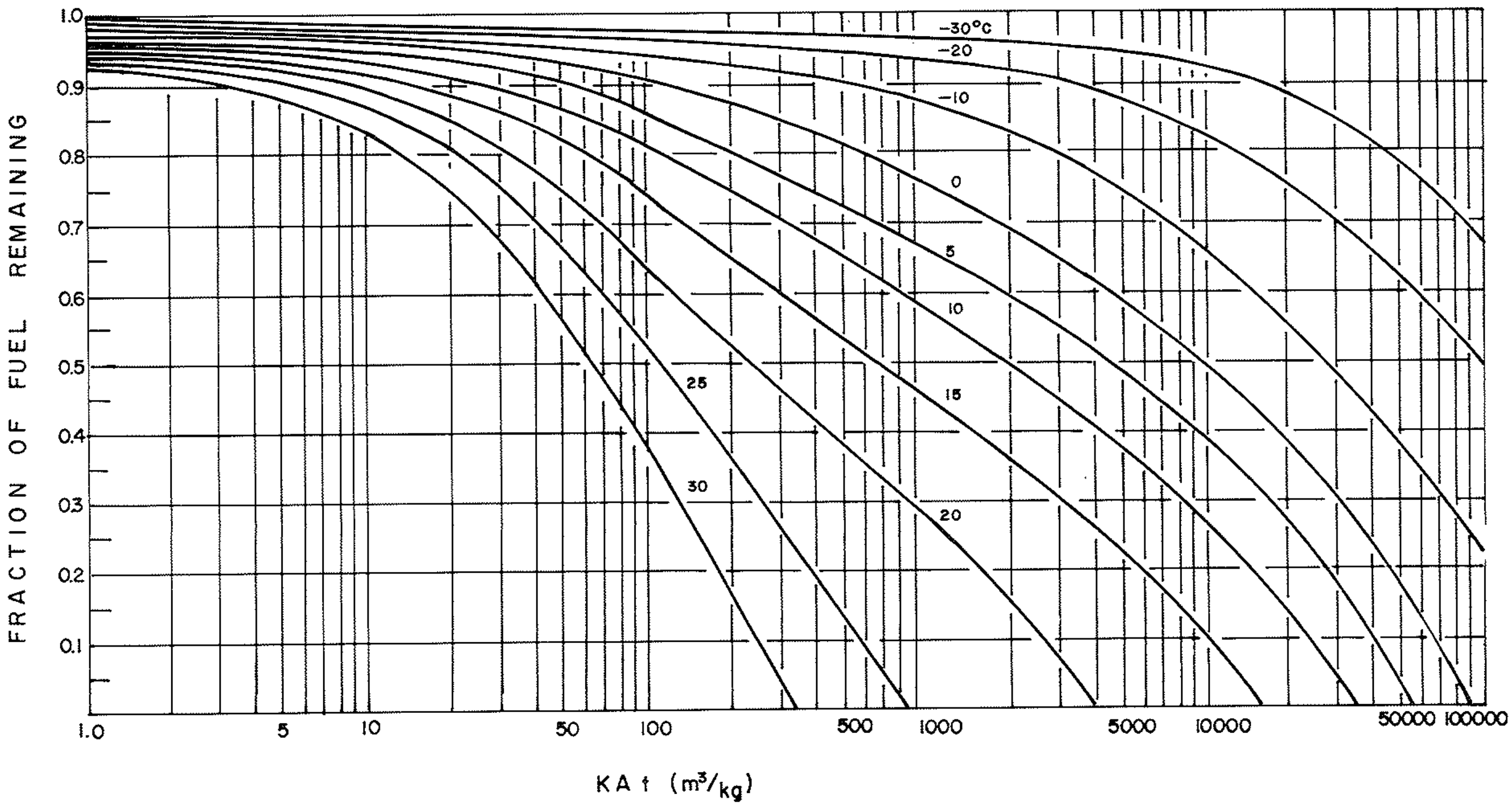

Fig.5 - Evaporation curves for winter diesel fuel

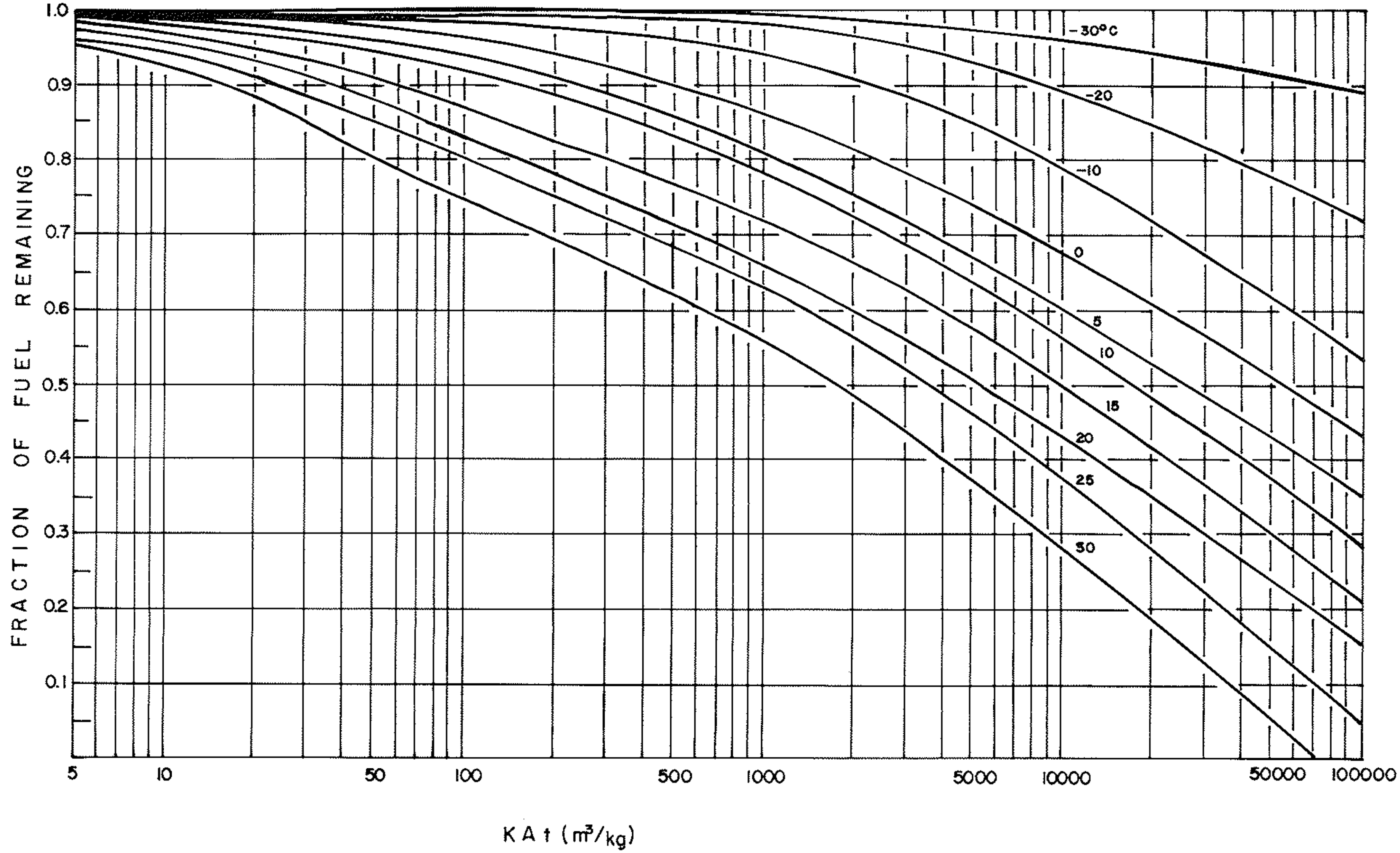

Fig.6 - Evaporation curves for summer diesel fuel

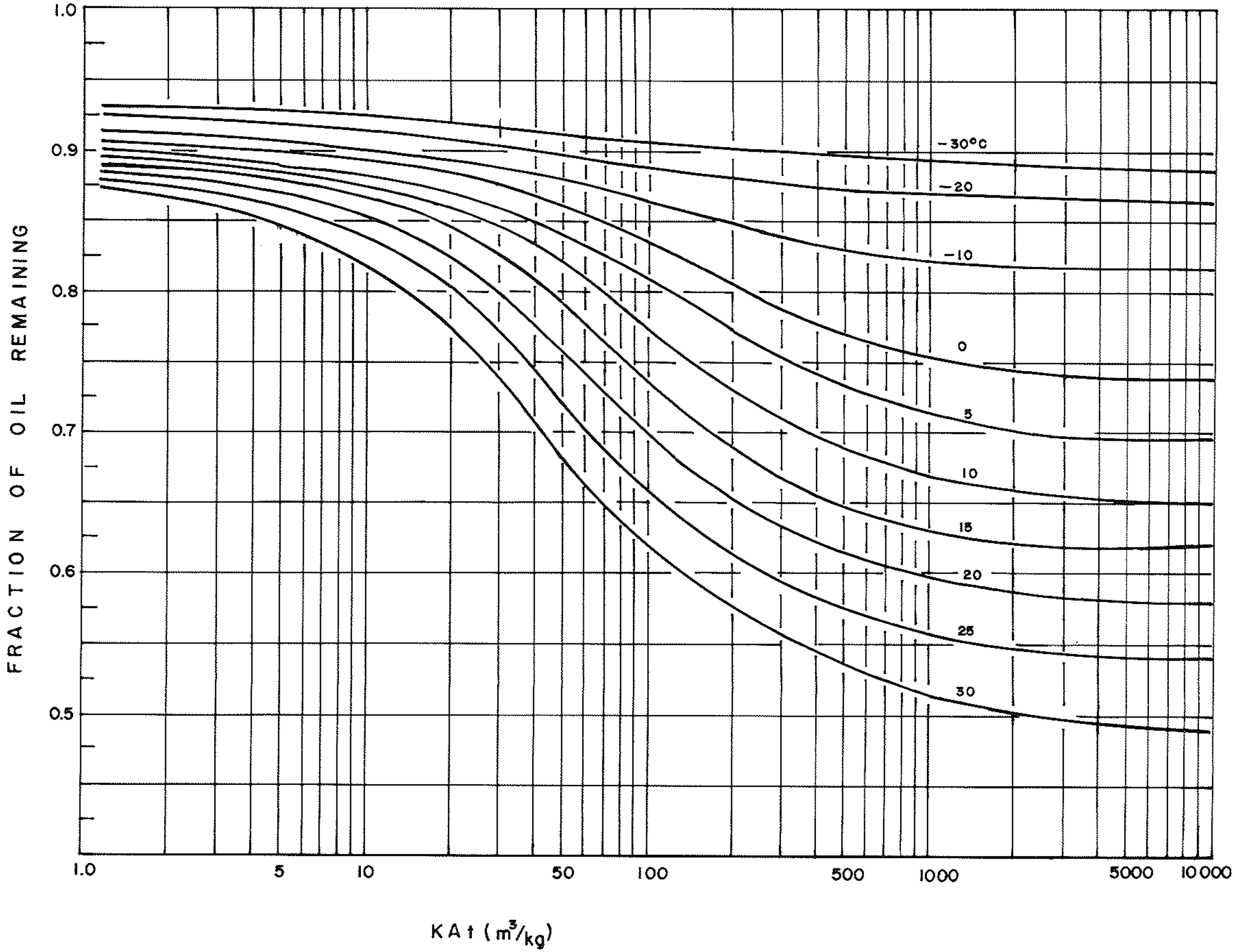

Fig.7 - Evaporation curves for light and medium crude oils

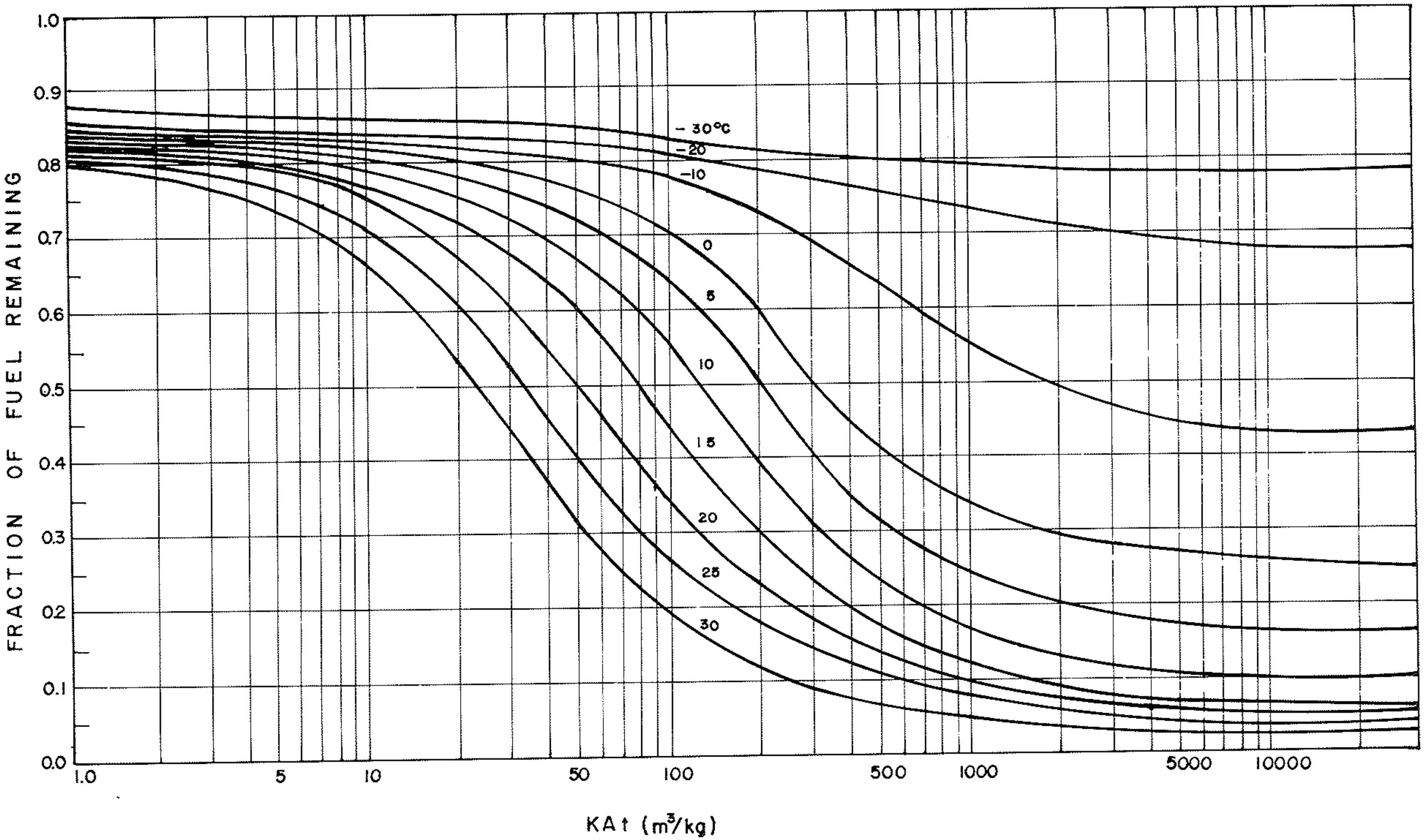

Fig.8 - Evaporation curves for Turbo Jet Fuel (A-1)

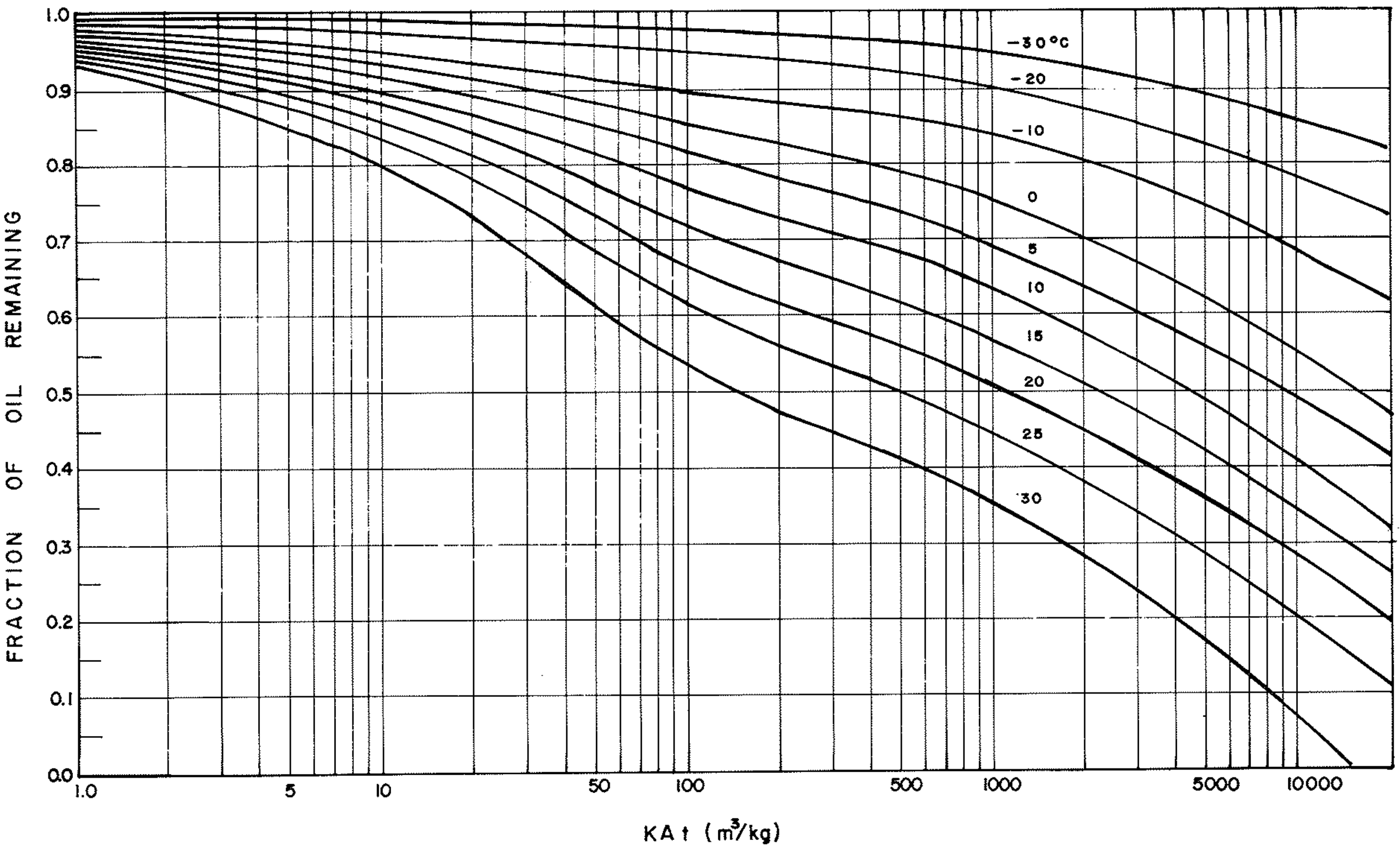

Fig.9 Evaporation curves for No. 2 Heating Oil

THE EFFECT OF CRUDE OIL AND CRUDE OIL/COREXIT 9527 SUSPENSIONS ON CARBON FIXATION BY A NATURAL MARINE PHYTOPLANKTON COMMUNITY

Submitted by: B.K. Trudel
Room 3091
100 Sussex Drive
Ottawa, Ontario

Phone: (613) 992-6549

Summary

The effect of suspensions of Lago Medio crude oil and the oil dispersant Corexit 9527 on marine phytoplankton production was determined by measuring, in situ, the rate of inorganic carbon fixation by a natural marine phytoplankton community during acute exposure to oil-seawater and oil-dispersant-seawater suspensions containing 0.01 to 6.00 mg oil ml^{-1} (measured, I.R.). The results showed that the dose-response relationship between ambient oil concentration and carbon fixation is the same in oil-dispersant-seawater suspension as they are in oil-seawater suspensions. This suggests that oil dispersed with Corexit 9527 in the manner used here is no more toxic to phytoplankton than oil that has been dispersed physically. Concentrations of oil in seawater as low as .10 μg oil ml^{-1} caused a 10% reduction of carbon fixation in both oil-seawater and oil-dispersant-seawater suspensions.

Introduction

Chemical dispersion of surface-borne oil reduces or eliminates the hazard presented by the oil to shorelines, their communities and the inhabitants of the air-water interface. However, chemical dispersion of oil slicks presents at least two hazards to the inhabitants of the water column and the ocean floor: (1) the oil-dispersant mixture entering the water column may be far more toxic than the naturally dispersed oil alone; and (2) the dispersant drives more oil into the water column more quickly than would arrive thereto by natural means. The latter results in higher concentrations of oil in the vicinity of the oil slick than would be found under conditions of natural dispersion. In biological terms, the decision to use chemical dispersion on spilled oil becomes a decision to accept the hazard to pelagic and demersal organisms in order to avoid the possible hazards of surface-borne oil. It is impossible to accurately assess the value of these alternative courses of action without being able to predict, quantitatively, how biota might respond to conditions resulting from these courses of action.

The present study addresses the question: "Are oil-seawater suspensions resulting from chemical dispersal of oil more toxic than oil-seawater suspensions resulting from purely physical dispersal of oil?". The degree of inhibition of inorganic carbon fixation by natural phytoplankton communities was determined under a range of ambient oil concentrations in oil-seawater suspensions and oil-dispersant-seawater suspensions. Studies were done in situ using natural phytoplankton populations, and using the dispersant, Corexit 9527, and Lago Medio crude oil in relative concentrations likely to be encountered at spill sites. Thus dosing conditions were controlled to simulate actual spill conditions as closely as possible.

Materials and Methods

Crude oil: Lago Medio crude oil was obtained from Texaco Canada Ltd. Refinery, Dartmouth, Eastern Passage, Nova Scotia. At the beginning of the study this crude oil stock was split into 20 aliquots of 25 ml, each of which was placed into a 25 ml glass vial with a foil lined screw cap. Each vial was filled until no air space remained. Vials were stored at room temperature (20°C) in the dark. A fresh vial of oil was used for each repetition of the toxicity test.

Corexit 9527: The dispersant was obtained in April 1976 from Exxon Chemical Co., 8230 Stedman, Houston, Texas. The dispersant was stored in 5 gallon metal containers at room temperature until used. A working solution of Corexit 9527 was prepared fresh daily by mixing Corexit 9527 with filtered sea water in a ratio of one part Corexit to 9 parts water ($^{v}/v$).

Isotope stock solution: Five millicuries of 'carrier-free' ^{14}C-labelled $NaHCO_3$ in solution in distilled water was obtained from New England Nuclear, Boston.

Radioisotope working solution: This solution was prepared by adding 5.0 mCi of ^{14}C-labelled $NaHCO_3$ stock solution to 250 ml of millipore filtered, autoclaved "sodium chloride dilution solution" (Strickland and Parsons, 1968). Twenty-five ml of this working solution was then placed into each of ten sterilized 25 ml glass vials with screw caps. These volumes of working solution were kept in the dark at room temperature (20°C) until used.

On the day of the experiment the radioisotope working solution was filtered under vaccuum through a 0.45 micron membrane filter.

In order to estimate the concentration of ^{14}C-labelled $NaHCO_3$ in the radioisotope working solution used in each test, duplicate 10 microlitre aliquots of the filtrate were placed in glass scintillation counting vials containing 15 ml Aquasol-2, made basic with a drop of 0.5N NaOH. This radioisotope working solution contained approximately 14 uCi ml^{-1} of ^{14}C.

Oil-seawater (OS) and oil-dispersant-seawater (ODS) suspensions: A fresh stock OS suspension was prepared daily by agitating for 5 minutes by hand, 1.50 ml of Lago Medio crude oil with 600 ml of filtered (Whatman, GF/C) seawater in a 1000 ml separatory funnel and allowing it to stand for 30 minutes. Approximately 500 ml of the aqueous phase was drawn off and was diluted in the following way, using filtered seawater; 1 to 2.5; 1 to 10; 1 to 15; 1 to 100 and 1 to 250. Thus OS stock solutions ranging in concentration from 0.5 to 100 mg oil l^{-1} were prepared. Before dilution, the OS suspension was shown to contain 55-110 mg oil l^{1}. The ODS suspensions were prepared in a similar manner except that a smaller amount of crude oil, 0.10 ml, and an equal volume of Corexit 9527 working solution were added to 600 ml of filtered seawater prior to agitation. The ratio of dispersant to oil used was the minimum value shown by Doe and Harris (1976) to be effective in dispersing 100% of oil in 10 min at 1°C.

Before dilution these ODS suspensions contained 65-145 mg oil l^{-1}. Twenty-five ml aliquots of each dilution of OS and ODS suspensions were transported into the field in 30 ml glass vials.

Experimental: The effect of ambient concentrations of physically or chemically dispersed oil on production of natural phytoplankton communities was determined by measuring the rates of inorganic carbon fixation of phytoplankton samples to which various amounts of oil, as dilutions of OS or ODS suspensions, had been added. Approximately 18 litres of seawater containing phytoplankton were collected from a depth of 3 m, filtered through 1 mm mesh to remove large zooplankton, placed in a blackened 20 l plastic bottle and mixed thoroughly. For each of 12 EXPERIMENTAL samples 450 ml of seawater from the blackened plastic bottle was placed in a 500 ml B.O.D. bottle and twenty-five ml of the appropriate dilution of OS or ODS suspension was added. Each bottle was then filled with seawater and inoculated with 1 ml of ^{14}C-labelled $NaHCO_3$ working solution. Three CONTROL samples containing only seawater and isotope working solution were also incubated. To control for possible effects of dilution, temperature change, and contamination resulting from the addition of the OS and ODS suspensions, three SHAM experimental samples were included containing seawater, isotope working solution, and 25 ml of GF/C filtered seawater used to prepare the OS and ODS suspensions. Bottles were incubated at a depth of 3 m for 4 hours. Incubation was always conducted between 11.30 hrs and 16.00 hrs, N.S.T.

Following incubation, photosynthesis was stopped by addition of 2 ml of saturated $HgCl_2$ solution to each sample. Phytoplankton were separated from seawater by filtering 300 ml of each sample through a 47 mm dia 0.45 micron membrane filter under vacuum (10 p.s.i.).

Any free inorganic ^{14}C retained on the filter was removed by rinsing the filter with 10 ml of prefiltered seawater and by fuming the filter over concentrated HCl for 5 minutes. Filters were then air dried and placed into vials containing 15 ml of the scintillation counting cocktail, Aquasol^{-2}.

The amount of inorganic ^{14}C fixed by the phytoplankton during incubation was determined by measuring the amount of radioactivity remaining on the membrane filter. The radioactivity of each filter was determined using a Beckman LS-233 Liquid Scintillation Counter. Correction for quenching was made using the external standard ratio method.

Measurement of oil concentrations in toxicity tests: A 100 ml aliquot from each EXPERIMENTAL, SHAM, and CONTROL sample was extracted with a 10 ml volume of CH_2Cl_2 in a 250 ml separatory funnel. The CH_2Cl_2 extract was stored until analysed in a 25 ml glass vial with a foil lined screw cap in the dark at room temperature. The concentration of petroleum hydrocarbons in this CH_2Cl_2 extract was determined by comparison with a series of standard solutions of Lago Medio crude oil in CH_2Cl_2 using a Turner Model 110 fluorimeter.

Tests demonstrated that the presence of Corexit 9527 in suspensions did not interfere with the efficiency of extraction of oil from the suspension nor did it interfere with oil determination in CH_2Cl solutions using fluorescence method.

Taxonomy and enumeration of phytoplankton: The taxonomic composition and cell density of the phytoplankton community was determined by microscopic analysis of a 125 ml sample of the sea water used in the test. This sample was preserved with 10-12 ml of neutralized formaldehyde solution.

Date and location of study: This toxicity test was repeated successfully on six dates from October 20, 1977 to November 20, 1977 in Conception Bay, Newfoundland.

RESULTS

Phytoplankton abundance, community composition, and primary production. The phytoplankton community at a depth of 3 m in Conception Bay, Nfld. was composed almost exclusively of microflagellates (95% of cell numbers) during October and November, 1977. Estimates of biomass density varied widely from date to date, ranging from 24.5×10^3 to 122.8×10^3 cells l^{-1}. Estimates of primary production rates in controls also varied widely from day to day, ranging from 0.29 to 2.00 mg C $m^{-3}hr^{-1}$.

Petroleum hydrocarbon concentrations: The concentrations of oil to which the phytoplankton were exposed was determined by measuring the oil concentration in a 100 ml aliquot from each EXPERIMENTAL, SHAM and CONTROL sample. The EXPERIMENTAL samples, to which physically dispersed oil had been added, contained 0.01 to 0.83 mg oil l^{-1}. The oil/Corexit 9527 treatment group contained 0.02 to 6.00 mg oil l^{-1}. The levels of hydrocarbons in the CONTROLS and SHAMS ranged from 0.01 to 0.08 mg oil l^{-1}.

Toxicity of oil and oil/dispersant mixtures to phytoplankton. Carbon fixation was inhibited by as much as 50% in samples treated with physically dispersed crude oil and as much as 85% in samples treated with crude oil dispersed with Corexit 9527. The relationship between carbon fixation and crude oil concentration for both physically and chemically dispersed oil is given in Fig. 1.

In seventeen of the thirty-six experimental samples measured hydrocarbon concentrations could not be distinguished those of SHAMS [1]. Carbon fixation rates in these samples (taken as a group) were not significantly different from SHAMS so due to uncertainty regarding real crude oil concentrations in these tests, these data were omitted from further analysis. Linear regression was performed on the remaining data relating carbon fixation rate, as a fraction of SHAM rates, to the logarithm of measured oil concentration. Data from all repetitions of the test were grouped for this analysis. As expected, carbon fixation rates were negatively related to ambient crude oil concentration. Intersection of the regression line with the rate of carbon fixation in SHAMS, an estimate of the zero-effect concentration for crude oil, occurred at approximately 0.07-0.08 mg crude oil ml^{-1}.

---

[1] There was no detectible difference between SHAMS and CONTROLS with respect to hydrocarbon levels or rates of carbon fixation on any date.

The results of oil/Corexit 9527 treatment tests, were treated in the same way as were those of the oil tests. Intersection of the regression line with the carbon fixation rate in control tests occurred at approximately 0.07 - 0.08 mg oil l^{-1} as in the tests with oil alone. The slope and position of the regression lines relating carbon fixation and oil concentration for both phsically dispersed oil and chemically dispersed oil were so strikingly similar that no further statistical analysis was considered necessary. It was concluded that crude oil, dispersed with Corexit 9527 in the manner described here, is no more toxic to phytoplankton than physically dispersed oil.

DISCUSSION

Toxicity of physically dispersed oil. The above data (Fig. 1) demonstrate that effects of oil on phytoplankton carbon fixation are detectible at oil concentrations of 0.1 mg oil l^{-1}. Gordon and Prouse (1973) found toxic effects at slightly lower measured concentrations of oil in Bedford Basin and in the Atlantic Ocean but these small differences may have resulted from the high background levels of oil in the present study.

Effects of chemical dispersal of crude oil. The use of a chemical dispersant on crude oil presents at least two problems to the inhabitants of the water column. Dispersant speeds up the entry of oil into the water column making oil concentrations in the water column rise rapidly. Application of chemical dispersants means potentially toxic, xenobiotic compounds are added to those already present. From the results of the present study, the phytotoxic effects of a given concentration chemically dispersed crude oil appear to be no different from those for an equal concentration of physically dispersed crude oil, when the dispersant, Corexit 9527, is used in the present fashion. In other words, the toxic response of the phytoplankton community to physically and chemically dispersed oil appears to be independent of the method of dispersion when the dispersant Corexit 9527 is used. This does not mean, however, that the use of Corexit 9527 to disperse oil will have no effect on the phytoplankton community at the spill site. On the contrary, by its very nature the chemical dispersant speeds the entry of oil into the water column, drastically raising local oil concentrations. The work of several authors suggests that maximum oil concentrations reached in the spill site are increased by as much as a factor of ten or more from 1-4 mg oil l^{-1} to 10-40 mg oil l^{-1} when a dispersant is applied (Cormack and Nicols, 1977; Mackay and Leinonen, 1977). From the dose-response curve generated in the present study, it appears that oil concentrations of 1 or 2 mg oil l^{-1} under the slick in the absence of chemical dispersion, are sufficient to cause at least 50% inhibition of carbon fixation (Fig. 1). However, with chemical dispersion, oil concentrations may increase to 35 mg oil l^{-1} or higher for a brief periods. This would appear to be sufficient to completely arrest carbon fixation for at least as long as it would take for ambient oil concentrations to be reduced by diffusion and dilution. The longer term effects would be determined by the reversibility of phytotoxic effects of oil, a subject about which little has been published to date.

The effect of an oil spill or the chemical dispersion of an oil spill may not be limited to the immediate vicinity of the spill. A cloud of dissolved and suspended oil spreads by diffusion from the centre of the spill. Oil concentrations in the cloud decline by dilution as the volume of the cloud increases. Horizontal diffusion theoretically proceeds ad infinitum but short term inhibition of carbon fixation would be restricted to the region within which oil concentrations are high enough to cause a toxic response. The size of this "region-of-effect" can be estimated for each of the different spill countermeasures available using the above dose-response curves, the amount of oil spilled the fraction entering the water column, and a simple horizontal turbulent diffusion model for oil.

Toxic mode of action of oil on phytoplankton: There appear to be at least two models to explain the toxic action of petroleum hydrocarbons on phytoplankton. One theory is that oil droplets touch and adhere to phytoplankton cells and disrupt the plasma membrane or interfere mechanically with exchanges with the aqueous medium. Alternatively, toxicity may be due to direct interference in metabolic processes caused by hydrocarbons taken up algal cells from solution in the surrounding aqueous medium. Use of dispersants results in formation of small oil droplets (Canevari, 1971). The oil droplets formed during chemical dispersion are smaller (0.4-0.6 micron, equilibrium particle diameter) than those formed by physical dispersion alone (0.4 - 4.0 micron, equilibrium particle diameter), under conditions of suspension formation used here (Hallett, pers. comm.). Under both conditions, however, soluble hydrocarbons enter the aqueous phase from droplets with a half-time of 20 min. (Mackay and Leinonen, 1977) so the experiment was long enough to permit 95% of the light hydrocarbons to leach into solution prior to the beginning of incubation. It is more reasonable to conclude that for the two kinds of suspensions the similar toxicities resulted from similar concentrations of dissolved hydrocarbons rather than coincidentally similar effects of suspension of different particles sizes and densities.

If dissolved hydrocarbons are indeed responsible for toxicity of oil suspensions it is highly likely that factors such as suspended and dissolved matter will bind these hydrocarbons thereby influencing the bioavailability and therefore the effective dose of toxic materials in much the same fashion as they do metals and pesticides. It is reasonable to expect, therefore, that these variables will influence the toxicity of hydrocarbons to phytoplankton and likely to other biota.

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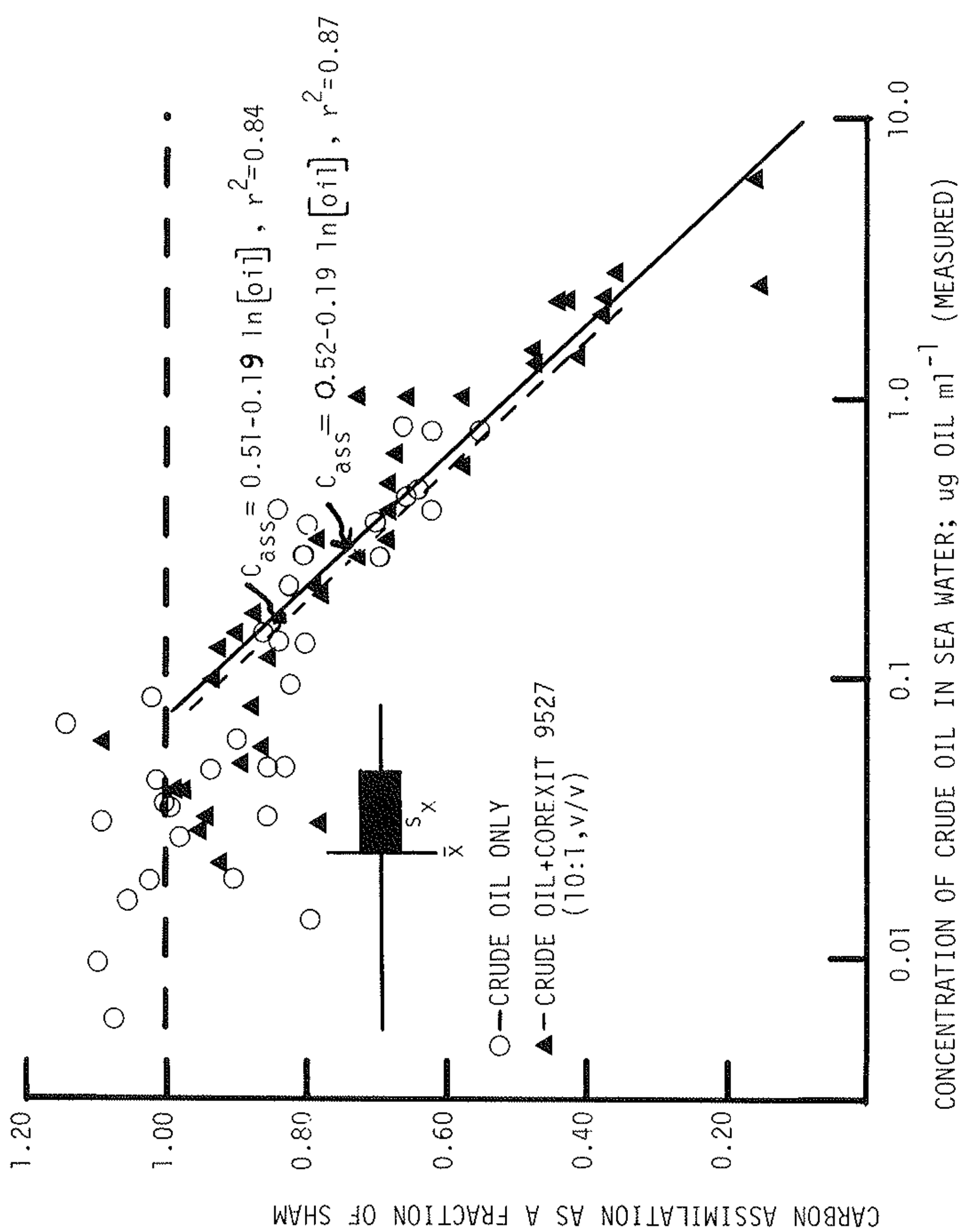
TABLE 1 - Summary of toxicity tests treatments

	TREAMENT	
Test Number	Contaminent	Light/Dark
1	25 ml OS, full strength	L
2	25 ml OS, 1:2.5	L
3	25 ml OS, 1:10	L
4	25 ml OS, 1:25	L
5	25 ml OS, 1:100	L
6	25 ml OS, 1:250	L
7	25 ml ODS - full strength	L
8	25 ml ODS - 1:2.5	L
9	25 ml ODS - 1:10	L
10	25 ml ODS - 1:25	L
11	25 ml ODS - 1:100	L
12	25 ml ODS - 1:250	L
13-15	25 ml Millipore filtered seawater	L
16-18	No toxicant or diluent	L
19-21	No toxicant or diluent	D
24-24	25 ml Millipore filtered seawater	D
25	25 ml OS - full strength	D
26	25 ml OS - 1:2.5	D
27	25 ml ODS - full strength	D
28	25 ml ODS - 1:2.5	D

Figure 1. Effect of crude oil and crude oil/Corexit 9527 mixtures on carbon fixation in marine phytoplankton communities, under conditions of in situ incubation (oil alone----; oil/dispersant----; mean beackground hydrocarbon concentration[1]; standard deviation of background hydrocarbons; the range of background concentration of hydrocarbons in the narrow horizontal bar).

1. Background hydrocarbon concentrations were determined by measurement of hydrocarbons in CONTROLS and SHAMS.

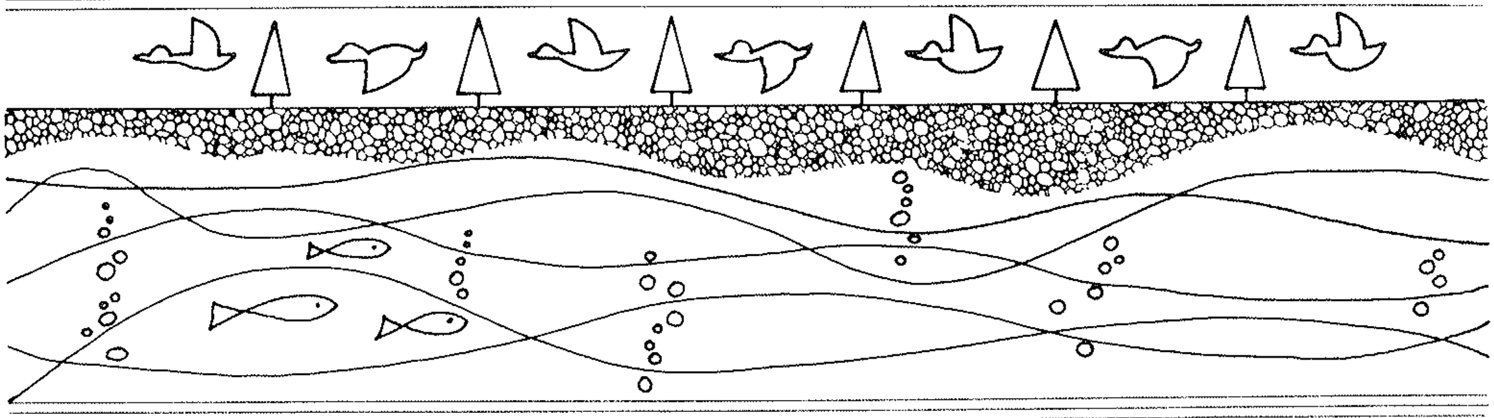


CARBON ASSIMILATION AS A FRACTION OF SHAM
1.20
1.00
0.80
0.60
0.40
0.20
0.01
0.1
1.0
10.0
CONCENTRATION OF CRUDE OIL IN SEA WATER; ug OIL ml^{-1} (MEASURED)
C_{ass} = 0.51-0.19 ln[oil] , r^2=0.84
C_{ass} = 0.52-0.19 ln[oil] , r^2=0.87
$\bar{x}$
s_x
○—CRUDE OIL ONLY
▲—CRUDE OIL+COREXIT 9527 (10:1,v/v)

SPILL TECHNOLOGY NEWSLETTER

An informal newsletter published bi-monthly by the Environmental Emergency Branch, Environmental Protection Service, Ottawa, Canada.

VOLUME 3(3) ISSN 0381-4459 May-June 1978



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Spill Technology Newsletter

EDITORS

Dr. S.L. Ross & Mr. M. Fingas

Research and Development Division
Environmental Emergency Branch
Environmental Impact Control Directorate
Environmental Protection Service
Department of Fisheries and The Environment
Ottawa, Ontario
K1A 1C8

Phone: (819) 997-3921

The Spill Technology Newsletter was started with modest intentions in 1976 to provide a forum in Canada for the exchange of information on oil spill countermeasures and other related matters. The interest in it was such that we now have almost 2,000 subscribers in Canada and around the world.

To broaden the scope of this newsletter, and to provide more information on industry and foreign activities in the field of oil spill control and prevention, readers are encouraged to submit articles on their work and views in this area.

INTRODUCTION

This could be our largest and most technical issue ever. If you think it is too long and too technical, please let us know! We are asking you to fill out a questionnaire on the second last page of this issue; by completing and returning it to us, we will be in a better position to understand and satisfy your interests. Please also fill out the "address correction sheet" on the last page, if your STN address is not correct.

In this issue we have:

-A report from Henry Quam of Imperial Oil Ltd. describing a very successful R&D project on controlling oil spills in ice-covered rivers. For the few of you in Canada who aren't aware, Henry and other dedicated Albertans in the oil industry and government have been doing outstanding oil spill work like this for many years now.

-Two articles from Mr. A.J. O'Sullivan on oil pollution in Ireland and his observations on the Amoco Cadiz Spill. Thank you Mr. O'Sullivan for these interesting reports.

-Four submissions from the EEB staff. Of particular note is the 1½-page article by Dr. Thornton asking for readers' comments and ideas on an oil spill field experimental effort he is now in the process of coordinating. Mr. Meikle would also appreciate comments on his article which outlines current objectives for oil spill equipment development for Canada's Arctic.

-An excellent article by Professor Jerome Milgram on the clean-up of offshore oil spills.

-An article by Dr. John Vandermeulen summarizing the results of his successful symposium on the recovery potential of oiled marine northern environments held in Dartmouth last fall.

Good reading and please fill out the forms in the back.

UPCOMING CONFERENCES

The 1978 Mid-Continent Conference and Exhibition on Control of Chemical and Oil Spills will be held September 6-8, 1978 in Detroit, Michigan. The conference is cosponsored by the U.S. Environmental Protection Agency, Hazardous Materials Control Research Institute, Information Transfer Inc., and the States of Michigan, Indiana, Illinois, Wisconsin and Minnesota. For further information contact Bobbie Zucker, Conference Coordinator, Information Transfer Inc., 1160 Rockville Pike, Suite 202, Rockville, Maryland, 20852 or phone (301) 279-7969.

REPORTS AND PUBLICATIONS

- The publication "Environment Source Book", a guide to sources of information on the environment in Canada, was produced as a joint project of the federal and provincial departments of the environment. This book is available in limited quantities from:

  Enquiry Centre
  Information Services Directorate
  Fisheries and Environment Canada
  Ottawa, Ontario
  K1A 0H3
  Phone: (819) 997-2800

- Three new reports listed below are available from the Minister of Mines and Energy, Government of Newfoundland, 95 Bonaventure Avenue, St. John's, Newfoundland:

  "Preliminary Offshore Environmental Study. Volume I. Physical environmental baseline study with application to the prediction of oilspill movement and oilspill countermeasures techniques for the drilling area off Newfoundland and Labrador." By NORDCO Ltd., St. John's, Newfoundland. 164 p. October, 1977.

  "Preliminary Offshore Environmental Study. Volume II. A preliminary biological baseline description and environmental impact analysis of blowouts for the shelf zone of Newfoundland and Labrador." By NORTHLAND ASSOCIATES Ltd., St. John's, Newfoundland. 286 p. October, 1977.

  "Preliminary Offshore Environmental Study. A preliminary physical and biological environmental baseline study and environmental impact analysis of blowouts for the shelf zone of southeastern and southern Newfoundland Waters." By NORTHLAND ASSOCIATES Ltd. and NORDCO Ltd. 344 p. April, 1978.

- The third edition of "Polar Continental Shelf Project - Titles and Abstracts of Scientific Papers Supported by PCSP" is available upon request from:

  The Polar Continental Shelf Project
  Department of Energy, Mines and Resources
  4th Floor
  880 Wellington Street
  Ottawa, Ontario
  K1A 0E4

- The Center for Short-Lived Phenomena has initiated a weekly newsletter entitled "Oil Spill Intelligence Report." The publication covers the following topics: reports on major oil spills; innovations in equipment, dispersants, and techniques; new developments in oil spill research; notices of contracts and bids; and coverage of legislation and litigation. Subscritions for one year is $347 (U.S.) and $549 for two years. Address inquiries to Oil Spill

Intelligence Report, 221 Columbus Avenue, Boston, Massachusetts, 02116, U.S.A.; phone (617) 536-7780.

- Statistics Canada has produced a statistical profile on "Human Activity and the Environment" (190 pages; price $2.80 in Canada, $3.40 elsewhere). This publication can be ordered from: Publications Distribution, Statistics Canada, Ottawa, Ontario, K1A 0T6; or from Publishing Centre, Supply and Services Canada, Ottawa, Ontario, K1A 0S9.

- The following reports are available from the U.S. Department of Commerce, National Technical Information Service, Springfield, Virginia, 22161; telephone (703) 321-8543. Most reports are also available on Microfiche at $3.00 each (U.S.A. Price). Canadian buyers add $2.50 to each paper copy and $1.50 for each microfiche report.

  "Performance Testing of Selected Inland Oil Spill Control Equipment" W.E. McCracken. Mason and Hanger-Silas Mason Co. Inc., Leonardo, New Jersey. August, 1977. 125p. PB-279 078/0SL $7.50

  "Performance Testing of Three Offshore Skimming Devices" H.W. Lichte and M.K. Breslin. Mason and Hangar-Silas Mason Co. Inc., Leonardo, New Jersey. April, 1978. 80p. HCP/P3241-01 $6.00

- The "APOA Review", a publication of the Arctic Petroleum Operators' Association, was initiated in February of this year. The bulletin reviews activities and reasearch of the association. For further information write to: APOA Information Service, P.O. Box 1281, Postal Station "M", Calgary, Alberta, T2P 2J2 or phone (403) 266-5074.

- The Environmental Emergency Branch has released three new publications, the titles and abstracts of which appear below. These publications may be obtained upon request from the editor(s) of this newsletter.

Field Evaluation of the Super Seahawk and Marco Class V Oil Skimmers - (EPS-4-EC-78-2)

Two oil spill recovery devices, the Super Seahawk and the Marco Class V, were evaluated at Esquimalt Harbour near Victoria, British Columbia in August 1977. The former is manufactured by Bennett Pollution Controls Limited, North Vancouver, B.C. and the latter by Marine Construction and Design Company, Seattle, Washington. The two devices were evaluated on the basis of the parameters: Oil Recovery Rate (ORR), the rate at which the device recovers oil; Oil Recovery Factor (ORF), the volume of oil recovered by the device versus the volume presented to it; Oil Content Factor (OCF), the percentage of oil in the liquid recovered by the devices; and Emulsification Fact r (EF), the percentage of water in the oil which was recovered by the device. These parameters were measured during trials in which three types of fresh oil (Alberta Crude, Diesel and Bunker C) were spilled in limited quantities (less than one barrel) directly in front of the skimmers. The trials took place under environmental conditions ranging from clear skies and calm seas to rain and slight chop.

No quantitative data were obtained for the Super Seahawk due to the small amount of oil it was able to collect. The device was considered to require extensive redesign.

In the case of crude oil trials, Oil Recovery Rates for the Marco Class V ranged from 0.3 to 7.9 litres per minute. The Oil Recovery Factor ranged from 4.4% to 91% and the Emulsification Factor from 34% to 1%. For diesel oil trials, Oil Recovery Rates ranged from 3.2 to 14.1 litres per minute. The Oil Recovery Factor ranged from 35% to 78% and the Emulsification Factor from 45% to 1%. Only three trials were carried out using Bunker C. The Oil Recovery Rates obtained were 12.5, 13.7 and 14.2 litres per minute. The Oil Recovery Factor approximated 100% in each case. The Emulsification Factors were 24%, 17% and 19%.

In addition to the quantitative results, judgement values were made on construction, ease of operation and safety. The Marco Class V was judged to be acceptable for all three criteria. The Super Seahawk was judged to be acceptable in construction and operation, but potentially unsafe if manned in seas with wave heights exceeding one metre.

Field Evaluation of Eight Small Stationary Skimmers - (EPS-4-EC-78-5)

One hundred and five tests were conducted in the Quebec City harbour to evaluate eight small, stationary-type oil recovery devices. Two levels of evaluation were conducted:

1. A quantitative evaluation, based on the test data and including the following parameters:
   (a) oil recovery rate;
   (b) oil content factor - the percentage of oil in the liquid recovered by the device;
   (c) emulsification factor - the percentage of water in the oil which was recovered by the device.
2. A technical evaluation which included:
   (a) machine operation;
   (b) handling;
   (c) maintenance;
   (d) construction;
   (e) system cost.

The tests were performed by skimming crude and diesel oil in floating layers of thicknesses varying from 1 mm to 12 mm. The environmental and test conditions are reported. The performance of each unit is discussed and some suggestions for design modification put forward.

Performance Assessment of Test Liners For Petroleum Product Storage Areas in Northern Canada (EPS-4-EC-78-6)

In early 1976 the Environmental Protection Service of Fisheries and Environment

Canada started assessment of liner systems appropriate for containing petroleum products. The study was directed toward suitable liners that could be placed economically in existing northern petroleum storage facilities located on pervious ground.

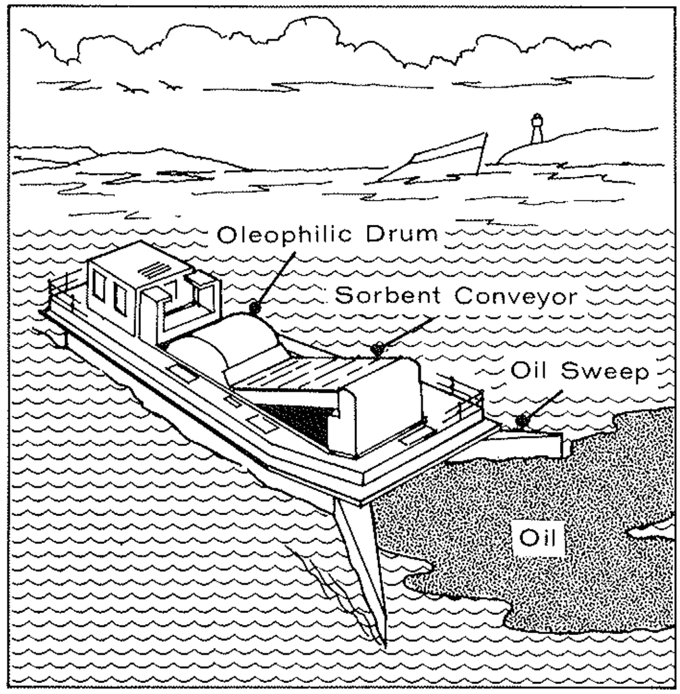
Test sections of four potential liner materials were installed at a tank farm near Yellowknife, N.W.T. during the summer of 1976. The four liner systems were: a processed bentonite, which was mixed with in-situ soils; a molten, spray-applied sulphur, which formed a rigid liner; two urethane coatings, spray-applied onto a fabric backing; and two types of urethane foams.

EBA Engineering Consultants Ltd. undertook an assessment of the test sectins during the summer of 1977 in order to evaluate performance of the various materials after a year of exposure to the harsh northern climate. The report culminating that study contains a summary of procedures used and problems encountered during installation of the test sections. Detailed field observations taken during the summer of 1977 are documented. Results of laboratory testing on samples of the liner materials are reported. Based on these data, suitability of the four liner systems is appraised.

Proper equipment is necessary to mix and compact the bentonite liner correctly. Because such equipment cannot be used in congested areas, this material is not considered appropriate for existing tank farms. The sulphur liner exhibits a propensity to crack, at least in its present stage of development. An unacceptably high level of maintenance would likely be required to maintain liner integrity. The urethane coatings performed adequately over one year, but now show initial signs of weathering damage. Their use in limited term installations only is prudent until the ultimate degree of weathering can be assessed. Urethane foam liners show good potential for use as liners in petroleum product storage areas.

- The proceedings of the symposium on "Recovery Potential of Oiled Marine Northern Environments" held at Halifax, Nova Scotia in October 1977 have been published as Volume 35, No. 5 (May 1978) of the Journal of the Fisheries Research Board of Canada. Single issue of this journal may be purchased for $4.00 to Canadian buyers and $4.80 elsewhere. Orders should be directed to Publishing Centre, Supply and Services Canada Limited, Ottawa, Ontario, Canada, K1A 0S9.

NEW PRODUCTS



BODAN-WERFT Oil Collecting Vessel

Boden-Werft (Boden Werft GmbH, Postfach 9160, 7993 Kressbronn Stuttgart, Federal Republic of Germany, phone (07543) 6861) has introduced a model of oil skimmer employing an oleophilic drum concept of recovery. The unit also has a sorbent conveyor placed forward of the main heavy drum. The vessel on which the recovery unit is mounted is self-propelled and measures 15x5 metres.

AMOP EXPERIMENTAL OILSPILL PLANNING

Submitted by: Dr. D.E. Thornton
Research and Development Division
Environmental Emergency Branch
Environmental Protection Service
Environment Canada
8th Floor
9942 - 108 Street
Edmonton, Alberta
T5K 2J5
Canada
Phone: (403) 425-6932

The Arctic Marine Oilspill Program (AMOP) is a 5-year, $7 million technolgoy program to develop oil spill countermeasures for Arctic waters. An article describing the program objective, philosophy and administration appeared in the January-February, 1977, Volume 2(1) issue of this Newsletter. Also, a mid-year review of the projects initiated during the first year was published in the September-October 1977, Volume 2(5) issue.

A need for experimental oilspills in an arctic marine environment has been identified within AMOP. In order to satisfy this requirement, a technical planning committee, involving personnel from the private, public and academic sectors, has been formed to design a program of field experiments to be initiated next summer and to continue for 2 years.

The initial task of the technical planning committee is to identify the core field projects and to list them in order of priority. The purpose of this article is to invite you, the reader of this Newsletter, to submit projects, involving the controlled discharge of oil in an arctic marine environment, which you perceive should be considered for inclusion in the AMOP experimental oilspill program.

At this stage, the project documentation need only be very brief, but should include the project objective; an indication of the main site requirements; the probable timing; and a rationale explaining the relevance to potential arctic oilspills and justifying why the work must be performed in the field. (It is possible that secondary projects, with weaker rationales, may be integrated into the program if they can "piggy-back" on suitable core studies).

AMOP monies will be used to fund the core studies selected by the technical planning committee. Some support will be provided to agencies wishing to implement secondary studies, overlapping with the AMOP objective, which may be included in the program without jeopardising the core projects.

The projects will be separated into three main categories (in AMOP order of priority):

1. Oilspill Countermeasures

2. Oilspill Behaviour and Fate
3. Biological Effects

A final integrated program design is scheduled for submission to the regulatory authorities by the end of February, 1979. However, an extensive liaison and review process involving regulatory personnel at the working level, northern communities, public interest groups, and the scientific community is planned for working documents and drafts during the planning stage. Hence, project suggestions should be forwarded before the end of August, 1978, to Dr. Thornton at the above address.

The intent of this invitation and the extensive review and planning process is to attempt to optimize the utilization of the oil discharged and to minimize cost and environmental impact.

THE SYMPOSIUM ON RECOVERY POTENTIAL OF OILED MARINE NORTHERN ENVIRONMENTS

Submitted by: J.H. Vandermeulen
Department of Fisheries and the Environment
Fisheries and Marine Service
Marine Ecology Laboratory
Bedford Institute of Oceanography
Dartmouth, N.S.
B2Y 4A2

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With current growing concern over the presence of foreign chemicals entering our living environment (e.g. Addison 1977; Giam et al. 1978) there has been increased interest in the fate and effects of petroleum hydrocarbons, whether from oil spills or from other land-based industrial or domestic sources. Each year sees a number of conferences organized around this concern, most notably the biennial American Petroleum Institute-sponsored meeting on Prevention And Control Of Oil Spills, and the American Institute of Biological Sciences-sponsored meetings emphasizing the biological and ecological aspects. These conferences and others like them are essential in bringing together the various workers with diverse interests in this rapidly growing field, and do much to stimulate further research and exchange of ideas. However, they can not always address those questions of general shared interest that emerge as central themes.

One such central question has been the problem of environmental recovery following an oil spill. As several studies have shown (e.g. Baker 1976; Sanders et al. 1977; Thomas 1977; Vandermeulen and Gordon 1976) recovery as well as the process of recovery are not understood. It was for this reason that in the fall of 1976 we began to organize this symposium on the recovery potential of oiled northern marine environments, our rationale being that without some idea of the ability of an environment or ecosystem to respond to or absorb a spill or chronic influx of oil any discussion of environmental impact is largely academic. By bringing together the top workers in this field, representing the various disciplines, an integrated discussion of the more general property of environmental recovery processes would hopefully lead to recognition of some general principles common to the various spills studied. The least such a discussion could lead to would be an evaluation of a possible time scale for the total recovery of a polluted beach or bay. The approach seemed reasonable, for over the last few years a number of well-known oil spills have been studied to the point where a sizable body of knowledge and of understanding had become available, and could be brought together under one roof, for comparison and discussion. It was this comparative aspect of the symposium that was very important, for by discussing all known spills studies together it might be possible to extract some common principles of environmental impact and recovery. With the recovery potential of oiled environments as the central theme, and with the 1969 West Falmouth spill and the 1970 Arrow spills as focal points, over 160 participants from nine countries met in Halifax, Nova Scotia, to discuss just how much oil an environment can tolerate, what the recovery pattern or patterns may be, and what the weak links or fragile components are in the sequence of recovery steps following a spill.

The format of the meeting consisted of three consecutive sessions, each of about a dozen papers, and each focusing on a different aspect of the main theme of the symposium. Papers were arranged so as to lead naturally into one another, with each session building up on the preceding session. The session chairmen, all recognized experts in their fields, summarized the presented papers both in light of their own understanding of the problem as well as in terms of the main points from the preceding session, and relating the main message of the papers to the main theme of the symposium. In this way the 3½-day meeting built up continuously to a final summary discussion at the end of the last session and the last paper.

Taken in order, the first papers dealt with the chemical and physical changes in the oil following a spill. The presentations then moved to the various absorption and degradative mechanisms operating in the environment, be they physical, microbial, or physiological. The final series of papers focused on the long-term recovery patterns, and was built around long-term studies of the Torrey Canyon disaster, the West Falmouth incident, the Arrow, the General M.C. Meigs grounding on the west coast of Washington, and the recent Metula accident in the Strait of Magellan. Throughout the symposium the emphasis was on long-term follow-up studies, with strong emphasis on documented field work as distinct from simulated laboratory studies. Some laboratory studies were included so as to illustrate a particular spill phenomenon or to examine certain physiological effects that can be studied in the field only with great difficulty.

What was achieved? It is too simplistic to expect that hard numbers for such a complicated problem would emerge at the end of the symposium. Each spill and each oiled area differs in so many respects that even a simple estimate at recovery time becomes at best an educated guess. That was not the prime purpose. The symposium was held to bring together under one roof the top workers in this field, and to provide an opportunity to examine different spill studies, be thy biologically, chemically, or ecologically oriented, in terms of the long-term recovery from a major oil spill. In this the symposium succeeded. The mood during the 2nd and 3rd day grew more thoughtful as the topics changed from the mechanics of oil transport to bioavailablity and in turn to the physiological repercussions and enzymatic degradation mechanisms. Figuring very strongly in this was the series of papers in Session III, dealing with long-term ecological recovery patterns. Introduced by Southward and Southward's study of intertidal fauna and floral alteration patterns following the Torrey Canyon disaster, 1967 to the present, this last session brought together all the long-term studies available to date. In retrospect this session was almost a research exercise in itself, and probably sufficient reason for having participated in this symposium.

Nonetheless there were a number of points raised that deserve separate mention and comment. Probably the most critical observation made was that raised by Clark and Mann in their summary after the final session, in which they pointed out the oft forgotten observation that natural inherent variations in the environment are part and parcel of nature, and that these variations can often be of a significant magnitude. Thus where a change in tissue growth or in population abundance seems obviously related to some environmental disaster such as an oil spill, these changes may equally well be part of a natural variability in organism growth or abundance, totally unrelated to the oil spill in question. The paper by Dr. Notini (Sweden) describing ecological changes relating to a Baltic oil spill illustrates this point. In this study changes in population abundance were found to coincide not only with oiling, but also with fluctuations in surface water temperature. Therefore extreme care must be exercised in the experimental design of these sort of ecological impact studies, and in attributing changes to oil spills and oil exposure. The science of oil spill impact assessment must be as "tight" a science as that of pure research.

Despite this criticism there is, nonetheless, the demonstrated fact of the devastating effect of oil on marine environments, the persistence of petroleum hydrocarbons and the persistence of their biological impact. And this was probably the real message of the symposium. For even though the third session demonstrated the eventual recovery of oiled marine populations and ecosystems, somewhere between 5 and 15 years depending on the spill conditions, papers in Sessions I and II documented repeatedly the persistence of oil, particularly of the larger molecular weight components, for possibly longer duration than the observed ecological recovery times. A number of papers addressed this phenomenon, as well as documenting the changing composition of oil. One common feature of environmentally altered petroleum is the loss of the n-alkanes and the lower molecular weight hydrocarbons, with the parallel enhancement of the aromatic components. In fact, Cretney et al. suggest that this long-term resistance to degradation of the large molecular weight residuals, such as the pentacyclic triterpanes, makes these compounds useful candidates for long-term source identification of oil and of oil spills.

Of greater concern is this same persistence of hydrocarbons in tissues, after brief and after chronic exposures of organisms to various oils or oil components. Organisms do rid themselves of foreign molecules and tissues do depurate, but the mechanism of depuration is not understood, nor is depuration complete in all cases. Loss of tissue-bound hydrocarbons seems to be aided by the cytochrome-P_{450} based aryl hydrocarbon hydroxylase system. At least, this is the case in vertebrate tissues. The situation is less clear-cut in the marine invertebrates where this enzyme system has been identified in a number of phyla, but seems nonexistent in such ecologically and commercially important groups as the bivalve molluscs. The potential implications of (a) a degradative bottle-neck in the marine foodchain, and of (b) bio-accumulation and concentration of the larger aromatic molecular weight compounds in marine tissues seem obvious, albeit very poorly understood. For the fact is that in terms of understanding the potential disruption of marine foodchain kinetics by petroleum hydrocarbons, science is presently only scratching the surface.

Any discussion of the potential of an ecosystem to absorb an oil spill must necessarily include the role of hydrocarbon utilizing bacteria, for microbial degradation is generally thought to be the final long-term degradative step in removal of hydrocarbons from the environment. This applies especially to those hydrocarbons bound up eventually in the sediments. A number of papers, reporting from various spill studies including the Arrow and the Metula spills, considered this aspect of environmental defense against pollution. It would appear, however, that microbial degradation is less effective than formerly thought, with microbial processes occurring at low rates and being dependent on nutrients other than hydrocarbons. Also, the mechanisms involved in this supposedly ultimate line of environmental defense in hydrocarbon degradation are generally unknown (Stewart and Marks). Perhaps the most startling observation, and of immediate relevance to the northern and arctic environment, was that microbial breakdown of oil trapped within or under arctic ice is almost negligible. Oil trapped in this manner did not show any appreciable changes during the course of a winter (Atlas et al.). The repercussions of these observations, in the field, in terms of northern exploration and development are foreboding at best. More amazing, however, is that these observations have come to light only now, in 1977, 10 years after the Torrey Canyon disaster. This indicates a very large gap in our understanding of the potential impact of oil on our environment.

Perhaps the most remarkable point made during the entire symposium, however, did not come from the speaker's platform but arose from the floor during a general discussion, and related to the use of "control" or "reference" sites. For despite all efforts, true hydrocarbon-free reference sites apparently no longer exist. This is not a new observation. Most workers in this field are aware of this dilemma and have attempted to deal with the problem. All reference sites contain petroleum-derived hydrocarbons, and other nonindigenous compounds for that matter, to greater or lesser degree. It should be noted that in many cases this contamination of reference sites is not man-made. Atmospheric transport of forest-fire debris can account for some of this general background contamination. More serious is the fact that a large part is due to man's efforts. Most oceanic shorelines receive a low-level but continuous input of water-borne petroleum hydrocarbons, and these must eventually become available for biological accumulation and metabolic conversion. The same holds true for benthic sediments where concentration in anoxic layers can be high but rates of microbial degradation are very low. Man can and does pollute his environment consistently and very pervasively, a legacy for future generations.

To return to the main theme of the symposium - "what is the recovery potential of oiled marine environments" - the answer is that oiled marine environments will eventually return to a stable state, in from 5 to 15 years. Nature has a battery of defense mechanisms, including self-cleaning by wave action and beach erosion (Owens), biological conversion (Stegeman; Vandermeulen and Penrose; Gordon et al.), and microbial degradation (Atlas et al.; Colwell et al.; Stewart and Marks). However, very little is known of the process of contamination, the manner in which a foreign compound or compounds interfere with the normal functioning of living systems. Petroleum hydrocarbons are, after all, compounds foreign to biological systems, and most are not compatible with the processes of life.

Ultimately of course the question is whether we find the idea of long-term recovery acceptable. In terms of such other man-made perturbations as the deserts of the Middle East or the denudation of the Scottish Highlands, recovery time of oiled environments seems a small matter (Mann and Clark). But although these examples involved enormous human costs over a much greater time period, there were no changes in the basic processes of life. Those incidents did not leave residues of problem compounds in our environment, and did not have the potential of physiological disruption or of long-term generation of mutagenic or carcinogenic derivatives. We are relieved to learn that environments do recover following oiling. However, is the damage or injury done during the recovery process worth funding more research and spending more money to prevent oil spills or for that matter other chemical contamination? The matter of research funding was raised repeatedly during the course of the symposium. For although a significant amount of money has been directed to petroleum pollution research, both by government and industry, it became apparent that there exists a lack of consistent funding of such essential long-term studies as were the subject of this meeting. Thus several of the studies included in this volume were funded by "bootlegging" funds fpom other projects to maintain minimal research effort and quality. The decision of course can not be made until all the facts are in, and judging by this symposium of the top scientists in this field, the facts are not in and we are indeed only scratching the surface.

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OIL POLLUTION ON THE COAST OF IRELAND

Submitted by: A. J. O'Sullivan
Chremer and Warner Ltd.
Consulting Engineers and Scientists
Dublin, Ireland

INTRODUCTION

Since 1966 the Advisory Committee on Oil Pollution of the Sea has been carrying out a survey of oil pollution incidents on the coast of England and Wales. In 1973 this survey was extended to Scotland and in 1975 Ireland was also included. The purpose of the survey is to build up statistics and information on the occurrence of oil pollution, its source if known and the extent of any damages or clean-up costs incurred. Such information is of considerable value in formulating oil spillage contingency plans, and in deciding how and where to allocate equipment and funds.

In 1977 the Advisory Committee on Oil Pollution of the Sea requested Cremer and Warner Ltd. to assist with the collection of information from Ireland. Questionnaires were distributed to maritime county councils, corporations, borough councils, and district councils; to harbour commissioners and port authorities and to a major oil terminal operator. In Northern Ireland, information was received also from the Department of the Environment and the Coastguard. We are very grateful indeed to all of these organisations for responding to our request for information or observations; without their help this survey would not have been possible. It is also worth noting that questionnaires reporting no pollution are as useful to the survey as those reporting pollution; we need equally to know what parts of the coast are remaining free of pollution.

GENERAL COMMENT

On the whole, Ireland continues to remain relatively free from pollution by oil. Despite there being a greater number of incidents on the south coast than in previous years, the overall extent of pollution was less. On the east coast the reduction was most evident; no spillages at all being reported from the Port of Dublin which handles a great deal of tanker traffic. Other major ports relatively free from pollution included Waterford, Belfast (where only two spills took place), Foynes, Limerick, and the Gulf Terminal in Bantry Bay. No spillages were reported from any of the oil and gas exploration activities off the south and west coasts or from the construction of the two platforms and pipeline associated with Marathon's Kinsale Head gas field.

East Coast:

Carlingford Lough to Carnsore Point (the coasts of Louth, Meath Dublin, Wicklow and part of Wexford).

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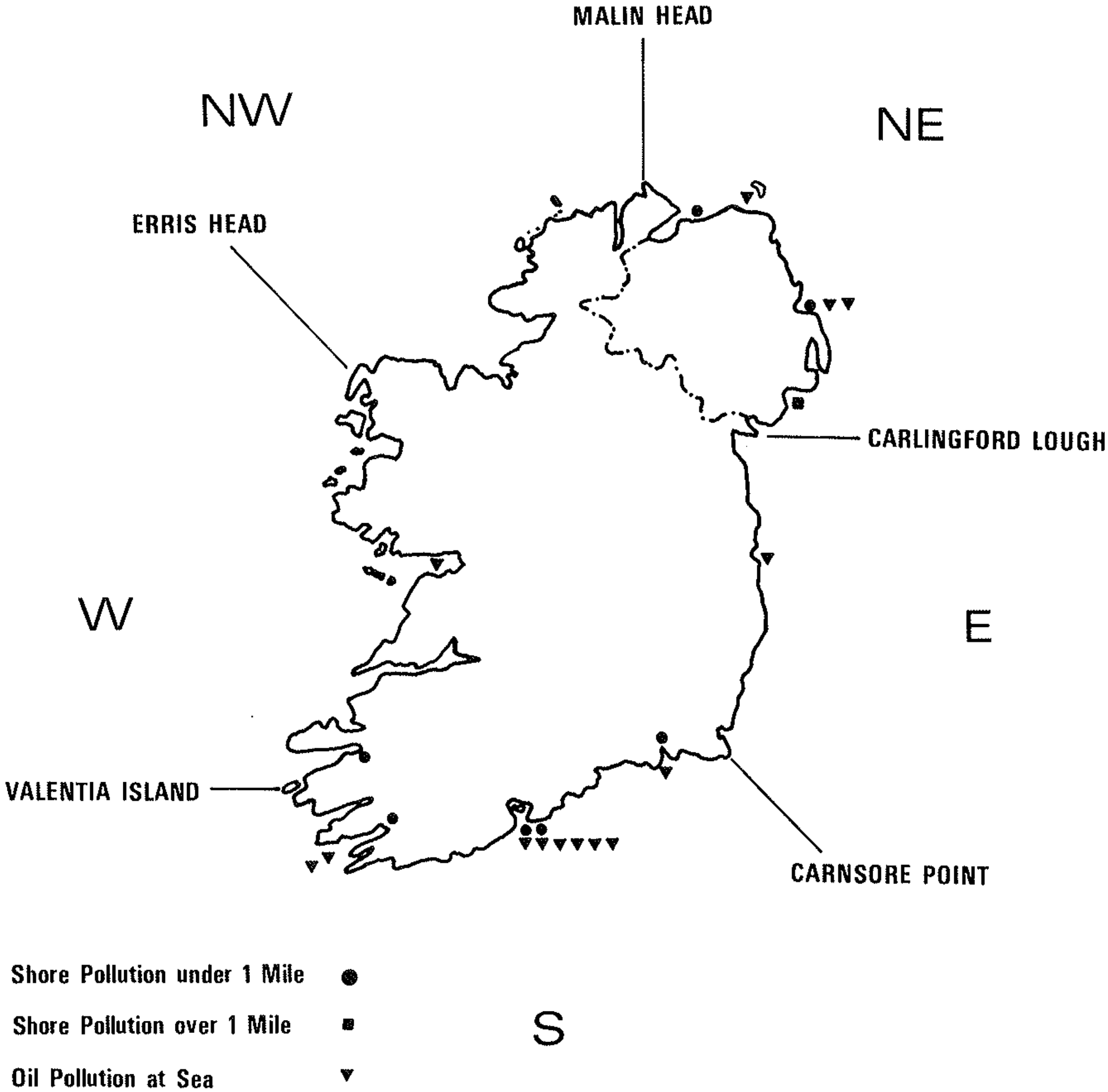

Oil Pollution on the Coast of Ireland 1977

This district was entirely free from pollution by oil with the exception of a small spillage of diesel oil (20 gallons approx) in Dun Laoghaire harbour in early July. This represents a significant decrease since 1975 when 11 spills were reported.

South Coast:

Carnsore Point to Valentia Island.

There was a greater number of incidents on the south coast during 1977 than in recent years, but the total amount of oil involved was smaller and overall pollution was very much less.

The largest oil spill took place at the Great Island Electricity Generating Station in Waterford Harbour when some 15 tons of fuel oil were lost in late May. Salmon nets were reported to be damaged, but the spill was contained using booms and was quickly cleared with dispersant.

In Cork Harbour eight spills occurred but all were minor, consisting mainly of heavy fuel oil, and were cleaned up within a few days. In two cases dispersant was used; in three manual or mechanical means were employed, and in the remaining three incidents, the oil subsequently disappeared by wave and tidal action.

In Bantry Bay only 3 spills occurred during the year. All were very minor, two being cleaned up using dispersant (together with straw in one case) and the largest spill (150 gallons) was removed by the oil recovery vessel stationed at the Whiddy Island Terminal. A further biological survey of Bantry Bay will be carried out in April 1978 by the Oil Pollution Research unit at the request of Gulf Oil Inc.

West Coast: Valentia to Erris Head

Two spills occurred during the year. The first, a small spill of fuel oil from a storage tank near Killorglin, County Kerry, was cleaned mechanically. In August about 100 gallons of waste oil entered Galway Docks via the city sewers and was dispersed by Galway Harbour Commissioners.

North-West Coast: Erris Head to Malin Head

This coast continued to be free from oil pollution.

North-East Coast (Northern Ireland):
Malin Head to Carlingford Lough (coasts of Derry, Antrim and Down).

Some six spills were reported, two in Belfast Harbour and the remaining four on the coasts of Antrim and Down. In October parts of Dundrum Bay and the Mourne coast were polluted by small amounts of solidified oil, while in December the shores around Portstewart and Greenisland (Belfast Lough) were similarly affected. Also in December, oil began to leak again from the 12 year old wreck of the MFV "Ella Hewitt" in Church Bay, Rathlin Island. The oil was reported to have caused some damage to birds, seals and fishing activities during an initial period of heavy discharge. Clean up was mainly by dispersant in the area of the harbour.

OIL POLLUTION SURVEY 1977

Table 1: Statistics of questionnaires sent and returned

IRELAND

Organisations to whom questionnaires were sent	Number of questionnaires sent	Number of questionnaires returned	Reporting oil pollution	Reporting no oil pollution
Maritime County Councils	14	10	4	6
Corporations, Borough Councils and District Councils	9	4	1	3
Harbour Commissioners and Port Authorities	29	17	5	12
Department of the Environment (NI)	1	1	1	-
Coastguard (NI)	1	1	1	-
Oil Industry	1	1	1	-
TOTALS	55	34	13	21

Table 2: DISTRICTS COMPARED WITH PREVIOUS YEARS

IRELAND

DISTRICT	Questionnaires reporting more pollution in 1977 than in 1976	Questionnaires reporting less pollution in 1977 than in 1976	Questionnaires reporting more pollution in 1977 than in previous years	Questionnaires reporting less pollution in 1977 than in previous years
Ireland East Coast	-	1	-	1
Ireland S. Coast	1	3	-	4
Ireland West Coast	1	-	1	1
Ireland North-West Coast	-	1	-	1
Northern Ireland i.e. Ireland North-East Coast	1	2	1	-
TOTALS	3	7	2	7

TABLE 3:- STATISTICS OF SPILLAGES REPORTED IN IRELAND

DISTRICT	Location	Number of spills reported	Number over 1 mile	Number under 1 mile	Number of spills cleaned by any method	Number cleaned manually or mechanically	Number cleaned by detergent or dispersant	Number of incidents where costs reported	Number reported cost of cleaning operations £
Ireland East Coast (Carlingford Lough to Carnsore Pt)	Shore	-	-	-	-	-	-	-	-
	Sea	-	-	-	-	-	-	-	-
	Ports	1	-	1	1	1	-	-	-
	TOTALS	1	-	1	1	1	-	-	-
Ireland South Coast (Carnsore Pt. to Valentia)	Shore	1	-	1	1	1	1	-	-
	Sea	2	1	1	2	1	2	1	795
	Ports	10	-	10	10	4	3	3	6200
	TOTALS	13	1	12	13	6	6	4	6995
Ireland West Coast (Valentia to Erris Head)	Shore	1	-	1	1	1	-	-	440
	Sea	-	-	-	-	-	-	-	-
	Ports	1	-	1	1	-	1	-	-
	TOTALS	2	-	2	2	1	1	1	440
Ireland N.W. Coast (Erris Hd. to Malin Hd.)	Shore	-	-	-	-	-	-	-	-
	Sea	-	-	-	-	-	-	-	-
	Ports	-	-	-	-	-	-	-	-
	TOTALS	-	-	-	-	-	-	-	-
N. Ireland:- N.E. Coast (Malin Hd. to Carlingford L.)	Shore	4	1	3	4	3	1	-	-
	Sea	-	-	-	-	-	-	-	-
	Ports	2	-	2	2	1	1	2	330
	TOTALS	6	1	5	6	4	2	2	330
TOTALS		22	2	20	22	12	9	7	£7765

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INCINERATORS FOR OIL SPILL CLEAN UP

Submitted by: H.B. Ewing
Research and Development Division
Environmental Emergency Branch
Environmental Protection Service
Ottawa, Ontario
K1A 1C8
Phone: (819) 997-1788

Background

One of the methods of disposing of the collected materials following an oil spill is to burn them. The materials fall into one or more of the following caterygories:

1. liquid combustibles (oil and oil/water mixtures);
2. solid combustibles (oil-soaked organic or sorbent materials); or
3. solid non-cumbustibles (oil-soaked sand etc.).

The type of incinerator required to cope with these materials varies with the material, the amount of oil and the amount of water. The following are brief descriptions of several different types of incinerators that might be considered.

1. Flare type incinerators are used to burn liquids. Basically they contain an atomizing system and a source of combustion air. Once combustion has been initiated it is usually self sustaining.
2. Open Pit type incinerators are used to burn combustible solid waste materials. They are basically a hole or pit with forced air input top and bottom. After start up the burning is normally self sustaining. They are usually loaded by a front end loader or by other similar means.
3. Stoker type incinerators are similar to the old coal furnace of yesteryear. They consist basically of a grate on which the burning take place. They can be of the continuous-feed or batch-feed type. The burning is self-sustaining. They will burn combustible solids and will also burn off combustible from incombustible matter, eg., burn oil soaked gravel to give clean gravel.
4. Kiln type incinerators are long horizontal drums with the centre axis inclined slightly to the horizontal. The oil soaked incombustible material, eg., beach, sand, is fed into one end and tumbled slowly by the rotating kiln to the other end. The combustibles are burnt off in the process. Once started, the combustion is usually self sustaining but an auxiliary burner may be used.

Activities of the R&D Division

The matter of liquid disposal has been quite extensively studied, particularly because of the demands of the the oil industry in the production of offshore oil and gas fields. There are many portable burner systems on the market for burning liquid combustibles. The R&D Division is planning a study to identify the burners that are most suitable for the disposal of liquids collected during an oilspill cleanup operation.

The second category of materials to be disposed of is solid combustibles. These consist primarily of oil and water soaked organic materials or sorbents (straw, peat moss etc.). Tests carried out in September 1976 at Turner Valley indicated that oiled combustibles could be burnt in a portable trash incinerator. However there were certain drawbacks such as the requirement for auxiliary firing and the amount of smoke and ash produced.

Open pit incinerators have been used by industry and municipalities for some time to dispose of combustible wastes and appear to be well-suited for the disposal of combustible oil-soaked material gathered during cleanup operations. However, all the present incinerators are too large and heavy to be air transportable into remote areas. Environment Canada in 1977 commissioned a study to design one that would be constructed in kit-form and be transportable by helicopter for assembly on site.

A prototype version is to be built, erected and tested later this year.

The third category of materials to be incinerated is that of the oil soaked non-combustibles, usually sand and gravel. Actual experience in the Magdalen Islands has indicated that it is possible to burn oil out of oil-soaked sand well enough to permit returning the treated sand to the beach. A rotary kiln seems most effective for the purpose and in 1977 one was designed under contract for Environment Canada. The capability of a rotary kiln has been successfully demonstrated by trials at the Ontario Research Foundation. A cost benefit analysis, however, has indicated that burial of the contaminated material is a less expensive alternative because of the high capital cost of a kiln; if capital cost is partially ignored, the use of the kiln becomes the least expensive option.

In 1977 P.A.C.E.* contracted for the design, construction and testing of a low-cost rotary kiln constructed out of a culvert and other readily available material. This kiln will burn out in a matter of weeks, but the fact that it can be locally built when needed out of basically "junkyard" material far outweights its expected limited life. The construction and testing of a prototype version of this kiln is to take place during the summer of 1978.

The results of the tests of the open pit incinerator and the rotary kiln will be reported at a later date.

*Petroleum Association for the Conservation of the Canadian Environment

Canadian Environmental Emergencies Event Summary for 1977

Submitted by: LCDR B. E. Baker, Deputy Manager
National Environmental Emergency Centre
Environmental Protection Service
Ottawa, Ontario
K1A 1C8

Telephone: (819) 997-3742

This summary of environmental emergency events has been compiled from data extracted from the National Analysis of Trends in Emergencies System (NATES) database. It is presented in the same format as the summaries for 1974, 1975 and 1976 in the January-February 1978 edition of the Newsletter.

It must be remembered when reviewing this summary that the extent to which spill information is obtained is governed by local reporting regulations and by federal/provincial or interdepartmental bilateral agreements. NATES, therefore, cannot give the complete picture of all spills and events that have occurred across the country.

The following are some specific points covering the data in the summary:

a. under the "non-oil" classification of the "material spilled" section are 2 events shown where the quantity spilled is listed as unknown. Although reporting sources are encouraged to make every effort to determine the amount spilled in each event it is not always possible. As shown in Table 1 there was a total of 91 events in 1977 in which the amount spilled was reported as "unknown".

b. The number of spills differs from the number of events because more than one material may be spilled in a single event.

c. Environmental emergencies can occur where no spill takes place. Such was the situation in the case of 2 events involving radioactive materials. The potential for a spill was present however, none occurred. There were 6 such events reported in 1977.

d. In previous summaries saltwater spills in petroleum production fields have been grouped with "others". Since it is considered to be significant it has been shown separately for 1977.

Table 1 is a breakdown of 1977 oil spills by volume. Note in this table the volume is expressed in Imperial gallons whereas volume in all other tables is expressed in metric tons. There were 5 events in which more than 100,000 gallons of oil were spilled. Briefly they were as follows:

1. In January 1977 an equipment failure in a pipeline near Edmonton caused a spill of 350,000 gallons of crude oil. Cleanup resulted in recovery of over 60% of the oil spilled.

2. Vandalism caused a production field spill of 250,000 gallons of crude oil, 250 kilometres northwest of Edmonton in February 1977. Again more than 60% was recovered.

3. A pipeline spill of 350,000 gallons of crude oil took place at Edmonton in February 1977. Most of the oil was recovered.

4. On 28 May 1977 a pipeline leak at Stewart Creek, B.C. near Fort St. John resulted in 175,000 gallons of crude oil being spilled into Stewart Creek. The oil spread to Pine River and the Peace River polluting 160 kilometers of shoreline.

5. 135,000 gallons of marine diesel were on board the Canadian National Ferry WILLIAM CARSON when she sank in heavy ice off the coast of Labrador in June 1977.

TABLE 1.

Petroleum Spills By Volume - 1977
(Imperial Gallons)

0 to 10 gal	10 to 100 gals	100 to 1000 gals	1,000 to 10,000 gals	10,000 to 100,000 gals	100,000 to 1,000,000 gals	Unknown	Total
97	310	292	225	49	5	91	1069

The percentage of events caused by human error and equipment failure remains fairly constant at just over 40% for each of the past four years (1974-1977) as shown by Table 2.

TABLE 2

Percentage Breakdown of Most Common Reasons:

Year	Number of Events	Human Error	Equip. Failure	Material Failure	Other Reasons
1974	891	26.5	6.3	6.5	60.7
1975	1,484	21.8	22.2	13.0	43.0
1976	1,071	21.9	23.2	23.3	31.6
1977	1,418	20.7	24.3	3.3	51.7
Overall	4,863	22.7	19.0	11.5	46.8

The following tables show the number of events and amounts spilled that have been reported for the years 1974 to 1977. It is interesting to note that although the total number of reported events (Table 3) for 1977 is relatively high, the volume of material spilled (Tables 4, 5 and 6) is the lowest for the four years shown.

TABLE 3

No. of Events Reported

Source	1974	1975	1976	1977
TANKERS	16	15	21	27
BULK CARRIERS	19	9	16	38
OTHER WATERCRAFT	105	57	24	26
TANK TRUCKS	50	55	111	150
OTHER MOTOR VEHICLES	102	137	30	47
TRAINS	30	42	37	48
PIPELINES	55	45	22	161
AVIATION	3	17	15	23
MINES & WELLS	10	578	533	537
REFINERIES & MARINE TERMINALS	14	9	14	25
STORAGE DEPOTS	57	43	48	109
SERVICE STATIONS	6	13	18	35
INDUSTRIAL PLANTS	175	258	77	69
OTHER SOURCES	249	208	105	123
TOTAL	891	1484	1071	1418

TABLE 4

Amount Spilled (Metric Tons)

Source	1974	1975	1976	1977
TANKERS	362	81	1,574	826
BULK CARRIERS	33	652	23.5	105
OTHER WATERCRAFT	3,525	427	950	548
TANK TRUCKS	529	559	965	1,446
OTHER MOTOR VEHICLES	869	1,640	348	484
TRAINS	2,288	6,534	4,026	6,611
PIPELINES	10,396	2,838	4,618	3,358
AVIATION	6	39	29.5	75
MINES & WELLS	10,237	759,614	14,775	11,636
REFINERIES & MARINE TERMINALS	1,049	160	368	1,232
STORAGE DEPOTS	713	3,705	1,620	2,933
SERVICE STATIONS	9	928	71	103
INDUSTRIAL PLANTS	51,364	5,933	2,220	13,343
OTHER SOURCES	5,216	439,879	234,054	30,069
TOTAL	86,596	1,222,989	265,642	72,769

TABLE 5

Petroleum Spilled (Metric Tons)

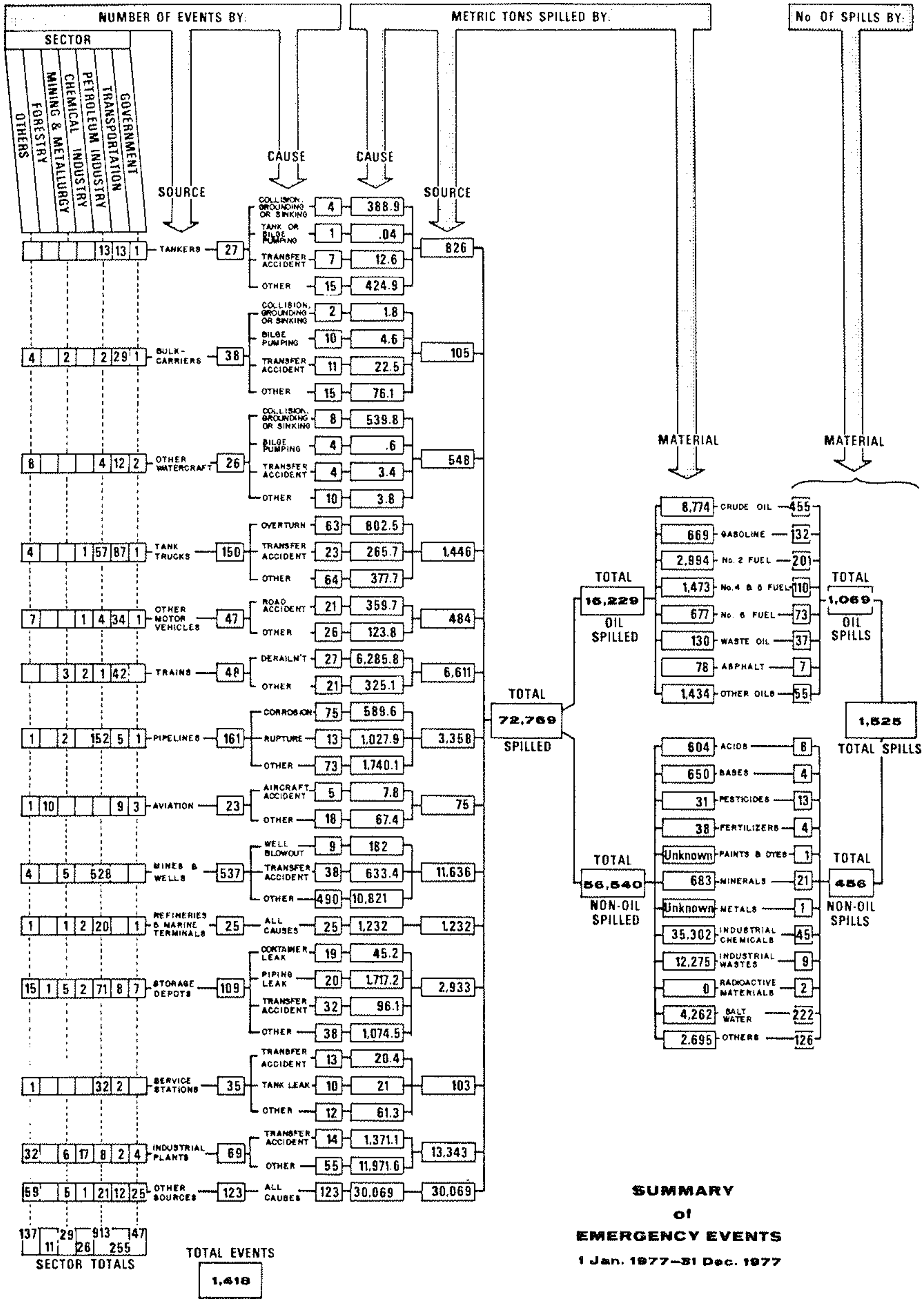
MATERIAL	1974	1975	1976	1977
CRUDE	10,007	10,088	9,636	8,774
GASOLINE	795	2,314	1,527	669
NO. 2 FUEL	553	588	971	2,994
NO. 4&5 FUEL	5,665	3,351	2,007	1,473
NO. 6 FUEL	1,004	2,219	1,669	677
WASTE OIL	630	313	25	130
ASPHALT	48	235	227	78
OTHER OIL	232	752	370	1,434
TOTAL	18,934	19,860	16,432	16,229

TABLE 6

Non-Petroleum Spilled (Metric Tons)

MATERIAL	1974	1975	1976	1977
ACIDS	81	2,919	1,346	604
BASES	756	182	50.9	650
PESTICIDES	.5	39	27	31
FERTILIZERS	26	397,511	449	38
PAINTS & DYES	10	814	.1	UNKNOWN
MINERALS	843	743,614	2,288	683
METALS	13.5	19	0	UNKNOWN
INDUSTRIAL CHEMICALS	7,529	6,290	1,930	35,302
INDUSTRIAL WASTE	47,019	28,039	1,322	12,275
RADIOACTIVE	0	0	5	0
SALTWATER	9,915	5,960	7,050	4,262
OTHER	1,469	17,742	234,742	2,695
TOTAL	67,662	1,203,129	249,210	56,540

The summary of emergency effects and the foregoing tables represent a great deal of work on the part of all those who have submitted reports on oil spills and other environmental emergencies. To all, a sincere "Thank You" for your valuable contribution to the Environmental Emergency Program.



SUMMARY
of
EMERGENCY EVENTS
1 Jan. 1977–31 Dec. 1977

THE AMOCO CADIZ OIL SPILL
A PRELIMINARY ACCOUNT OF EVENTS

Submitted by: A.J. O'Sullivan
Cremer and Warner
Consulting Engineers and Scientists
140 Buckingham Palace Road
London, England
SW1W 9SQ

Introduction

Between the 17th and the 30th March the Amoco Cadiz lost her entire cargo of 220,000 tons of light Arabian crude oil on the coast of Brittany, making this oil spillage the largest ever recorded. Statistically, the probability of occurrence of a spill of this magnitude is extremely low, being somewhere in the region of once in several thousand years. In addition to the widespread ecological consequences, it is therefore not only an unwelcome but a unique event.

Some 200 km of the coastline of Brittany, including areas of outstanding ecological and biogeographical interest, and whose landscape, flora and fauna are a major basis for the economy of the region, are affected. Much oil still remains on the shore and at sea, and the situation continues to change daily.

This paper can therefore be no more than a preliminary account of events. It is based on the author's observations extending over one week from 24th March to 1st April, and on discussions with colleagues at the Marine Biological Station at Roscoff.

At this stage long-term biological effects cannot be predicted with certainty, and these must remain the subject of later work and observations.

Sequence of Events

On Thursday, 16th March at about 1045 GMT, the Liberian-registered tanker Amoco Cadiz, 233,680 tons deadweight, suffered steering failure some 13 km N of the Ile d'Ouessant. The single-screw VLCC was bound from Kharg Island in the Gulf for Europort, Holland, and was due to call at Lyme Bay on the south coast of England for part discharge of her cargo.

Assistance was requested via Brest Radio (Le Conquet) at 1220; and by 1326 the West German salvage tug, Pacific, en route from Brest to Pas de Calais, had arrived and was preparing to pass a towline. The tow commenced at 1518 in westerly winds of 20 knots and over (force 8, gusting to 9 and 10 on the Beaufort scale) and a heavy swell. At 1715 the towline parted and after a number of unsuccessful attempts a second towline was finally made fast and towing re-commenced at 2155. A second salvage tug had been requested by radio, and the Amoco Cadiz also used her anchor in an attempt to halt her drift shoreward, the wind now having swung to the NW. At 2204 the tanker touched bottom, and some 6 minutes later her engine room was flooded, electricity supply ceased and radio contact was lost. Subsequently, a distress signal was made in the early hours of the following morning (March 17th) the crew were evacuated by helicopter.

The vessel had grounded at high tide on the Men Goulven rock some 2 km off the Breton coast near Portsall. As the tide ebbed the Amoco Cadiz broke in two immediately forward of the bridge, breaking 4 of her 15 cargo tanks and releasing about 58,000 tons of crude oil during the following day. The oil was driven ashore by the NW wind, and the harbour of Portsall and adjoining coast over a distance of about 5 km became heavily polluted.

During the next day (Saturday March 18th) the oil spread to cover an area some 40 kilometres long and 10 kilometres wide; and cargo loss had risen to 80,000 tons. The slick continued to spread eastwards over the following 24 hours; on Sunday 19th it was reported as being 100 km long and 10 km wide. Along the coast, pollution extended from Pointe de St. Mathieu, W of Brest, to the Ile Vierge near l'Aber-Wrach.

Over the next few days the oil continued to move slowly eastwards towards the Normandy Peninsula (Cotentin region) while threatening also the Channel Islands of Guernsey and Jersey. By March 24th rising winds and heavy seas caused the Amoco Cadiz to break up still further, releasing additional quantities of crude oil. The exact volume released was unknown but it was estimated that only about 35,000 tons now remained in the ship.

On March 25th the main oil slick extended from near Porspoder, about 10 km W of the wrecked tanker, to the Ile de Brehat, N of Paimpol. The slick was almost stationary, and extended out from the shore to a distance of 2 km, with a band of thinner oil 6 km seaward of it. The length of coast affected was estimated at around 200 km, from near Pointe de Corsen, W of Brest, to Perros-Guirec and the Sept Iles. Portsall continued to be repolluted and heavy accumulations of oil occurred around Roscoff and Pointe de Primel N of Morlaix. The estuary of l'Aber Benoit with its extensive oyster beds, was also heavily affected. The famous Cote de Granit Rose, from St. Michel-en-Greve to the Sillon de Talbert N of Lezardrieux and which was affected by oil from the Torrey Canyon in 1967, was also badly polluted.

Up to the 31st March the main oil slick had not moved, but there was increasing concern that the westerly winds forecast for the week-end of the 1st and 2nd April would push the oil in the direction of the Cotes du Cotentin on the Normandy peninsula. Already some isolated slicks had broken off from the eastern end of the main slick, and the islands of Guernsey and Jersey continued to be threatened.

The Clean-up Operations on the Beaches

Clean-up operations were begun immediately at Portsall, and as the oil moved eastwards along the coast, operations were extended to cover the affected areas. Booms were deployed to protect sensitive or economically important areas such as Aber-Benoit, while at sea French naval vessels began spraying dispersant.

The Polmar contingency plan for oil spil clean-up was activated on 17th March by the mayors of the local communities around Portsall. The initial efforts at actual clean-up were taken by the local authorities and by the farmers. These were subsequently aided by increasing numbers of volunteers and, towards the end of the first week, by soldiers and equipment of the French Army.

On shore no dispersants were used, the principal method of oil removal being suction by tractor-drawn slurry tanks normally used for collecting and spreading animal waste on farmland. A very large number of these machines, working day and night in some areas, collected oil from accessible beaches where it had accumulated. At Pouldu, for example, a small village about 3 km W of Roscoff, the local farmers recovered some 1500 tons of oil in one night. On some shores, where access and ground conditions allowed, suction equipped vehicles normally used for emptying road gulleys or cisterns were employed.

Close to each polluted site - and this included nearly every accessible point on the coast from Melon to Trebuerden and beyond - a collection point was established. At these points large metal tanks were placed for the reception of the oil/water/sand/seaweed mixture collected from the beaches. At many places, e.g. at St. Michel-en-Greve, Pointe de Sehar, large pits were dug and lined with plastic sheet. The slurry tankers discharged into these tanks or pits generally through a coarse grid to filter out seaweed and large objects. 20-40 ton road tankers were then used to transport the oil to major centres such as Roscoff from where it was taken by sea or rail to ports possessing waste oil reception facilities. At Saint-Nazaire for example, the collected material was being treated for subsequent refining. The final fate of the oil was not known at the time of writing.

On small beaches oil was sucked directly from pools or from the tide line, or holes were dug into which it could drain or be scraped. On more extensive beaches, such as St. Michel-en-Greve, horizontal furrows were ploughed in the sand parallel to the tide line. Oil then drained into these furrows and any remaining was scraped by hand or by tractor-mounted angled scrapers. Oil from the furrows was removed by suction tankers.

Other cleaning methods included the use of straw to absorb the oil (on the Ile de Batz near Roscoff), and the use of water jets to hose down sea walls and slipways. Some skimming devices were observed in several small harbours, e.g. Portsall, and one was being used in the lobster tanks at Roscoff which were badly polluted. Surprisingly, however, since the oil was reasonably fluid especially in the early stages of the incident, skimmers did not appear to play a large part in the coastal clean-up.

Booms were used in many sheltered and semi-sheltered areas to prevent the entry of oil into ports and estuaries. Deployment of booms was difficult in the conditions of strong tidal currents and winds, and even though a considerable amount of experience was gained during the first week of the incident, in general their use was not very effective. Nevertheless, by 28th March some 12,000 metres of inflatable booms had been deployed.

The size of the operation was quite impressive. The number of heavy road tankers must have been between 100 and 200, many of which were specialized waste-recovery vehicles from Holland. Subsequently, large convoys of French army road tankers were being used. Traffic control was also effective, but some secondary destruction or pollution of roadside verges and hedges was unavoidably taking place.

By the 30th March, some 6,500 people including 2,500 sailors and 2,500 soldiers were actively participating in the clean-up. In the two weeks since the spill about 30,000 tons of oil had been removed from the harbours and beaches; the amount yet to be cleared remained unknown. Costs for the Finisterre Department (region) were running at about a million francs (£120,000) per day, and this did not include the cost of the offshore operations being conducted by the navy.

Appearance and Biological Effects of the Oil

On such an extensive coastline of diverse character ranging from exposed rocky and boulder shores (as at Pointe de Landunvez 4 km W of Portsall) to large sandy beaches (e.g. St. Michel-en-Greve) and very sheltered rias and estuaries (as at l'Aber-Wrac'h and l'Aber Benoit) it is impossible to give a complete record of the extent and severity of the pollution. In addition, many places heavily coated with oil at first were later cleaned by wave action, while other places were polluted a number of times.

Any description of the extent or appearance of the oil can, therefore, represent only a single glimpse of a changing situation. Nevertheless such immediate observations may be useful in that they can provide a comparison point for subsequent observers thereby enabling a dynamic view to be built up.

Arabian light crude contains a high proportion of volatile fractions and about 40% would be expected to evaporate in the first 24 hours after discharge. At Portsall the oil was very fluid and dark in colour; and the odour of the oil was apparent for many km inland. During a visit to Portsall and the surrounding beaches on 30th March, some mortality of marine organisms was observed. Crabs (Carcinus maenas) and lugworms (Arenicola marina) were seen dead or moribund while there was a marked absence of gastropod snails on the rocky shore.

It was also learned that staff and students of the Université de Bretagne Occidentale at Brest had found during the previous few days large numbers of dead fish in the vicinity, including Raniceps species which is found at or below ELWS in the Laminarian zone.

Significant amounts of much thicker oil were also observed around Portsall - perhaps the remnants of the first escape from the Amoco Cadiz on March 17th. A small degree of mousse formation was noted.

Along the coast from Roscoff to the Baie de Kernic, a number of beaches and small coves were visited. At the Baie de Kernik itself oil had entered the small creek at Pont Christ and had polluted the saltmarsh during the spring tides. Another very sheltered area where oil was seen extensively was in l'Aber Benoit which had been polluted despite the presence of a floating boom at the entrance.

At a small beach at Porz at Vil (about 5 km SW of Roscoff) plaques of moderately fluid oil scattered on coarse sand were swarming with amphipods. Near Pouldu, where the shore had been heavily oiled and, subsequently, cleaned by wave action, no mortality was observed despite an extensive if light film of oil remaining on stones and in pools (26th March).

On the shore below the Marine Biological Station at Roscoff, rocky outcrops were covered with a continuous film of oil, but the intervening stretches of sand and gravel were only lightly oiled. Biological effects were light; many limpets (Patella sp) remained attached to the rocks, though the strength of their hold was loosened, only a small percentage of limpets had fallen. Littorina littoralis was still present on algal fronds, but many were lying dead or moribund in pools. A number of Gibbula (Monodonta) lineata were also seen in a dead or moribund condition. In many respects, the degree of mortality was similar to that observed in October, 1974 in Bantry Bay following the spillage of Kuwait crude from the tanker Universe Leader (O'Sullivan, 1975).

Eastwards from Roscoff, at St. Michel-en-Greve, very heavy pollution had occurred on this sandy beach. Above HWM where the high spring tides had carried the oil, it was becoming more fluid under the heat of the sun and was penetrating 5-10 cm into the dry sand. In a few places fresh wind-blown sand was covering this oily mixture. Extensive beach-cleaning operations were also producing a slurry of oil and sand in a few places. At LWM, soft lumps of oil with entrained sand were observed sunk in several inches of water. It is suggested that on this type of coastline where the inshore water may have a high particle content coupled with wave action, a significant proportion of even a light crude is sunk. A study of the behaviour and fate of these naturally sinking lumps would be of the greatest interest. A similar phenomenon was observed in Bantry Bay in 1974.

Around LWM a number of freshly dead razor shells (Ensis sp) were found together with a large number of empty Echinocardium tests. No other signs of mortality were noted. A degree of chocolate mousse formation was also observed at St. Michel-en-Greve.

At Pointe de Sehar further to the east chocolate mousse formation was very distinctive. The oil was clinging to algae-covered rocks, and had built up into an extremely dense and viscous mousse over 5 cm thick in places. In such conditions biological observations were impossible. The degree of mousse formation was surprising, and a possible explanation was put forward by Dr. Jean Vasserot from the Marine Biological Station who suggested that the dense algal cover could release stabilising muco-polysaccarides into the water as a result of irritation by the oil.

Also at Pointe de Sehar, the movement of vehicles up and down the shore was producing large quantities of a sand/oil slurry.

On the Cote due Granit Rose, on the beaches around Trebuerden, there was also a heavy degree of oiling with penetration of oil into the sand and formation of mousse in places exposed to wave action.

Coastal vegetation above HWM was also oiled by the strong winds and heavy seas during the week-end of 25 and 26 March. Oily spray was blown across trees, shrubs and gardens, and some degree of foliage damage is almost bound to follow.

More Detailed Investigations

At the Marine Biological Station, Roscoff, studies in progress for a number of years will provide a basis for observing the longer-term consequences of the oil. These include, in the intertidal zone, the following studies:

- (i) the population dynamics of two species of *Littorina*;
- (ii) feeding, reproduction and settlement of *Spirorbis* sp;
- (iii) qualitative surveillance of the populations of echiniderms and crustanceans;
- (iv) charges in the growth and developmetn of a number of species of red algae following pollution (including cytological and morphological studies);
- (v) changes in the concentration of bacteria, meiofauna, chlorophyll and organic material in and around polluted areas.

In the sublittoral, possible changes in the population of macrofauna inhabiting the mobile sediments in the Bay of Marlaix will be the subject of a continuing study.

CNEXO, the National Centre for Ocean Research at Brest, has also established a programme of ecological studies. The programme will run for three years, and will involve use of the "Landsat" remote sensing satellite. SEPNB, the Society for the Study and Protection of Nature in Brittany, has also begun a programme to study the consequences of the oil spill; and this is being co-ordinated with the Faculty of Science at the Universitē de Bretagne Occidental at Brest. Details of these studies will shortly be available.

Some Preliminary Conclusions

While at this stage it is not possible to predict the long-term biological consequences of such a massive spillage, some indications can be given of particular problems likely to arise:

1. Sheltered areas - the penetration of oil deeply into sheltered environments such as l'Aber Benoit, l'Aber Wrac'h and Baie de Kernic, and its incorporation into sediments and saltmarsh vegetation is likely to cause long-term effects.
2. Sandy shores - the penetration of oil into sand or the production of sand/oil slurry by the action of clean-up equipment is likely to result in oil being trapped in the sand for some considerable time.
3. Upper Shore Vegetation - oily spray will cause some effects on vegetation above HWM and for a short distance inland. Higher plants should recover within a year, but lichens will be affected for a longer period.
4. Algae - some temporary loss of algal cover is almost certain to occur particularly in places such as Portsall which have received repeated doses of fresh crude or Pointe-de-Sehar where the algae are covered by a dense mousse.

5. Intertidal macrofauna - difficult to predict, but possibly significant mortality around Portsall and adjoining beaches and on shore heavily or repeatedly polluted. Many shores will escape with only transient or negligible effects.
6. Seabirds - no observations of dead or oiled seabirds were made, but discussions with workers in the oiled seabird clinics indicated that severe mortality could be expected. Les Sept Iles, N. of Perros-Guirec, are a renowned seabird sanctuary with up to 25,000 birds. To the 31st March, 1,175 oiled seabirds had been collected (1,110 dead; 65 living); approximately half of these being puffins.
7. Economic effects - Since the economy of Brittany depends so heavily upon fishing (lobster, crawfish, crab, oyster, mussel, cockle, scallop, etc.), tourism and the provision of marine-based leisure activities, it will undoubtedly suffer. In addition, seaweed is gathered extensively for use as a fertilizer and soil conditioner, and the presence of the oil will also affect this activity.

Acknowledgments

I am very grateful to my colleagues at Cremer and Warner who encouraged this preliminary study of the spillage; and to those at the Marine Biological Station, Roscoff, especially Dr. Louis Cabioch and Dr. Jean Vasserot for much help and fruitful discussions.

EQUIPMENT DEVELOPMENT FOR ARCTIC OILSPILL COUNTERMEASURES

Submitted by: K.M. Meikle, P. Eng.
Head, Technology Development Unit
Environmental Emergency Branch
Environmental Protection Service
Environment Canada
Place Vincent Massey
Hull, Quebec

Phone: (819) 997-1788

Background

Exploration for oil in the Canadian Arctic and in northern waters off Canada's east coast could result in an oilspill even though every precaution is taken to guard against such an eventuality. A well blowout or a transportation accident could release a large amount of oil into arctic waters.

The oil could be either crude oil or a refined product; the latter would most probably be gasoline or diesel fuel but Bunker C is a possibility. So far, little is known regarding the type of crude oil underlying the Canadian Arctic, but it seems reasonable to assume that it is a light or medium gravity oil and it is probably accompanied by natural gas; the gas could be sour but so far H_2S has not been a problem.

Several oilspill scenarios have been postulated as the basis for countermeasures planning. The most detailed one examines the Southern Beaufort Sea (1) and, more recently, Lancaster Sound (2) and the Labrador Sea (3) have been considered in some detail. Estimates as to the amount of oil that could escape range from 160 m^3 (1000 bbls) per day to over 2400 m^3 (15,000 bbls) per day and the volume of the accompanying gas has been assumed to be about seven times that of the oil at atmospheric pressure. Conditions in the area can also vary widely: for example, from 24 hours of daylight to 24 hours of darkness; seas calm to over sea state 5 on the Beaufort scale; open water to 10/10 ice cover.

Considerable technological progress has been made since the Arrow, Torrey Canyon and Santa Barbara spills highlighted the need for equipment to deal with oil spilled at sea. For the most part though, the equipment that has been developed was designed for use in temperate or southern waters; very little has been designed with arctic conditions in mind.

The Arctic Marine Oilspill Program (AMOP) is a 5-year, 7-million dollar program initiated in April 1977 to develop an improved capability for dealing with a marine oil spill in northern waters. Equipment development projects are a major component of that program.

Current Capabilities

The studies previously referred to concluded that:

(a) currently available techniques and equipment generally have limited effectiveness in the southeastern Beaufort Sea and in arctic offshore areas in general;

(b) conventional marine equipment and techniques could be applied in the southeastern Beaufort Sea during the 2-3 month relatively ice-free summer period were it not for the fact that relatively high sea states would probably prevent deployment during much of the open water period; moreover, even under ideal conditions, conventional containment and recovery equipment cannot be expected to provide a removal efficiency much greater than 50%;

(c) oil removal operations could be continued in the presence of brash or pancake ice, albeit with a reduced efficiency;

(d) much of the equipment and many of the techniques developed for open water situations can be employed with up to 10% ice cover but intrusions by large ice floes would necessitate the removal of countermeasures equipment;

(e) countermeasures are likely to be ineffective in the transition zone and surface operations in that area could be extremely hazardous;

(f) cleanup operations in the permanent polar pack are likely to be relatively ineffective;

(g) the effectiveness of cleanup operations at a blowout site in Lancaster Sound would be zero during the 8 month period from the end of September through May and would range from 8 to 45% for the rest of the year;

(h) current Canadian oil containment capability in the Labrador Sea is limited to the open water season and then only to periods of relative calm (Beaufort sea state 3 or less);

(i) although several recovery systems show potential for offshore operation, only about 4% of the total amount spilled might be recovered in the event of a blowout in the Labrador Sea.

Equipment-related studies during the first year of the AMOP program have indicated that:

(a) a special-purpose Air Cushion Vehicle (ACV) designed for oil recovery in ice-infested waters and for alternative general transport use would cost $6-8 million each plus development costs of approximately $8 million. An ACV optimized for the transport role but intended for use as an oil recovery vehicle in the event of an emergency would probably be a more economically viable solution;

(b) existing ACV's such as the Bell Voyageur could probably be adapted for use as oil recovery vehicles for ice-infested waters by installing an available recovery device such as an Oil Mop or a recovery device developed especially for use with an ACV. In addition to its ability to navigate over intervening ice and its all-weather capability, the Voyageur could accommodate a complete on-board oil recovery and disposal system;

(c) existing oil skimming devices such as the Oil Mop and Bennett can be installed in more sea-worthy hulls designed to survive in Beaufort sea state 6 and be transportable by C-130 Hercules aircraft;

(d) devices can be developed to divert new ice (floes up to 2.5 m across and 15 cm thick) to by-pass oil skimming devices;

(e) there are satisfactory pumps on the market for transferring oil/water/ice mixtures at fluid temperatures near $0^{o}C$; they are heavier than desired but still reasonably portable;

(f) an API gravity separator, measuring approximately 1.5 m wide x 1.2 m deep x 4.3 m long and weighing about 1 tonne, operating at near freezing temperatures under static conditions will separate 285 l/min (62.5 IGPM) of 400 cs oil mixed with water (75:25 oil:water); the water effluent will contain 40-60 ppm oil and the water content of the oil effluent will be about 2%;

(g) suitable burners are available on the market for disposal of recovered liquid oil;

(h) an as yet untested airportable prototype pit incinerator for the disposal of oiled combustible debris can be built for approximately $30 K;

(i) a fire-resistent boom can be built to contain oil for in-situ burning;

(j) it may be possible to adapt existing booms to contain oil for in-situ burning by adding a water spray system;

(k) a self-propelled skimmer modified for offshore use in the Arctic and with limited ability to recover oil in ice-infested waters (up to 6/10 new ice, max. floe size 3 m across x 15 cm thick) could be produced for about $325,000;

(l) rail access to the Arctic terminates at Hay River, NWT; Whitehorse, YT; Churchill, Man; Moosonee, Ont; and Schefferville, Que;

(m) direct year-around road access to the Canadian arctic coast is non-existent; completion of the Dempster Highway will provide such access to Inuvik, NWT;

(n) marine year-around transportation into arctic waters, as controlled by the Arctic Waters Pollution Prevention Act, is only possible for Arctic Class 6-10 ships and only Arctic Class 10 ships have year around access to the Sverdrup Basin area. Arctic Class 1 ships can enter the southern Beaufort Sea between 1 July and 31 October, Lancaster Sound from 15 July to 15 October, and the proposed drilling areas in the Davis Strait from 1 August to 31 October. Arctic Class 3 vessels can operate in the Southern Beaufort Sea and Lancaster Sound from 10 June to 31 December and in the Davis Strait area from mid July to late January;

(o) there is at least one year-around all-weather airfield for C130 Hercules aircraft adjacent to each of the arctic drilling areas, albeit the one for Lancaster Sound (Resolute Bay) is about 200 nautical miles distant. The probability of IFR flying conditions at these fields ranges from 80-98% thoughout the year. For April through July in the Beaufort Sea and Sverdrup Basin areas the probability of VFR conditions is similar (80-90%), but it reduces thereafter until it is only 30% in October. The VFR probability is slightly lower for the Lancaster Sound and Davis Strait areas, and conditions deteriorate in those areas after August; for November through January there is only a 0-10% probability of VFR conditions.

At Goose Bay the probability of VFR is generally lower than elsewhere, ie, 40-70% for March through September dropping to 30% during December and January.

Assumptions and Constraints

In setting out to develop equipment objectives for the second year of AMOP the following assumptions have been made:

(a) with the possible exception of localized operations to extract oil from concentrated areas under landfast ice, no cleanup operations will be attempted in the Arctic in the dark;
(b) no mechanical cleanup operations will be attempted in the transition zone at any time because of the hazardous working conditions and the low return anticipated for the very large effort that would have to be expended;
(c) remote area cleanup operations will be terminated before freeze-up because crews will not be prepared to work in adverse weather after the birds have gone, and because the reduced frequency of VFR flying conditions will make essential aircraft support too unreliable;
(d) mechanical cleanup operations are possible in offshore leads but the level of effectiveness will be low compared to the effort and risk that would be entailed;
(e) mechanical cleanup operations in open water will be required both offshore and nearshore; offshore capability will be required at sea states up to and including Beaufort state 5;
(f) safety and logistics considerations will make nearby (within 10-20 km) mother ship or shore-base support a mandatory requirement for both offshore and nearshore cleanup operations in the Arctic;
(g) special effort will be made to provide maximum possible ACV support and, notwithstanding their potential as self-contained oil recovery systems, their primary role will be for search and rescue and for logistic support.

The following factors have also been recognized:

(a) while self-propelled skimmers have a valuable capability and all available assets will no doubt be mustered, they will be few in number because of portability constraints and cost (both capital and upkeep); few organizations can afford to maintain dedicated, single-purpose vessels in readiness for occasional oil skimming operations;
(b) ice floes will probably impede cleanup operations in open water to varying extent depending upon the area (low probability in the Beaufort Sea area because of prevailing winds, highly probable in the bays along Lancaster-Sound); the ice will also vary as to type but, because work will be terminated before freeze-up commences, it will be predominantly old first year ice and hence floe thickness will be 0.5 m at least (i.e., not the 10-15 cm thick grey ice as specified in the criteria developed for the initial design studies);
(c) there is no large reserve of labour with sufficient arctic experience that can be tapped for labour intensive cleanup operations.

Objective

The overall objective is to develop a simple, flexible system that is not labour intensive and that makes maximum use of conventional equipment and readily available materials. To the extent practicable, the system must contain and collect oil at the blow-out site but, because it is most unlikely that a 100% effective method can be devised for every eventuality, the system must also deal with oil distributed in comparatively small separate accumulations scattered over very large areas. This latter capability must take precedence in view of the widespread environmental impact that will otherwise result.

System Concept

The overall concept is to deploy a number of subordinate (satellite) units from a shore base or mother ship to deal with oil inshore. Offshore cleanup at the blowout site and elsewhere will be performed by supply ships and other large sea-going vessels.

To deal with oil offshore at the source (blowout or leak) an offshore ice-strengthened vessel will be required and it must have:

- (a) adequate accommodation and services for cleanup personnel;
- (b) sufficient offshore boom to collect oil on at least a 1,000 m front and concentrate it for pick-up;
- (c) seaworthy work-boats to stream and recover the boom quickly, thereby minimizing oil loss during ice intrusions;
- (d) oil pickup equipment able to skim fresh crude at the rate of at least 160 m^3 (1000 bbls) per day and preferably 1600 m^3 (10,000 bbls) per day and also have a good capability to recover the refined products that might be encountered;
- (e) a pumping system to bring the skimmed fluid on board and sufficient temporary storage for at least 160 m^3 (preferably 1600 m^3) to permit continued skimming during temporary burner shut-downs of up to 1 day;
- (f) a liquid oil burning system with a capacity at least equal to that of the oil pick-up equipment and able to burn oil or oil-water emulsions containing up to 25% water by volume.

Elsewhere than at a blowout site or other source, the oil could be in unconfined slicks or be at least partially contained by ice or shoreline features. In either case, the oil will have weathered; up to 40% of the original volume could have evaporated in transit and some emulsification may have occurred. Requirements for this part of the system include an offshore ice- strengthed vessel, arctic service sea-going barge/tug combination, or shore base with:

- (a) accommodation and services for one or more satellite elements;
- (b) sufficient offshore boom to contain and concentrate unconfined oil on a 500 m front in open water;
- (c) ice-deflector boom to divert drifting floes past bays and permit oil to pass through for collection in the ice-free area immediately behind the deflector;
- (d) seaworthy work-boats to stream, tend, and recover the booms;

(e) oil pickup equipment to skim the weathered oil and associated emulsion;
(f) a transfer system to bring the skimmed fluid on board;
(g) temporary onboard storage for the collected fluid;
(h) oil/water separation capability (including emulsion-breaking capability) compatible with the requirements of the oil burning equipment;
(i) liquid oil burning equipment of sufficient capacity to dispose of the combined collection capability of the satellite units and the offshore system;
(j) equipment to dispose of combustible oiled debris;
(k) dedicated helicopter support to locate oil, perform local search and rescue, and provide local transportation and communications;
(l) one or more seaworthy work-boats to operate between the base and its satellites and to tow or transport temporary oil and oiled debris containers;
(m) communications equipment.

For inshore operations, each base ship or shore facility will require a number of subordinate satellite units capable of operating for up to 10 hours at a distance of up to 20 km. Each such unit would need:
(a) in-shore boom to contain and concentrate oil;
(b) at least one small stationary skimmer;
(c) equipment to pick up and hold oil deposited on shore;
(d) containers for approximately 95 m^3 (600 bbls) of skimmed fluid (small Dracones or equivalent);
(e) a transfer system to off-load collected fluid into temporary containers;
(f) temporary containers for oiled debris;
(g) radio communication and emergency locator equipment;
(h) a seaworthy boat to carry a crew of 2 or 3 and the foregoing items of equipment.

To address currently known technological deficiencies and develop the system as outlined, the following work is planned for fiscal year 1978/79:
(a) develop improved non-self-propelled skimmers for offshore use from a ship;
(b) develop improved small skimmers for use by the satellite cleanup units;
(c) test the API gravity separator at sea to determine its suitability for use on board ship;
(d) design pumping systems for transferring recovered oil from skimmers into temporary storage facilites;
(e) evaluate available liquid oil burners for suitability as disposal devices for shipboard use;
(f) determine the performance limitations of water-spray and air bubble barriers as oil containment devices;
(g) as opportunity permits, operate the CCG Voyageur ACV over oil slicks to confirm its suitability as a potential oil recovery platform;
(h) investigate arctic applications of the Tsang ice deflector barrier;
(i) identify potential work-boat options;
(j) study the feasibility of sub-sea containment and collection of oil

at or near the sea-bed;
(k) construct and test an air-portable incinerator for oiled debris;
(l) develop prototype cleanup devices for removing oil from sand beaches.

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THE CLEANUP OF OIL SPILLS FROM UNPROTECTED WATERS

Submitted by: Jerome Milgram
Professor of Ocean Engineering
Massachusetts Institute of Technology
Cambridge, Massachusetts
02139
U.S.A.

Editor's Note: This article has been reprinted with permission from OCEANUS, Volume 20, Number 4, Fall, 1977. For brevity two pictures and their references have been deleted.

Should a major offshore oil spill occur tomorrow, it would be impossible to clean up the largest portion of the spill. In fact, there has never been a major spill in unprotected waters in which more than a few percent of the oil has been cleaned up. This situation exists despite the fact that over the last 10 years, much of the technology has been developed to clean up such a spill, and we have learned how to develop the rest. The total spill clean-up systems that are needed have not been implemented. While there is some question of whether preparedness for dealing with such spills would be worth the cost, there is no question that the issue should be aired on a national basis and a conscious public decision rendered as to whether we should pay the price and be prepared, or save the money and accept the risk.

When oil comes ashore anywhere, it results in major damage. Frequently the impacted area cannot be used for its regular purpose. Many forms of beach life are often killed with several years required for natural replenishment. The same applies to marshes, shellfish beds, and other near-shore life.

While no long-term major damage has been conclusively demonstrated from an oil spill that has moved offshore, there is evidence of the toxic effects of such oil on various forms of aquatic life inhabiting unprotected waters, including spawning fish and birds. The long-term effects of such spilled oil are the subject of current research. We can thus state at this point in time that the adverse effects of spilled oil coming ashore are much more severe, as far as the general public is concerned, than those from oil spills that move offshore.

****

Most oil spills can be divided into three categories:

1. Chronic oil spills at oil-handling depots, such as refineries and ports; characterized by frequent discharges of small amounts of oil.
2. Intermediate-sized spills in protected waters. Generally, these are spills ranging in size from a few hundred gallons to many thousands of gallons and are caused by accidental opening of valves during oil transfer operations, and the grounding or ramming of vessels in harbors. Because of the proximity of these accidents to

shore installations, leaks can usually be stopped and damaged vessels can be offloaded before extremely large amounts of oil are released into the water.

3. Major spills in unprotected waters; they usually occur because of ships grounding on shoals, or as a result of blowouts from offshore wells.

Oil spills in the first two categories are far more frequent and much easier (and therefore cheaper) to clean up than those in the third category. Much technology has been developed for the smaller spills and that technology is being continuously improved. There is little question about the advisability of developing and using this technology. More questions exist about what should be done about large spills in unprotected waters.

Cleanup of Spills in Offshore Waters

Some offshore oil spills are very large - that is, millions of gallons. Cleaning up such spills requires the ability to contain and collect enormous quantities of oil. Spilled oil moves away from its source through the combined effects of spreading and mass transport by winds, currents, and waves. The combined speed of these forces is usually in the range of 0.5 to 2.0 knots. Oil does not usually spread in the form of a single pool of nearly constant thickness, but rather in relatively thick pools with an approximate diameter in the range of 0.5 to 10.0 meters and a thickness of 0.05 to 1.0 centimeters. These pools, in turn, are situated in a very thin oil layer with a thickness of 0.001 to 0.1 centimeters. Generally, it is oil in this form that must be removed if cleanup is to be achieved.

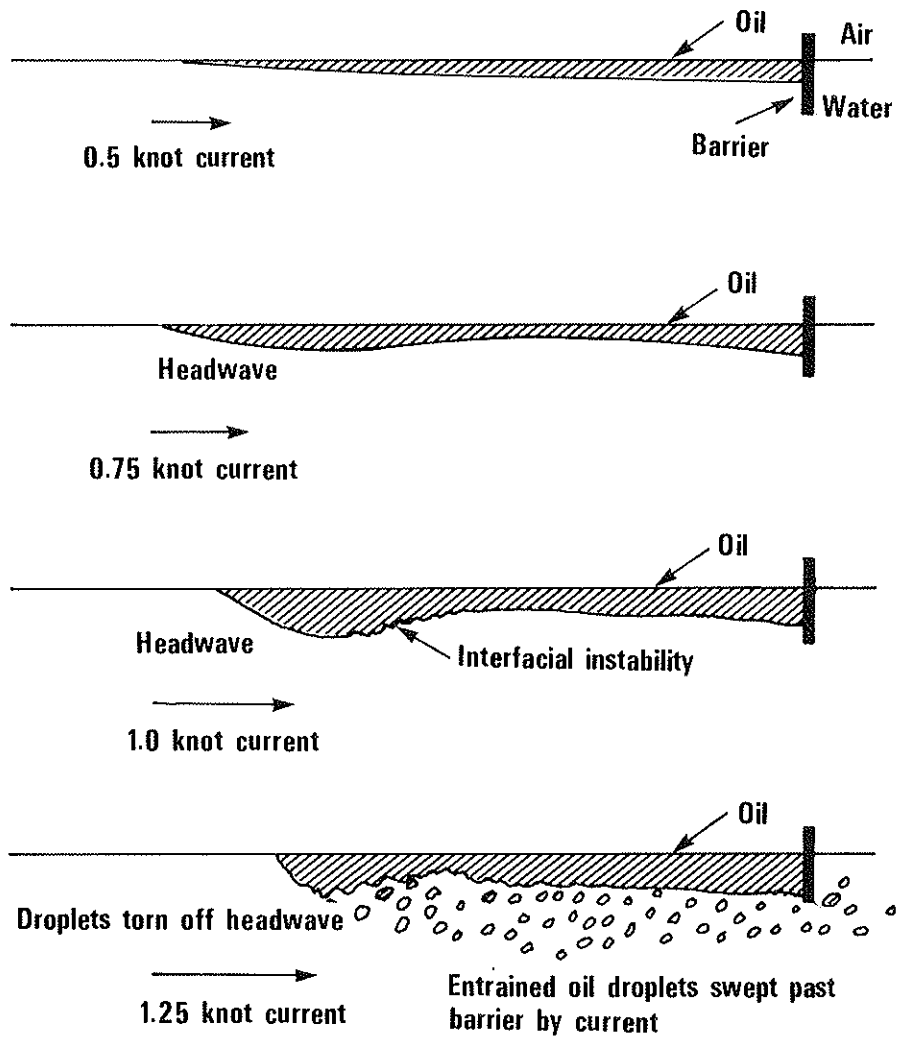
Any clean-up device must have some relative velocity between the oil (and the underlying water) and itself. Most clean-up devices slow down the oil, which results in an oil pool buildup in front of the device. When a pool of oil is held in a relatively stationary position above flowing water, there are hydrodynamic limitations on the relative velocity between the fluid and the device (Figure 1). This is precisely the situation that exists when oil is contained by a barrier in a relative current. During skimming, when oil is slowly withdrawn from the pool, the change in velocity is insignificant. Thus we can understand the speed limitations on both the containment and skimming phases by examining the containment situation alone.

As shown in Figure 1, when a relatively motionless pool of oil held against a barrier by slowly moving water, the thickness of the oil is a slowly varying function of distance from the leading edge of the slick. At very low water speeds (less than 0.4 knots), the dominant force on the oil is the shear force of the water on the bottom of the slick.

As the water speed is slowly increased, a critical speed is reached above which the oil-water interface is unstable with respect to Kelvin-Helmoltz waves.* These waves make the surface near the leading edge of the slick very rough. Separation of the basic flow behind the wavelets results in a vastly increased "effective skin friction" that drives the oil toward the barrier and causes the pool to thicken. Directly behind this thickened region, called the headwave,

* Created by an instability in motion caused by a coupling between the pressure field and the motion itself.

Figure 1. A simple oil boom or floating fence (black bar in chart). If the boom is towed slowly, with a speed relative to the water and oil of 0.5 knots, the oil is held against the boom as shown at the top; in the absence of ocean waves, the oil pool is relatively smooth. At a higher relative speed of about 0.75 knots, the oil pool forms a headwave near its leading edge, as shown in the second drawing. At a still higher relative speed of about 1 knot, the size of the headwave is substantially increased and there is instability in its lee; and at an even higher speed (about 1.25 knots), oil droplets are torn off the headwave by the water stream and may be carried below and past the collection device.



the basic flow is partially separated so that the local skin friction is very small. Further downstream, the skin friction slowly grows to a typical value of the skin friction coefficient of 0.01. It can be observed that the oil-water interface has fairly long waves behind the region locally thickened by the "skin friction" effects on the region of the Kelvin-Helmholtz waves. For still higher velocities, the combination of the Kelvin-Helmholtz waves and the unsteady boundary layer flow in the water beneath them results in oil droplets tearing off from the bottom of the slick, which then pass beneath the containment or collection device.

The loss of oil droplets by this process is known as entrainment loss. For most types of oil, this loss is small at speeds below 1.0 knot and large at higher speeds. Therefore, for a large oil spill, 1.0 knot is a practical upper limit of the relative velocity between a collection or containment device and the fluid.

For smaller spills, collection devices, such as belts moving across the water surface or devices that can actually slow down the water in front of the slick, can extend the upper limit of relative speed to about 2 or 2.5 knots. However, the relationship between the physical size of such devices and their oil-collection capability makes them impractical for the cleanup of large spills at sea. Such devices are generally limited to oil collection rates on the order of 50 gallons per minute, whereas devices for the cleanup of major spills must collect at least 500 gallons per minute. Therefore, the 1-knot speed limit exists for the cleanup of large offshore spills.

A typical average combined oil thickness over the thick and thin regions is 0.05 centimeters. At a relative encounter speed of 1 knot, achieving a 500-gallon-per-minute collection capability requires that the width of the clean-up device be approximately 125 meters. For thinner layers of oil or higher collection rates, a greater width is needed. Because of this requirement, a single collection vessel is an inappropriate device for the cleanup of most offshore spills.

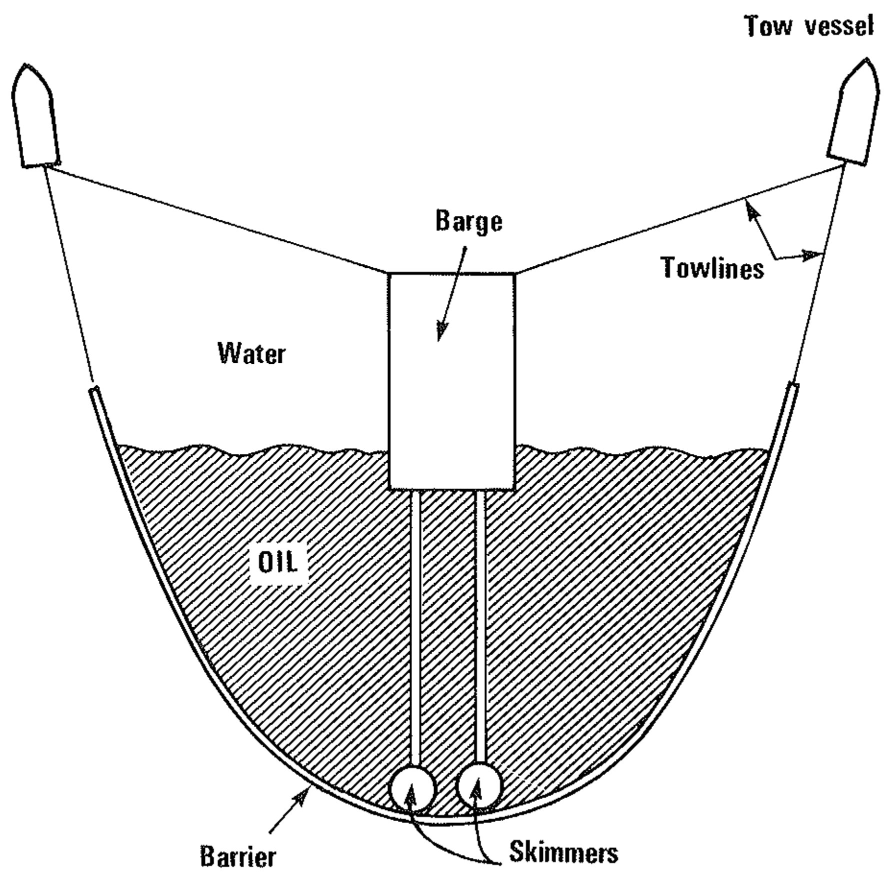
To achieve the large gap width, an oil barrier (boom) must be used. Essentially, this is a floating fence that maintains a skirt beneath the surface of the water and a sail above it to prevent the passage of oil over or under the barrier. At relative water speeds below 1 knot, effective containment and concentration (local thickening of the oil pool in the barrier) of an oil slick can be achieved by a barrier.

The largest environmental difference between spill cleanup in protected waters and that in unprotected waters is the presence of much larger waves in unprotected waters. Clean-up equipment for offshore spills must be effective in the presence of different sea states. Generally speaking, an effective clean-up device must follow the vertical up and down motion of waves with high precision so that the portion of the device that is designed to collect oil remains in the oil most of the time, not in the air or the water. Devices with this capability for long, gentle waves of any height and steep seas up to 2 meters high have been developed and constructed.

There is considerable evidence that in short, steep waves more than 2 meters high, the frequent breaking of the waves entrains so much oil into the water column beneath the surface that cleanup from the surface may not be feasible. When such rough conditions subside, much of the entrained oil rises to the surface and can be cleaned up from the surface at that time. This influences two aspects of spill clean-up equipment and procedures. One, the need for surface clean-up equipment to work in waves much higher than 2 meters may not exist, although the equipment must remain undamaged in rougher seas so it is available for use when conditions improve. Secondly, the need for carefully planned logistics is apparent. Clean-up operations need to take place in the regions where oil rises after conditions subside. Thus predicting what the distribution of oil will be after it rises is an important aspect of the problem. This is affected by how the oil droplets at various depths are transported by tidal currents and those induced by wind stress and by waves, as well as the way in which the droplets rise. Considerable knowledge in each of these areas where present knowledge is deemed insufficient.

One way to collect oil is to build collection devices into a barrier in such a way that they do not impede the wave-following ability of the structure. The devices can then deliver the collected oil to storage vessels through flexible hoses (Figure 4). An alternative would be to install small lightweight skimming devices inside the U-shaped configuration of a towed barrier designed to be able to follow the vertical up and down motion of the liquid. Again, oil could be delivered to a storage vessel through hoses (Figure 5).

Figure 4. Device for high-volume collection of oil spilled offshore with skimmers inside U-configuration of towed barrier. The barrier provides a high oil encounter rate and a thick pool of oil in which the skimmers can operate efficiently. The tow vessels must not tow faster than 1 knot through the water. The oil shown in the sketch is the thick pool. Generally, a thin pool is encountered ahead of the tow vessels.



The preceeding discussion indicates four of the five crucial items needed in a total spill clean-up system:

1. A basic wave-following oil barrier that can provide the needed sweeping width and serve as an oil thickness concentrator. When towed at a speed of 1 knot through an oil slick, the pool that builds up at the center of the U-shaped configuration can be relatively thick. For example, for a total barrier length of 300 meters, designed with a draft of about 0.8 meters, an oil depth of 0.4 meters at the barrier can be achieved. It is far easier to design oil collection devices that can achieve a high oil/water collection ratio for such depths than it is to design such devices to work in much thinner oil layers.
2. Oil collection devices (skimmers) to actually collect the oil from the pool contained by the barrier.
3. An oil storage vessel into which the collected oil can be pumped and then stored.
4. Towing vessels that can maneuver the arrangement of barrier, skimmer, and storage vessel through an oil slick at a sweeping speed of 1.0 knot. Most existing tow vessels cannot move at such a slow speed and still maintain good steering control. However, the knowledge exists to design such vessels or to refit existing ones.

The final element that needs to be added is highly trained personnel. To do the job effectively, it would require a rapid response so that the oil did not spread too far before cleanup began, plus efficient procedures throughout the entire process. This could only be achieved by personnel who were thoroughly trained in the work, who were always ready to respond to such a crisis, and who would participate in frequent practice sessions.

So five crucial items have been listed: barriers, skimmers, storage vessels, towing vessels, and trained personnel. If a single one of these items is absent, no oil can be cleaned up. The solution to the problem thus is one that requires a total system. It should be pointed out that these items are those needed for actual clean-up operations. In addition, supporting equipment and facilities for the five items is needed to deliver, launch, and later recover barriers and skimmers. Shoreside facilities are needed to rapidly offload and later process or dispose of recovered oil contaminated with seawater. No such facilities presently exist, although we do know how to build them. Thus we see that preparedness for cleaning up large oil spills requires a multi-faceted and thoroughly coordinated effort.

Even with a total system, not all of the region containing spilled oil could be swept. And some oil would leak past the system. We thus would never be able to clean up all of the oil spilled in an accident. This leaves us with the question of what should be done about the oil that is not cleaned up.

The weight of the available evidence is that nothing should be done about oil that is not cleaned up and which is moving away from shorelines, if the expectation is that it will be evaporated, dissolved, dispersed or biodegraded to relatively safe concentrations before it reaches land. Generally, such processes take up to a few weeks, although longer periods may be required in

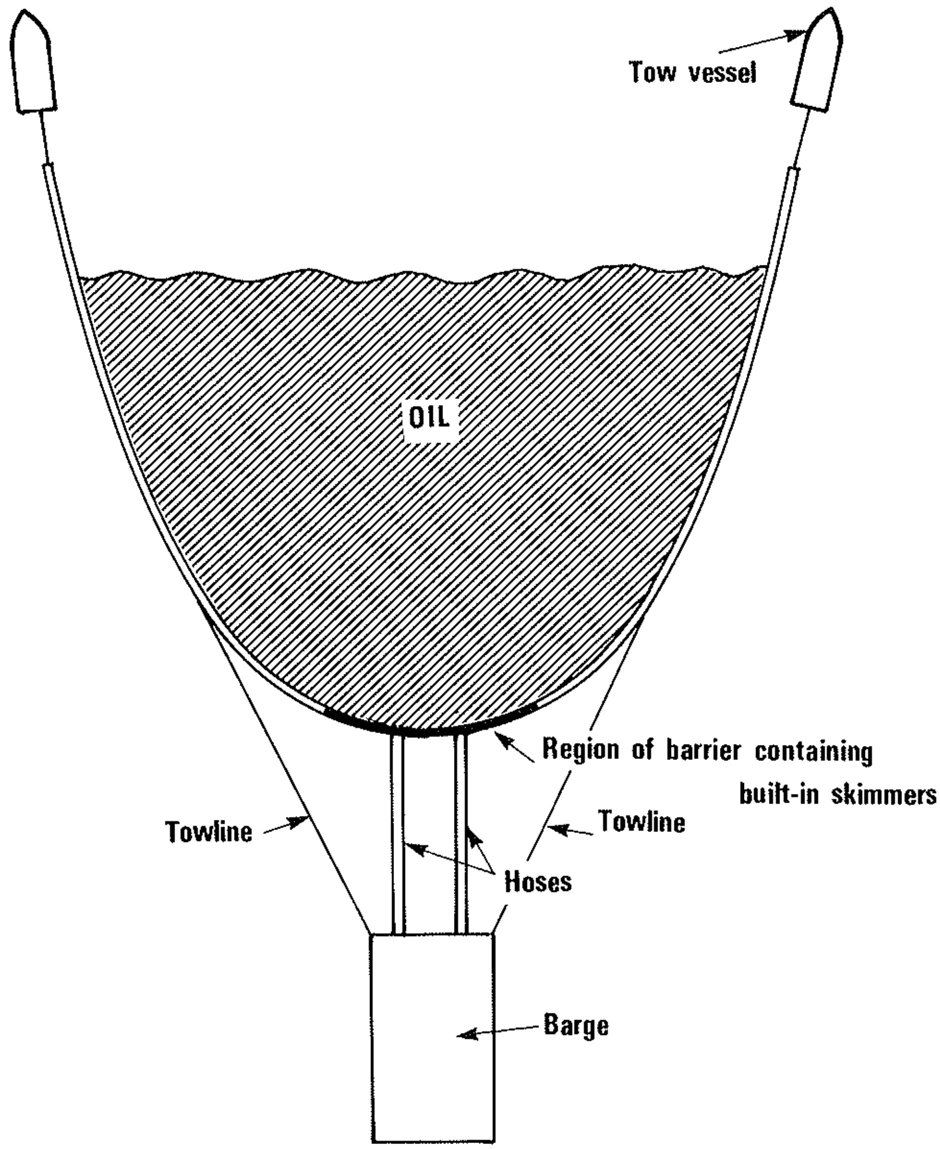


Figure 5. Barrier with built-in skimmers that affords high-volume collection of oil spilled offshore.

very cold water. For oil that is moving toward shore, the possibility should be considered of speeding a reduction in oil concentration by the use of dispersants.

Much research has taken place on the use and effects of dispersants on oil spills. Unfortunately, none has included controlled tests on the use of different types of dispersants on quantities of oil as large as could be expected from a large spill at sea, even after most of the oil was physically removed. At the present time, it is somewhat difficult to make an objective judgment about the benefits to be gained by the use of dispersants. According to Environmental Protection Agency (EPA) regulations, dispersants should almost never be used. The oil industry, on the other hand, takes the positon that dispersants should almost always be used. Neither position is particularly constructive.

Under certain conditions dispersants would probably be beneficial; under others, they would not. All dispersants are, to some extent, poisonous so that a net gain would only be achieved when the benefits of their use outweighed the toxicity effects. What is needed is a rational study, including field trials with large amounts of oil, to determine the conditions under which use of dispersants would be appropriate and those where such use is best avoided.

The Need for Policy Decisions

Since clean-up equipment for unprotected waters is both large and heavy, its delivery from a storage location to the site of an oil spill is limited to moderate waterborne speeds - 12 to 15 knots. Because rapid response (say, 6 to 8 hours) is essential in successfully cleaning up an oil spill, and since we would like to respond to spills up to 50 miles from shore, the limited delivery speed means that equipment at a fixed storage location is only appropriate for a stretch of coastline about 100 miles long. The equipment is expensive. A total spill clean-up system that collects 500 gallons per minute has a daily collection rate of 2,000 tons. A super tanker holds several hundred thousand tons. Effective protection would require that each equipment storage area have about 10 total spill clean-up systems - each costing roughly $2 million. In any stretch of coastline 100 miles long, the possibility of a major offshore oil spill occurring during a 5-year period is remote. Providing protection from a major spill would require an initial capital investment of about $20 million for each 100 miles of coastline, plus an annual maintenance cost of about $2 million.

Such remote eventualities make it economically impractical for oil spill clean-up contractors to make such expenditures. Protection against the damage of major oil spills, therefore, will only be provided if required by Federal or state legislation, or if the protection is provided by the government. We need to address the issue of whether or not the protection is worth the cost.

The cost would be approximately $250 million for the United States. Although such protection could clean up more than half the spilled oil, some would still be left. The alternative is to save the money and accept the increased risk of damage from offshore oil spills. A conscious decision is needed now as to which policy should be adopted.

During the last 10 years, a number of individuals and organizations have participated in research and equipment development for the cleanup of oil spills in unprotected waters. They now see that the results of their efforts are not being used to provide environmental protection. For this reason, many have left the field. It can be expected that more will follow unless a policy of protection is adopted. If the decision is put off for 5 to 10 years, the implementation would be far more expensive than if begun now.

The question of the benefits of the use of dispersants on volumes of oil of about 1 million gallons needs to be addressed whether or not the implementation of total spill clean-up systems takes place. Typically, the volume of dispersant required to disperse oil is about 10 per cent of the volume of the oil. This makes the required dispersant volume for dispersing an entire large spill impractically large. However, if dispersants can provide benefits, some protection of especially vulnerable shoreline areas could be provided by dispersing the oil that would be likely to come ashore in these areas. Naturally, if most of the oil was physically removed from the water, the amount of dispersant needed would be reduced.

At the present time, EPA reuglations prevent the needed tests of dispersants on large quantities of oil. Those regulations need to be changed so that we can find out when, if ever, dispersants should be used.

In summary, a national decision needs to be made first as to whether or not the implementation of total spill clean-up systems should take place. We know enough about the five crucial items needed for total spill cleanup to be able to provide effective systems. Research is presently taking place on ways to improve these systems. If they are to be provided, this research should definitely continue. If the decision should be to save the money and accept the risk, there would be little sense in continuing the research. Without the stimulation of the actual implementation of the systems, the most capable people in the field will probably leave. More research of dispersants is needed, including field trials with large amounts of oil. As a result of these tests, a realistic approach to dispersants, different from that of the EPA and the oil industries, could be developed.

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OIL RECOVERY FROM UNDER RIVER ICE

Submitted by:

Mr. H.A. Quam
Imperial Oil Limited
Box 2356
15th Floor
10025 Jasper Avenue
Edmonton, Alberta
T5J 2R5
Phone (403) 423-8862

A report on a project sponsored by:

Canadian Petroleum Association
Environmental Protection Service - Environment Canada
Petroleum Association for the Conservation of the Canadian Environment

Editor's Note: Copies of this report, the report issued by Canada Centre for Inland Waters and the report on "Ice Exercise North Saskatchewan River 1976" are available on request from the Canadian Petroleum Association, 1500, 633 - 6th Avenue, S.W., Calgary, Alberta, T2P 2Y5

Introduction

On March 17, 1976, the Devon Area "J" Spill Cooperative, supported by the Prairie Region Oil Spill Containment and Recovery Advisory Committee (P.R.O.S.C.A.R.A.C.), conducted a Research and Development project to try to develop methods of recovering oil from under river ice utilizing slots cut through the surface ice.

The objectives of the exercise were to evaluate ice cutting equipment, methods of handling the ice, and to determine optimum slot angles for maximum oil recovery.

The above project provided a great deal of information which was published in a report entitled, "Ice Exercise — North Saskatchewan River". Included in the recommendations of the report was the following basic fundamental requirement — "Additional research is required to determine slot configurations and widths. This would be done in a laboratory where these variables could be controlled. Future spill exercises could verify the results of these experiments."

The P.R.O.S.C.A.R.A. Committee interested in pursuing the above recommendation received enthusiastic support and adequate financing to begin preparations for further Research and Development on the Recovery of Oil from under River Ice.

The project was to include the testing of conventional oil spill recovery equipment with the primary objective to further develop the ice slotting techniques. However, during the laboratory modelling, ideas were advanced which led to the inclusion of testing the ability of a continuous plywood barrier placed below the ice, and an air bubble technique to divert the oil under the ice toward recovery slots.

A committee or task force was organized on November 4, 1976. This task force consisting of representatives from the financial contributors and participating members of the oil industry and government agencies coordinated the project which was completed, with the exception of the report, on March 7, 1978.

Excellent cooperation between the personnel from the government agencies involved and the oil industry prevailed throughout the entire project.

Objectives

— To determine the oil holding capacity of slots cut in the river ice.

— To determine if angled slots, cut into river ice, will divert oil from the area of fast current toward shore where it may be more readily recovered in a slower current.

— To remove the blocks of ice from the slots to ensure there would not be additional turbulence as a result of pushing the blocks under the ice.

— To test the oil diversion capability of a solid barrier placed below the river ice.

— To evaluate the use of an air bubbling device, as a diverter, for oil flowing under river ice.

— To use a limited amount of crude oil to compare the recovery characteristics of dyed rapeseed oil and crude.

— To monitor the oil and grease level in the river water upstream and downstream from the test site.

— To utilize professional divers to monitor and report on the movement of the oil in the water and at the ice-water interface.

— To test a specially constructed automatic skimmer.

Conclusions

It was established that a slot four feet by four feet cut in the river ice would hold about a five inch layer of oil on the water surface in an ice thickness of 28 inches and an average current velocity of 1.6 feet per second.

The work slot, which was 48 inches wide and cut at a 30 degree angle to the current, intercepted and diverted the vegetable and crude oils to the slower current at the downstream end of the slot.

The diver reported excellent recovery of the spilled oil at the work slot. As a result the removal of the ice from the catch-all slot was discontinued.

The catch-all slot, at a 15 degree angle to the current, intercepted and retained small quantities of vegetable oil (1.5 gallons) and crude oil (trace) which bypassed the recovery system.

The crude oil surfaced rapidly in the recovery slot and was easily recovered.

The water quality monitoring indicated that very limited quantities of spilled oil passed under the work slot.

The verbal reports by the diver provided instant information on the movement of the spilled oil.

The spilled oil travelled under ice at a maximum 25 to 30 percent of the average current velocity of 1.4 ft. per second.

Excellent oil recovery rates were achieved with the specially constructed Pedco skimmer located at the end of the slot.

The heating elements on the above skimmer were effective in preventing ice crystals, which were forming, from adhering to the leading edge of the weir.

The conventional trash pumps performed satisfactorily throughout the exercise.

The T-bar and cable inserted through a six inch hole augered through the center of the block proved to be an efficient method of lifting the blocks.

The blocks of ice which were cut to the recommended size were removed from the slot and handled with ease.

The ice cutting techniques, the ice cutting equipment, and the ice handling equipment were effective.

The plywood sheets (⅝" x 4' x 8') were easily installed in a single slot (8" wide) cut by the ditch witch.

The 25 sheets of plywood were wedged into the trench in 37 minutes.

The effectiveness of the plywood diverter, as installed, was unsatisfactory because the wedges used in the installation interfered with the movement of oil in the slot.

It was not possible to arrive at an evaluation of the air bubble diverter. The poor oil recovery may have been due to the following:

- the line of stagnation under the ice may have been further upstream than anticipated as oil was diverted past the skimmer on the upstream side.
- too much air was supplied resulting in excessive turbulence around the skimmer.
- the recovery slot did not appear to be in the correct position.

General recommendations

That all pre-selected oil spill control points be evaluated under winter conditions to determine their suitability to oil recovery from under river ice.

That oil spill recovery personnel be made aware of the techniques and equipment used in preparing slots at a 30 degree angle to the current and one to one-and-a-half times the thickness of the river ice.

That the blocks of ice cut in the slots be pushed under the ice when the bearing capacity of the ice does not permit the operation of heavier machines in complete safety.

That additional field research be carried out to improve upon the installation methods of the plywood diverter and to determine the minimum ice thickness with which it can be safely utilized.

That additional field research be conducted with the air bubble diverter to determine the correct placement of the recovery slot and to evaluate the potential benefits of the air bubble diverter under thin ice conditions.

That safety procedures be prepared as part of a contingency plan for oil recovery from under river ice. Standard company safety procedures must be followed during the preparatory period.

That the special automatic skimmer be modified to include two suction pipes to increase its capacity and to ensure continuous operation should one clog with slush.

That a sieve-type sweep be constructed to facilitate the clearance of ice fragments from the slot.

That special perforated shovels be obtained and kept with the emergency oil spill equipment.

That a sheet of plywood, or a section of portable scaffolding, equipped with a railing be placed across the slot in the immediate vicinity of the skimmer to permit safe tending of the skimmer and allow removal of ice from the slot with maximum safety.

That provision be made to warm the motors on the pumps to facilitate easy starting.

That a large circular saw (similar to the one used at the 1975 Ice Exercise) be obtained, as a part of the emergency equipment, to be used when the ice will not support heavy trenching machinery.

Project Information

Personnel for the Field Trials

Personnel were obtained from the above participants together with members from the Area "I" (Redwater) and Area "J" (Devon) Environmental Protection Cooperatives and contracting firms.

Project Financed by:

Canadian Petroleum Association (C.P.A.)	$ 28,750.00*
Environmental Protection Service (E.P.S.) Environment Canada	37,375.00
Petroleum Association for the Conservation of the Canadian Environment (P.A.C.E.)	37,375.00
Total	$103,500.00

* In addition to their financial contribution the Canadian Petroleum Association, through the P.R.O.S.C.A.R.A. Committee, was charged with the responsibility of coordinating and conducting the field exercise.

Participating Agencies

From: Environment Canada	
Canada Centre for Inland Waters	Burlington, Ontario
Environmental Protection Service	Edmonton, Alberta
Inland Waters Directorate	Edmonton, Alberta
From: Government of Alberta	
Energy Resources Conservation Board	Calgary, Alberta
Department of the Environment	Edmonton, Alberta
Alberta Fish and Wildlife Division of Alberta Recreation, Parks and Wildlife	Edmonton, Alberta
From: Imperial Oil Limited	
Production Research Division	Calgary, Alberta
Production Department	Redwater, Alberta
Production Department	Devon, Alberta
From: University of Alberta	
Department of Civil Engineering	Edmonton, Alberta
From: University of Calgary	Calgary, Alberta
Environmental Sciences Centre (Kananaskis)	

Preliminary Research and Findings

The recovery of oil in slots was thoroughly investigated in the cold room at the laboratory facilities of the Canada Centre for Inland Waters at Burlington, Ontario.

Crude oils were used in the slotting tests and for the solid diverter placed under the ice.

The air bubble diverter was tested at varying current speeds in open water.

The laboratory findings were:—

- The slotting technique was satisfactory providing the oil was removed from the downstream end of the slot at a rate equivalent to the rate of entry.
- The solid diverter placed under the ice worked quite well but performed much better in conjunction with a slot placed immediately on the upstream side of the diverter.
- The air bubble device successfully diverted the oil in open water in the flume.

The air bubble technique releases air under water through a perforated hose to form air bubbles. The rising bubbles create a vertical current of air and water which counteracts the surface current. This counter current produces a line of stagnation which diverts or averts the movement of the slick on the surface. To be effective the velocity of the counter current must exceed the combined velocities of the spreading spilled oil and the river current.

Equipment Testing (Prior to Field Exercise)

Conventional trash pumps were tested pumping river water over long periods of time at temperatures of -28° Celsius.

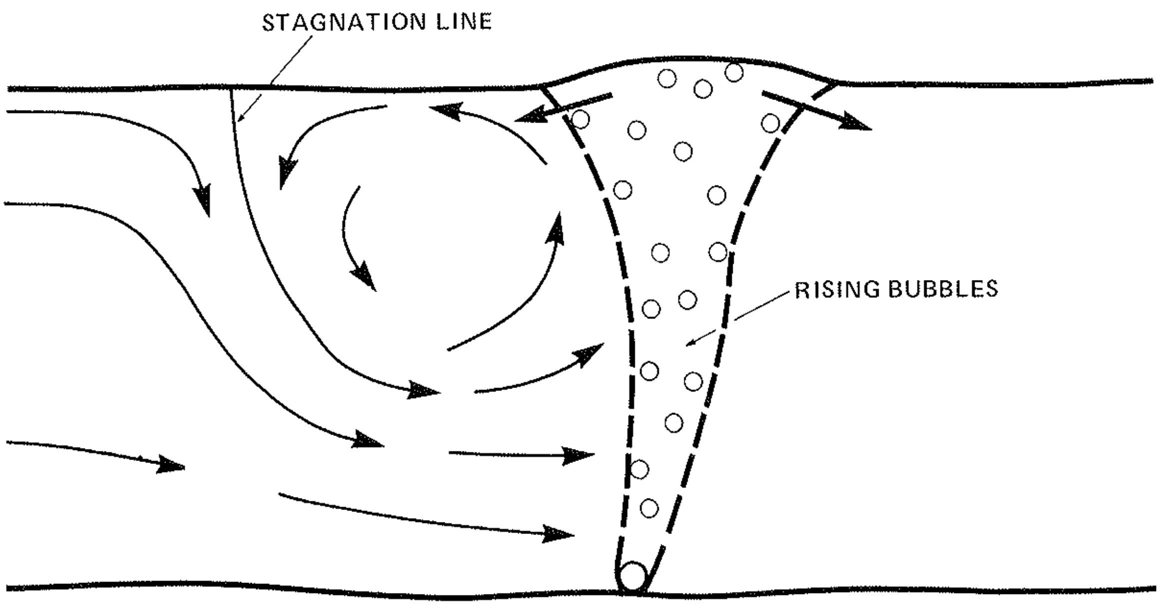
The pumps were tested on a slurry of oil and snow to determine suction retention capabilities.

Flexarctic Hose (84) was tested to determine flexibility.

Chain saws with special chains were tested. The chain saws were equipped with 32 inch bars.

FIGURE 1

THE PRINCIPLE OF AIR BUBBLE DIVERTER OPERATION



Findings of Equipment Test

Conventional pumps operate satisfactorily pumping water under continuous operation. They must be drained immediately after shutdown.

Conventional pumps will handle a thick slurry of oil and snow. The pumps lost suction occasionally but regained suction without shutdown.

Heat must be provided to facilitate easy starting of pump motors.

Flexarctic hose is completely flexible at -28°C.

It is difficult to guide a chain saw with a 32 inch bar to cut angles accurately. The bar tends to bend if the pressure exerted by the operator exceeds the cutting capability of the saw.

In -28°C temperatures the narrow slot cut by the chain saw freezes very quickly.

Site Preparation

One of the objectives of the exercise was to use crude oil. Therefore the site selected was well downstream from all city and industrial water intakes.

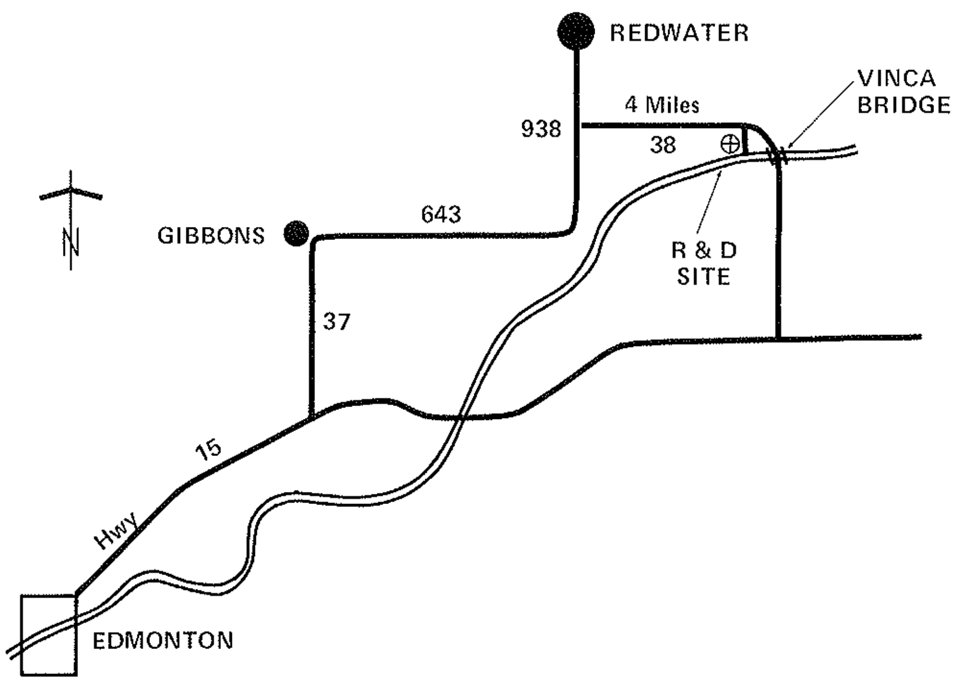
An area 1,500 feet long extending an average of 200 feet out from the north bank was cleared of snow on January 25 and 26, 1978. At the time of clearing the snow depth was 15 to 18 inches on the ice surface and the ice thickness ranged from 14 to 19 inches. The clearing of the snow resulted in thick hard ice forming for the field research.

The water outlets from the City utilities and industrial plants appear to have an effect on ice formation. On February 15, 1978 the ice formation at the site measured an average of 27 inches whereas the ice upstream from the City averaged 36 inches plus.

Site Location

The field exercise was held on the North Saskatchewan River nine miles southeast of Redwater, Alberta.

FIGURE 2 LOCATION OF WINTER OIL SPILL EXERCISE



River Conditions During Field Exercise

Average water depth	6 - 8 feet
Average ice thickness	2.3 feet
Average current velocity	1.4 feet per second

Ambient Temperatures: (Edmonton Municipal Airport)

6 a.m.	— -11°C
12 noon	— 1°C
6 p.m.	— -2°C

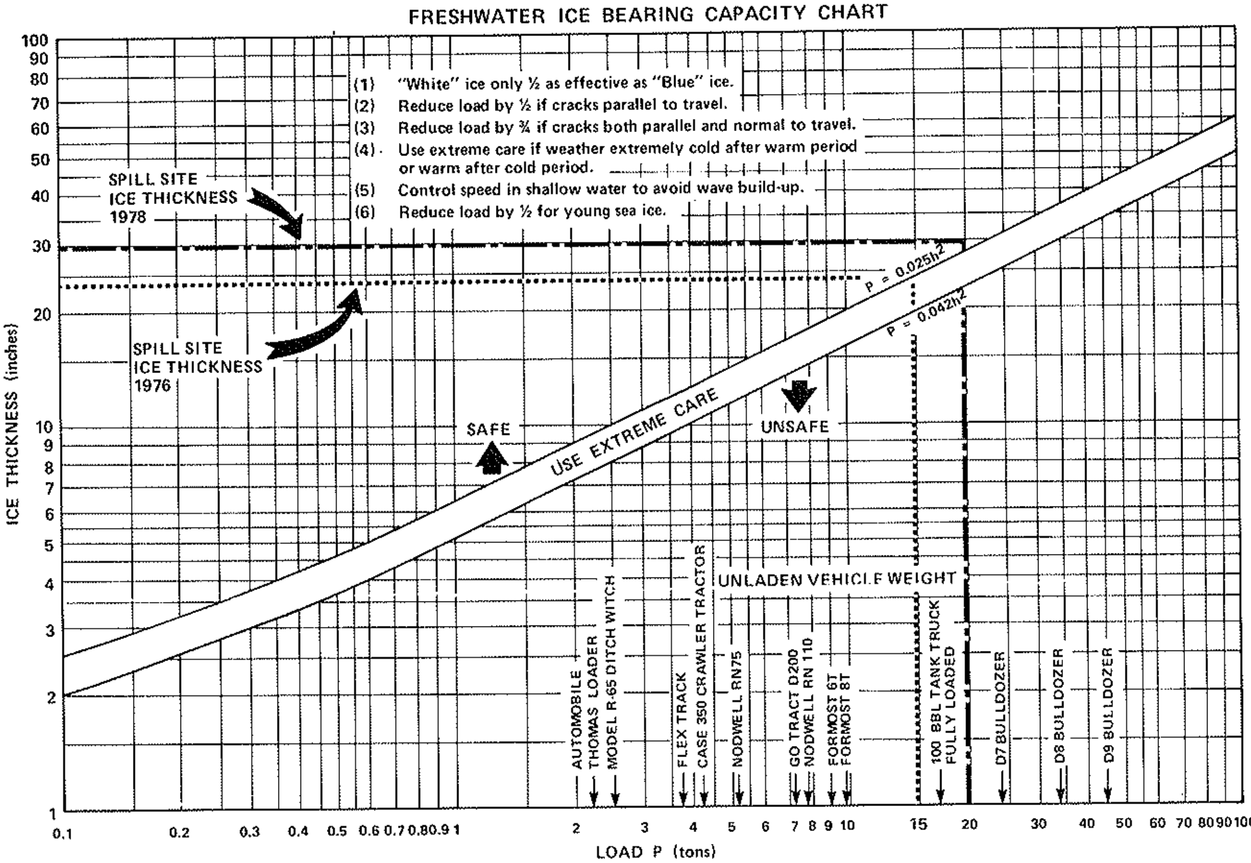
Safety

- — Weight bearing capacity of the ice was checked using the Fresh Water Ice Bearing Capacity Chart, Fig. 3.
- — Only skilled personnel were allowed to use the equipment.

— Life jackets, safety harnesses and lines were available for personnel working around the slots.
— An emergency vehicle equipped with breathing and resuscitation equipment was on standby.
— Barricades and warning signs were erected after completion of the exercise.

FIGURE 3

FRESHWATER ICE BEARING CAPACITY CHART



Oil Properties

Non-toxic, edible Rapeseed Oil, coloured with Automate Red 10B dye and Crude Oil (Leduc D-2) were used in the field trials.

	Density	Viscosity (cp)		Interfacial Tension with Water Tension (dyne/cm)
		0°C	4°C	
Rapeseed Oil	0.91 (24.5° API)	215.0	165.0	68.2
Crude Oil	0.84 (37.2° API)	28.8	17.4	25 (est.)

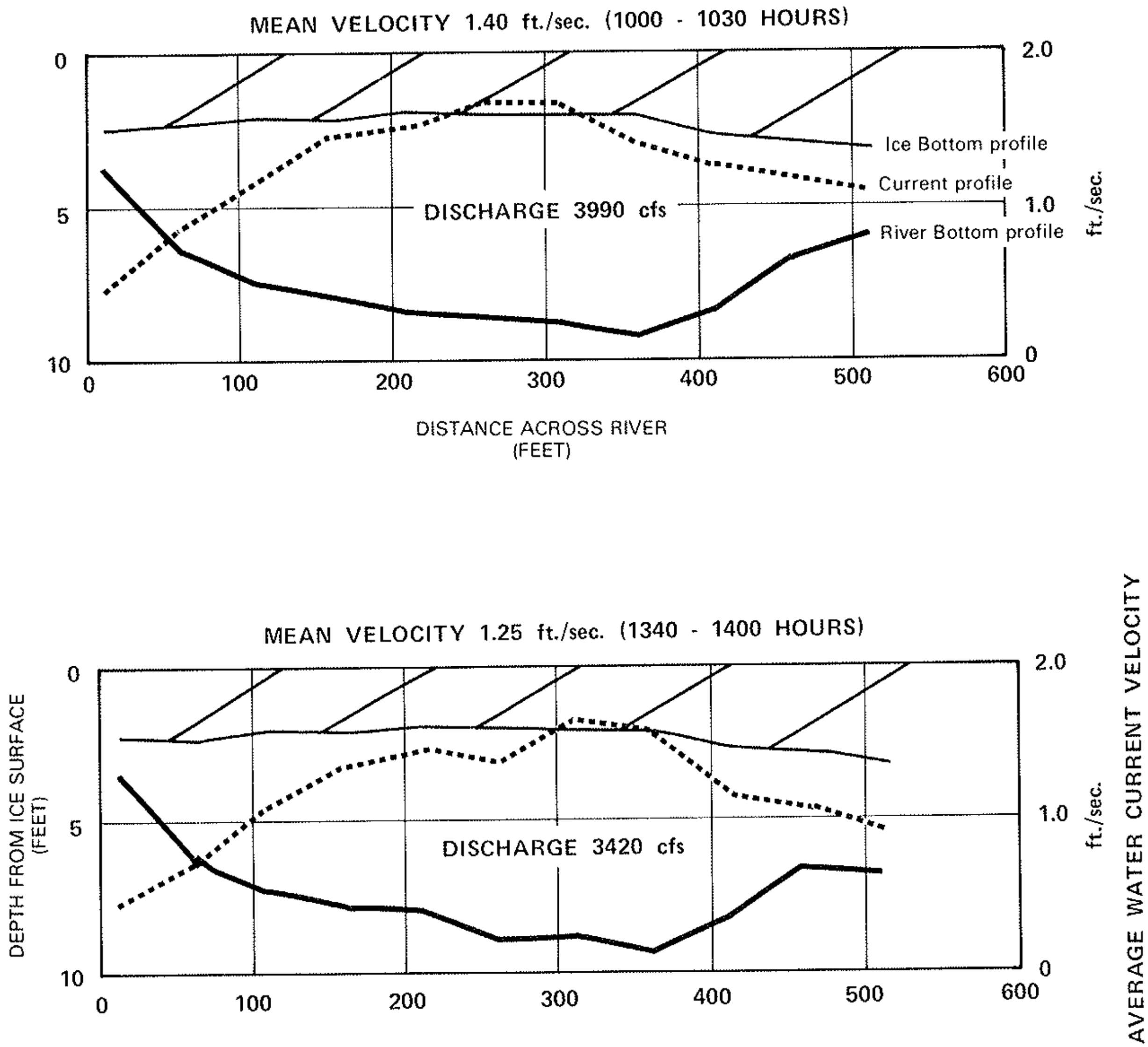
Field Trials

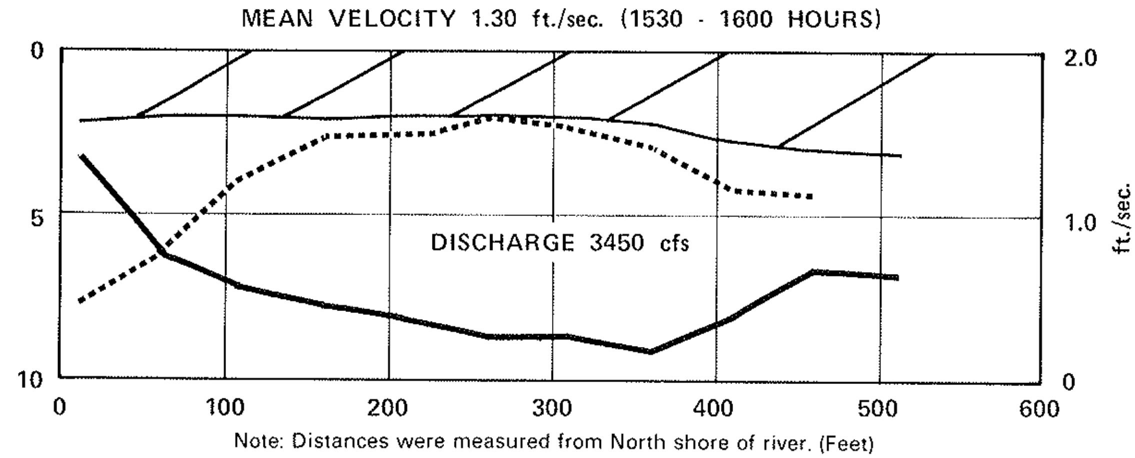
Ice Slots

Experimental layout was based upon preliminary river data. Fig. 4.

FIGURE 4

RIVER PROFILES

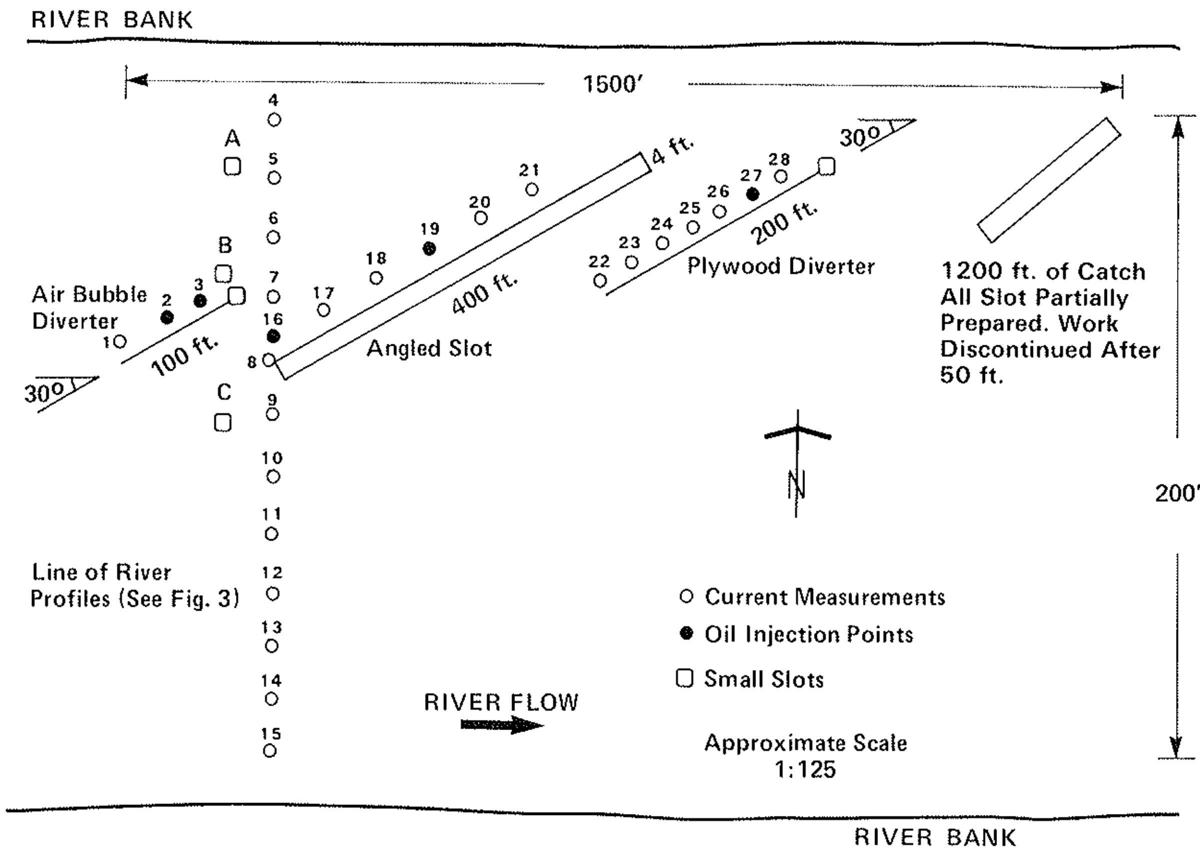




Site Plan

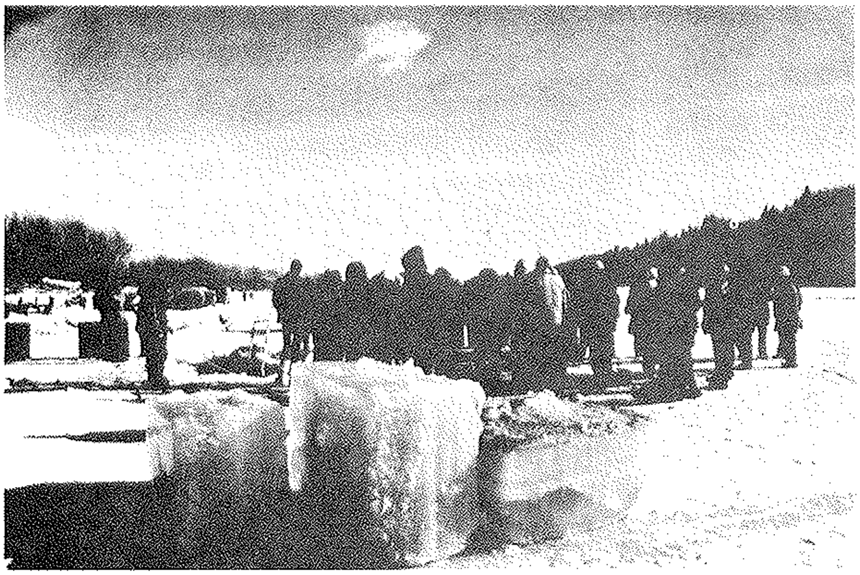
The site would accommodate an Air Barrier Diverter, three 4' x 4' slots to test containment capability of a slot at varying current speeds, a work slot cut at a 30° angle to the river current, a plywood diverter to be placed at a 30° angle, and a catch-all slot to be placed at a 15° angle to the current. It was assumed that 15° was the practical limitation of the slot angle.

FIGURE 5 SITE PLAN



General Observations

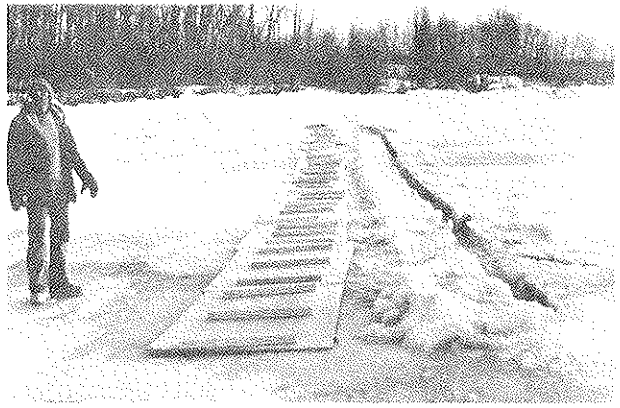
— The ice was 2.3′ thick.
— Ice close to the bank had a smooth undersurface. (Photo 3)



— Ice near to the river centre had wave-like undulations 1 - 2 inches in amplitude and about 12 inches in wavelength. (Photo 4)

— The freeboard in the slots was two inches. (Ice was 2 inches above water surface).

Trench Alignment

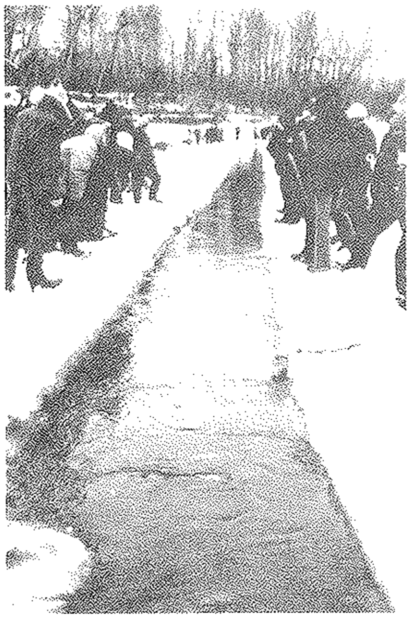


Plywood and wedges for underwater barrier

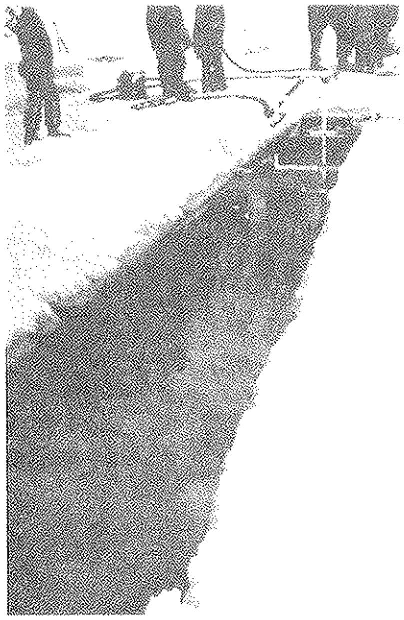
Ditch Witch

Note bar under block

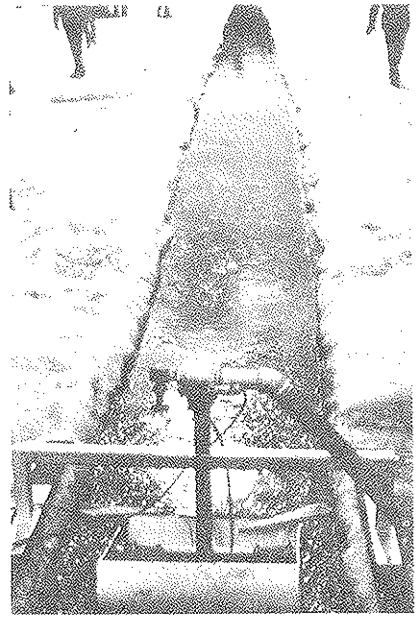
Pushing Blocks to downstream end of Slot



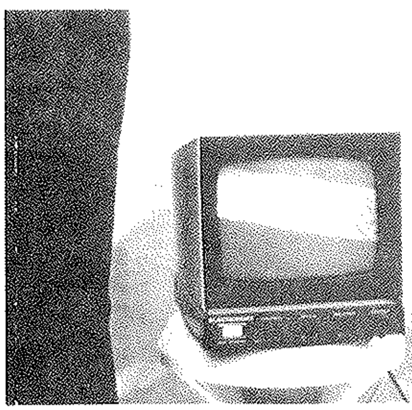
Ripples indicate good surface current



Oil globules moving to skimmer

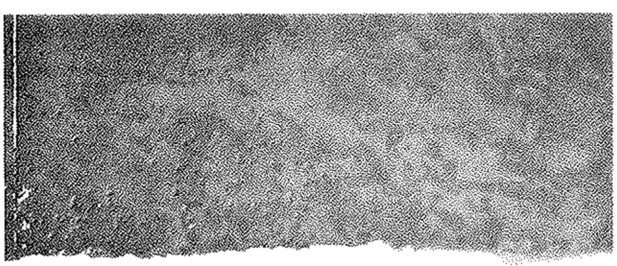


Oil coming over weir of skimmer

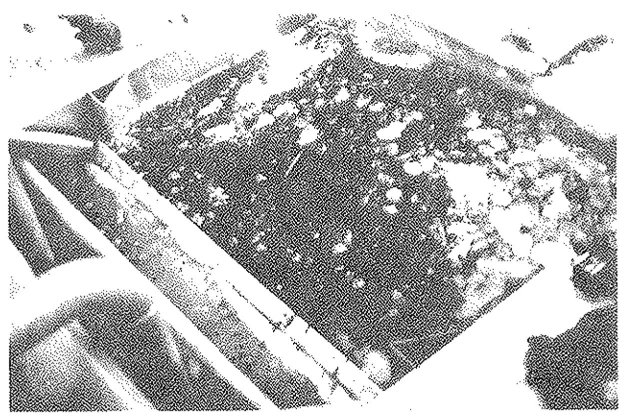


Underwater monitoring

Placement holes and grapple hooks for air bubble diverter



Oil droplets surfacing



Pedco skimmer in air bubble diverter recovery slot

Determination of Oil Holding Capacity of 4′ x 4′ Slots

Procedure

— Rapeseed Oil was added at the surface in 4 gallon increments using a sloping pour plate. (Photo 1)

— Oil slick thicknesses at the upstream and downstream edges of the slots were noted using transparent tubing (the tube was inserted below the oil-water interface, sealed at the top by hand and lifted, until the oil-water interfaces could be seen). (Photo 2)

Oil Thickness Retained at Varying Current Speeds

Retention Slot	Size in (in.)	Velocity (ft./sec.)	Downstream Side (in.)	Upstream Side (in.)	Reached Retention Limits
'A'	43 x 40	0.63	6	6	No
'B'	48 x 60	1.26	4	5½	No
'C'	46 x 48	1.58	3½	5½	Yes

Observations

- There was no loss of oil from retention slots 'A' and 'B'.
- There was no sign of turbulence at the oil-water interface in retention slots 'A' and 'B'.
- Underwater observations at retention slot 'C' indicated that globules of oil up to one and two inches in diameter were pulled away from the upstream edge of the slot and carried away about six inches below the ice.
- As a result of the increased current velocity at retention slot 'C' the oil holding capacity of the slot was significantly reduced.

30° Angle Work Slot

Procedure

- Locations of the cut lines were marked using a tennis court chalk marker.
- Holes were drilled in the centre of the blocks prior to cutting and removal.
- Cuts in the ice were made using chain saws and ditch witches.
- Blocks were removed using a T-bar inserted through the drill holes and ice blocks were lifted out with a crane.
- Slush was cleared from the open slots.

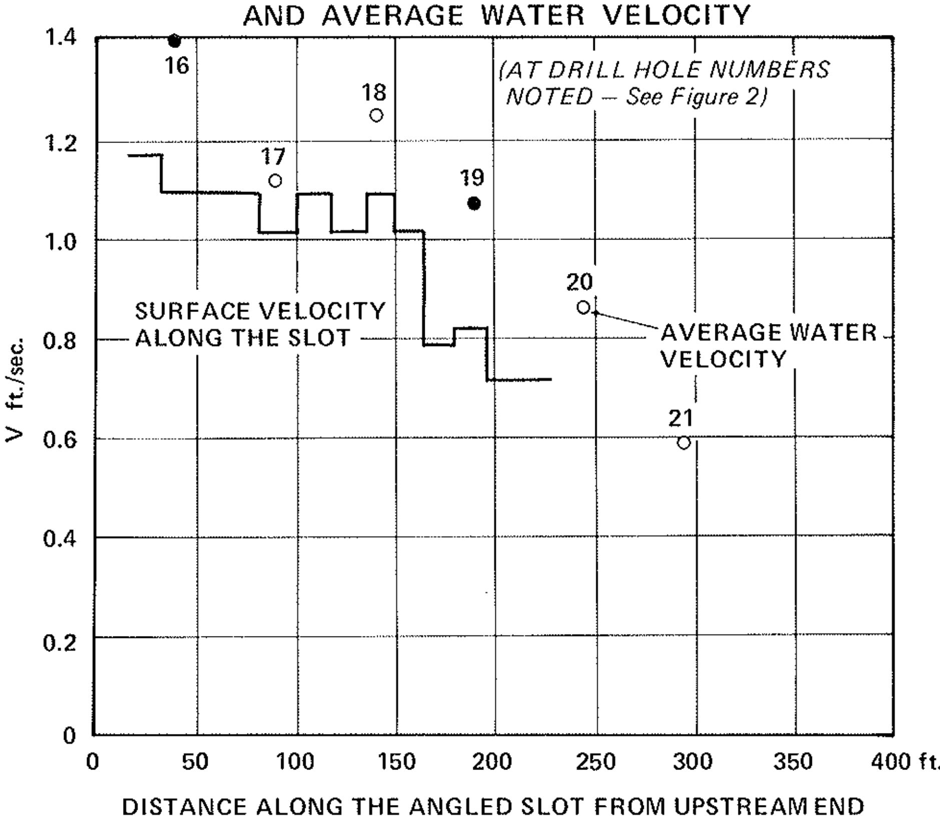
Oil Recovery at Angled Slot

Procedure

— Surface current in the slot was measured by timing the velocity of ½ inch diameter polyethylene balls, slush ice and rapeseed oil. Fig. 6.

FIGURE 6

SURFACE VELOCITY ALONG THE ANGLED SLOT AND AVERAGE WATER VELOCITY



— Polyethylene balls were injected under the ice approximately 20 feet upstream of slot to determine the probable oil trajectory.

— Approximately 4 gallons of rapeseed oil were released under ice through drill hole no. 19.

— The same oil release procedure was followed with larger volumes of rapeseed oil (about 40 gallons at no. 19 and 30 gallons at no. 16 and crude oil (17 gallons at no. 19).

— Oil was recovered using a weir skimmer and pumped into clear plastic tanks. (Photo 5) Visual observations confirmed excellent oil recovery was attained. (Oil and water emulsification prevented precise measurements.)

Observations

— A surface slick formed on the upstream side of the slot and moved toward the downstream end of the slot (See Fig. 6 for velocities).

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- The oil was effectively recovered by the weir skimmer.
- The recovery efficiency of the slot was excellent based on diver observations.
- The diver noted that no spilled rapeseed oil remained under the ice.
- At an average current velocity of 1.07 feet per second the rapeseed oil flowed under the ice at velocities of 0.05 to 0.13 feet per second. The crude oil flowed under the ice at a maximum velocity of 0.06 feet per second. (Small droplets of crude oil continued to surface for one hour after release.)
- At a current velocity of 1.4 feet per second the rapeseed oil flowed under the ice at a maximum velocity of 0.06 feet per second.
- These field values for the maximum velocity of oil under ice are consistent with the laboratory results which were used to construct Figure 8.
- The size of the rapeseed oil drops emerging from under the ice sheet ranged from less than 1/16 inch to about 1 inch. Crude oil drops ranged from less than 1/16 inch to about 1/2 inch.
- Large diameter drops surfaced near the upstream side of the slot and small droplets surfaced near the downstream edge of slot.
- All of the oil which surfaced in the slot was recovered.
- The majority of the oil released maintained contact with the underside of the ice. A few droplets were carried by the current past the downstream edge of the slot.

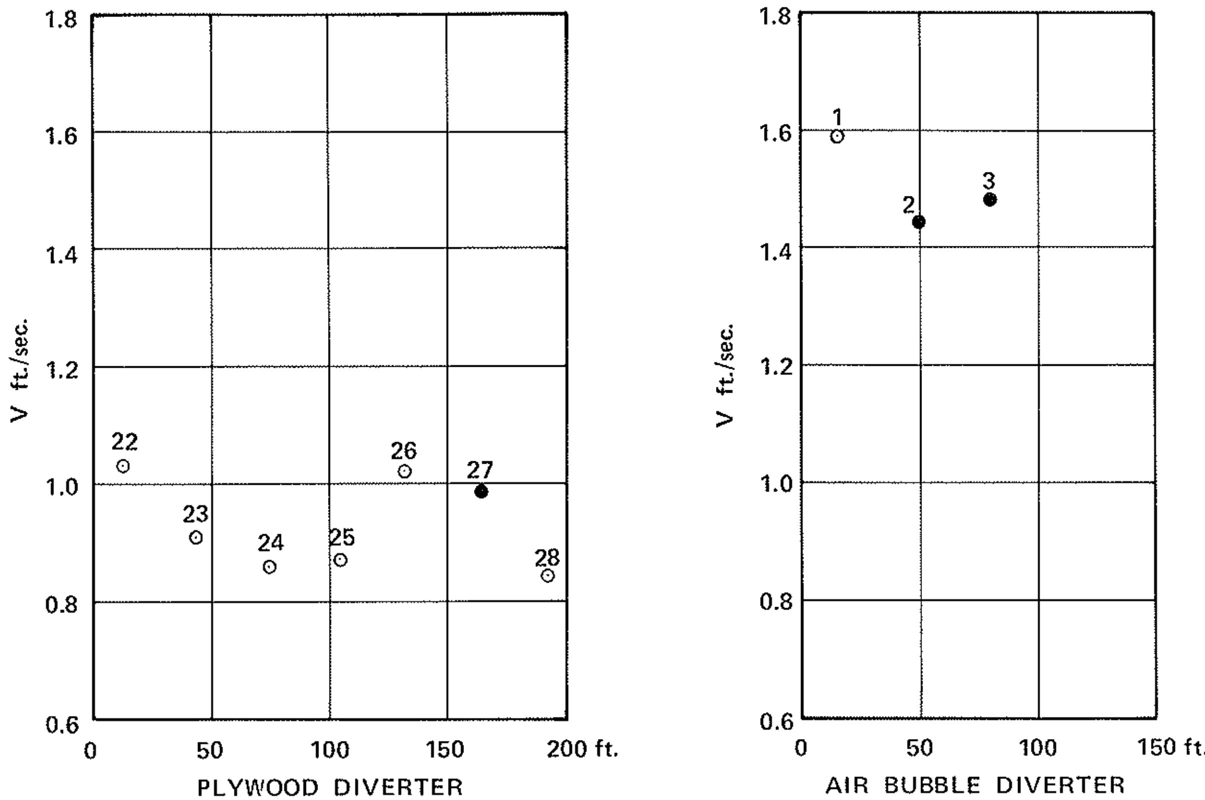
Plywood Diverter

Procedure

— Currents were measured 20 feet upstream of the barrier (holes 22 to 28). Fig. 7.
— Polyethylene balls were discharged in drill hole no. 22.
— Twelve gallons of rapeseed oil were discharged in hole no. 27.

FIGURE 7

WATER VELOCITY 20 ft. UPSTREAM FROM THE PLYWOOD DIVERTER AND AIR BUBBLE DIVERTER



Observations

— The polyethylene balls were not recovered.
— Only trace quantities of oil were diverted to the recovery area.
— Oil was found on both the upstream and downstream side of the plywood when the sections were removed from the eight inch slot.
— The wedges used to hold the plywood in position interfered with movement of oil in the slot. It is suggested that the plywood should be placed on the downstream side of the slot, rather than the upstream side (as was the case in the field trials) and that a method be devised to hold the plywood in position without creating a barrier to the current flow in the slot.

Air Bubble Diverter

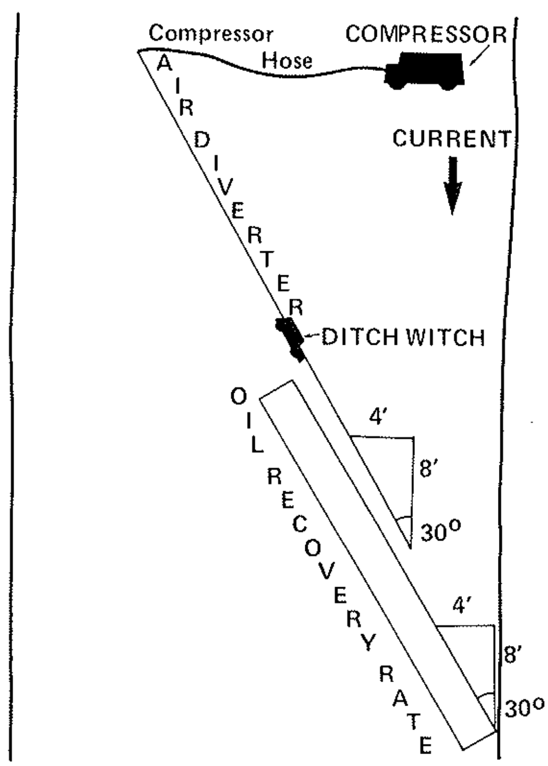
Procedure

— Ten evenly spaced 16" diameter holes were drilled at a 30 degree angle to the current flow extending a distance of 100 feet.
— Ice jigger and grapple poles were employed to position a 3/8 inch polypropylene rope underneath the ice from the upstream hole to the skimmer recovery slot.
— A 100 foot section of weighted 1½ inch perforated PVC discharge hose connected to a 2 inch air compressor discharge hose was deployed along the river bottom with the 3/8 inch rope.
— The 4 foot automatic Pedco barrel skimmer and one 4 inch Homelite trash pump were positioned at the recovery slot.
— Compressed air was pumped through the diverter at approximately 120 psi from an 850 CFM compressor.
— Fifteen gallon increments of rapeseed oil were injected underneath the ice 20 feet upstream of the air diverter at points no. 2 and 3. Fig. 7.

Observations

— Rapeseed oil injected at drill hole no. 2, Fig. 7, was deflected into the recovery slot.
— The proximity of the skimmer to the air diverter resulted in water turbulence which affected oil recovery.

FIGURE 8 AIR DIVERTER INSTALLATION



— Ice chips accumulated in the Pedco skimmer suction port resulting in loss of suction.
— Lack of an air regulator bleed-off valve on the air diverter manifold created air velocity surges resulting in oil-water emulsion being deposited on top of the ice cover restricting further testing.

Water Quality Monitoring

Procedure

The water was sampled through holes drilled 150 feet upstream and 300 and 600 feet downstream of the test site and located 100, 150 and 300 feet from the north bank. Samples of the water were taken in glass containers at the surface of the water and 12, 24 and 48 inches below the water surface. The samples at these four depths were then combined and analyzed.

Observations

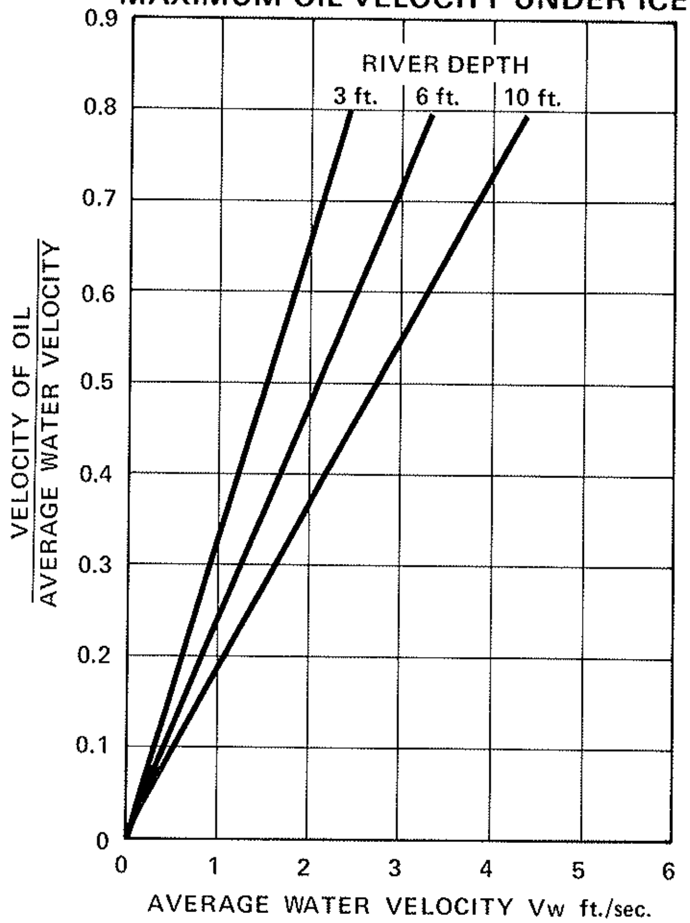
— The background level of oil and grease in the river water ranged from 0.8 to 1 ppm.
— Samples taken following the rapeseed oil releases in the small slots and the angled slot showed a slight increase in oil levels which ranged from 2 to 6 ppm.
— Samples taken after the air barrier test showed increased amounts of rapeseed oil in the test samples and ranged from 2 to 35 ppm. The high values are attributed to the fact that rapeseed oil was not contained by the recovery slot at the end of the air barrier. In addition, samples taken at the surface of the water contained oil which had accumulated throughout the test period.
— Small droplets (less than 0.12 inches diameter) of rapeseed oil and crude oil were visible on the surface of the water in the sampling holes.

Recommended Ice Slot Preparation Methods

Utilize the first preselected control point which will permit adequate time to prepare the slot before the spilled oil arrives.

FIGURE 9

CURVE FOR ESTIMATING
MAXIMUM OIL VELOCITY UNDER ICE



Note: The velocity at which oil will travel under ice is dependent upon the water velocity and the average depth of water below the ice.

Determine the thickness of the ice by drilling as many holes through the ice as necessary to supply sufficient data.

Check the weight bearing capacity of the ice. Fig. 3.

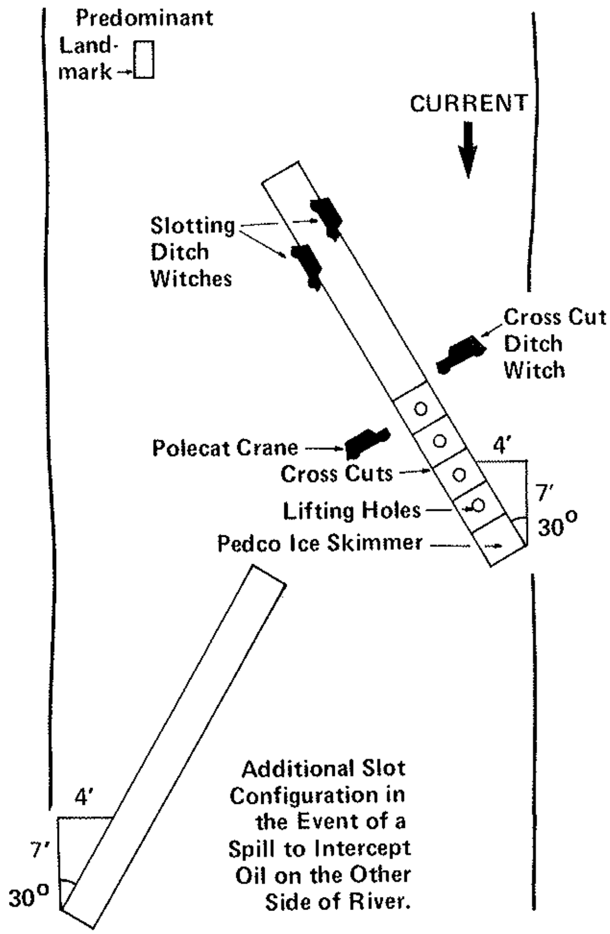
Select equipment type and number of machines necessary to complete slot(s) in the time available.

Use ditch witches for thick ice, circular or chain saw for thinner ice.

Using a suitable marking material or visual alignment (pole or landmark) position slot at a 30° angle to the river current. The width of the slot should be one to one-and-a-half times the ice thickness.

FIGURE 10

ICE SLOT INSTALLATION



In a spill situation it may be expedient to push the blocks under the surface ice on the downstream side.

Removal of blocks may be necessary due to sand bars or shallow water near shore. To remove blocks cut to a size of 1,000 - 1,200 lbs. to facilitate quick removal. Drill a six inch hole in centre of block to accommodate a cable and T-bar and lift out with a mobile crane.

Remove ice blocks from the immediate working area with a wide track crawler tractor to avoid overloading the bearing strength of the ice.

Remove slush and ice fragments from the slot.

Place recovery equipment in slot at the downstream end and attach suction hoses to pumps.

Pumps should be started and kept running to prevent freeze-up and to ensure skimmer and pumps will be functioning when oil arrives.

FIGURE 11

APPROXIMATE WEIGHTS OF ICE

THICKNESS (FEET)	LENGTH (FEET)	WIDTH (FEET)	WEIGHT (POUNDS)
1.0	1 2 3	1 2 3	56 224 504
1.5	1 2 3	1 2 3	84 336 756
2.0	1 2 3	1 2 3	112 448 1008
2.5	1 2 3	1 2 3	140 560 1260

Equipment Performance and Summary

Ice Removal

— The ditch witch proved to be the best suited equipment for cutting ice slots. Time required for ice slotting is dependent on the ice thickness and hardness.

— Ice block removal was accomplished quickly using the Mobile Crane or Polecat. Blocks must be sized to the capability of all the equipment available.

— Ice blocks were pushed close to shore to prevent excessive weight buildup on the ice surface, by a wide track crawler tractor. Blocks which were too large presented a problem with traction.

Ice Cutting and Removal Equipment

Ditch witch
R-65 (Tractor)

Advantages
— fast cutting rate
— provided wide (6") cuts for every ice block removed
— maximum depth — 6 feet

Disadvantages
— weight (5,000 lbs.)
— requires experienced operator
— slush and ice chips must be removed manually from slot.

Husqvarna Chain Saw
(32 inch blade)

Advantages
— readily available
— work in water
— easily portable
— experienced personnel not required
— lightweight

Disadvantages
— cutting rate is slow
— blade size limits maximum cutting depth
— difficult to cut sides of slot at desired angle to ice surface making ice removal difficult

Mobil Crane

Advantages
— readily available
— can lift out ice blocks quickly

Disadvantages
— weight (7,000 lbs.)
— requires experienced operator

Oil Recovery Equipment

Pedco Automatic Skimmer — 2 foot

Advantages
— 10 bbl. capacity per minute
— heated weir and suction pipe will reduce plugging with ice or slush
— lightweight construction
— weir automatically adjusts to an increase or decrease in the pumping rate

Disadvantages

Pedco Automatic Weir Skimmer — 4 foot

Advantages
— 20 bbl. capacity per minute
— lightweight construction
— weir automatically adjusts to an increase or decrease in the pumping rate

Disadvantages
— lack of heat tracing can cause ice to collect on weir or plug suction pipes.

Homelite Trash Pumps
(Gasoline Powered)

Advantages
— lightweight
— high capacity
— difficult to plug
— self-priming

Disadvantages

Gorman Rupp Trash Pump
(Diesel Powered)

Advantages
— economical
— high capacity
— difficult to plug

Disadvantages
— weight (difficult to move around)

SPILL TECHNOLOGY NEWSLETTER

An informal newsletter published bi-monthly by the Environmental Emergency Branch, Environmental Protection Service, Ottawa, Canada.

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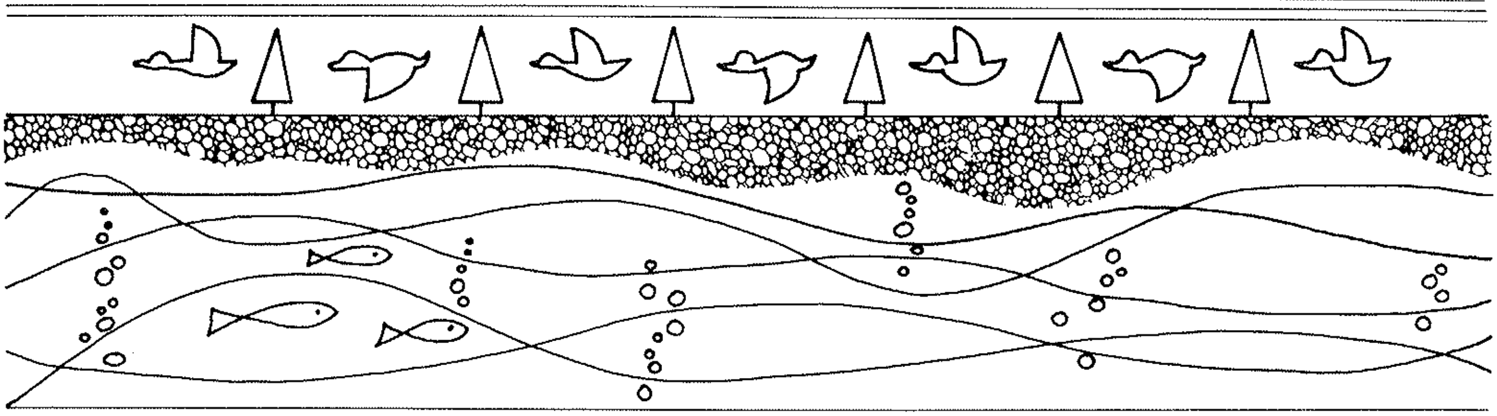

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EDITORS

Dr. S.L. Ross & Mr. M. Fingas

Research and Development Division
Environmental Emergency Branch
Environmental Impact Control Directorate
Environmental Protection Service
Department of Fisheries and The Environment
Ottawa, Ontario
K1A 1C8

Phone: (819) 997-3921

The Spill Technology Newsletter was started with modest intentions in 1976 to provide a forum in Canada for the exchange of information on oil spill countermeasures and other related matters. The interest in it was such that we now have almost 2,000 subscribers in Canada and around the world.

To broaden the scope of this newsletter, and to provide more information on industry and foreign activities in the field of oil spill control and prevention, readers are encouraged to submit articles on their work and views in this area.

INTRODUCTION

We would like to thank readers for filling in the questionnaire attached to the last issue; we hope to have an analysis of it completed in time for the next volume.

In this issue we have the pleasure of having two articles by Professor Donald Mackay of the University of Toronto, whose name should be familiar to most newsletter readers because of past articles and publications.

Dr. Mackay is one of those rare individuals who is always saying nasty things about both the oil industry and federal government, and yet seems to get a continuous flow of oil spill research funds from both. This unlikely situation is, simply stated, a testimony to the quality and integrity of the work he is doing for both sectors. Most of Dr. Mackay's technical interest in oil spills is in the development of practical and easily - assimilable knowledge on the fate and behaviour of oil spills. An example of this is demonstrated in his "article" on "Oil Spill Modelling: Problems and Purposes", which is really a background paper for an upcoming industry/government-funded workshop on the subject. A better example of Dr. Mackay's bold style is shown in his article "Why Clean Up Oil Spills?". Needless to say, as with all articles published in this newsletter, the stimulating views presented here by Dr. Mackay do not necessarily represent the views of anyone but the author. In any case, the provocative article asks a very important question that besieges many experienced oil spill control specialists and decision-makers in both the public and private sectors.

We welcome (as always) thoughts on the article or differing views on the subject. There surely are many!

REPORTS AND PUBLICATIONS

The Environmental Emergency Branch has released two new publications: the titles and abstracts of which appear below. These publications may be obtained upon request from:

Publications Coordinator,
Environmental Impact Control Directorate,
Environmental Protection Service,
Ottawa, Ontario.
K1A 1C8.

The Interaction of Crude Oil and Natural Gas with Laboratory - Grown Saline Ice
(EPS-4-EC-78-9)

Norman Wells crude oil and natural gas were injected under 35 cm of saline ice in the laboratory, and 20 cm of additional ice was grown under the oil and gas. The oil was observed to spread in a thin layer on the under-surface of the gas bubble. When the sheet was thawed, the gas was observed to escape when the minimum temperature in the ice sheet rose to -3.6°C, and this caused the release of a few drops of oil. The bulk of the oil, however, emerged at the same time as a pure oil spill in a control experiment. It is concluded that the presence of gas greatly increases the area over which spilled oil will surface, but does not affect the timing of its appearance.

Probabilities of Blowouts in Canadian Arctic Waters
(EPS-3-EC-78-12)

The work consisted of the development of a reliability analysis capable of generating blowout probability predictions for artificial island and drillship drilling systems used for exploratory drilling in the South Beaufort Sea.

Human, environmental, and equipment failure risk factors were considered in the analysis. The first phase of the work entailed collection and quantification of equipment and operator data on each of the systems, together with associated meteorological and geological conditions. The second phase consisted of a direct probabilistic risk analysis utilizing the fault tree technique. In this technique, only the probability of the most basic events need be specified. Calculation of an ever increasing hierarchy of event probabilities, up to a blowout event, is then carried out using a digital network based on probabilistic logic. The fault tree networks were modelled by means of a computer program to facilitate repetitive calculations of different ranges of input values required for the performance of a sensitivity analysis to identify the most critical factors in the risk system. Blowout probabilities were found to range from 1.5×10^{-3} per well for a blowout probably devoid of oil, to 2.3×10^{-6} for one associated with a major uncontained oil discharge. Drillship blowouts can be expected approximately four times as often as artificial island blowouts. Human operator error was found to be the main error source in both systems, and geological and environmental factors were also areas of high sensitivity. An estimate of the accuracy of the predictions was made. Correlation of the calculated probabilities with historical world statistics was adequate.

Editor's Note: A summary of the initial report on this topic was presented in the Spill Technology Newsletter Volume 2, Number 2. The above report represents the final version resulting from this study.

- The American Petroleum Institute has released the book, "A Manual for Cleaning and Rehabilitating Oiled Waterfowl". Single copies of the booklet are available free; additional copies up to 100 are priced at 35¢ each with discounts available on larger orders. For further information or orders contact:

  Distribution Services,
  American Petroleum Institute,
  2101 L St., N.W.,
  Washington, D.C., 20037.

- The Arctic Petroleum Operators Association (APOA) has produced a number of reports and the titles of these are listed below. The price of the reports depends on the length. Direct requests to:

  APOA Information Service,
  P.O. Box 1281, Postal Station "M",
  Calgary, Alberta,
  T2P 2L2.

  Telephone: (403) 266-5074.

Project No.	Project Title
A.	Contingency
97	Proposal for Full scale Laboratory Tests of the Lookheed Clean Sweep Arctic Boat R-2003 Oil Recovery System (Early release granted by Dome Petroleum Limited and participants.)
100	Test Program to Evaluate a New Concept of Oil Containment Boom for Use in Ice Infested Arctic Waters (Early release granted by Dome Petroleum Limited and participants.)
108	Burning an Oil Blowout Plume (Early release granted by Dome Petroleum Limited and participants.)
B.	Drilling and Drilling Structures
8, 20	Arctic Drilling Guidelines
12	All season Exploratory Drilling System -0 to 200 Feet or Water
13	Seasonal Drilling from a Barge
30	Beaufort Sea Exploratory Drilling System
C.	Environmental - Physical and Biological
3	Ocean Floor Sampling

4	Geological Analysis of Ocean Floor
11	Ornithological Study - Mackenzie Delta
34	Northern Resources Study - Boreal Institute
35	Environmental Study of the Baffin Bay-Davis Strait
37, 55	Contribution to IBP Project, Devon Island, 1973. The IBP Project resulted in publication of book "Truelove Lowland", published by The University of Alberta Press, 1977.
43, 61	Environmental Impact Assessment Program, Mackenzie Delta
63	Arctic Institute of North America's Beaufort Sea Symposium Available from AINA, 2920-24th Avenue, N.W., Calgary, Alberta
72	Beaufort Sea Environmental Program (Studies as listed in "APOA Review", Vol. 1, No. 1.) Available from the Institute of Ocean Sciences, Sidney, B.C.
115	Contribution to Polar Bear Research
126	Biological Review of Davis Strait
127	Davis Strait Biological Sampling Analysis and Observations
128	Ocean Current Studies - Davis Strait
134	Biological and Oceanographical Study - Davis Strait Area
135	1976 Biological Surveys - Davis Strait
138	Second Half - 1977 Davis Strait Environmental Program

D. <u>Ice</u>

1	"Nutcracker" Large Scale Ice Strength Tests
2	Sea Ice Survey - Properties and Movement of Ice and Current Measurements
9	Large Scale Ice Strength Test Phase II of "Nutcracker"
14	Summer Ice Reconnaissance, Beaufort Sea
16	Theoretical Analysis of Ice Failure
17	Pressure Ridge and Ice Island Scouring
19	Analysis of Records Showing Sea Bottom Scouring
25	Model Test Simulating Ice on Fixed Structures
31	Aerial Reconnaissance of Ice - Beaufort Sea
32	Analyze 1971 Scour Records and Run 1972 Program
33	Landfast Ice Movement - Mackenzie Delta
36	Ice Island Destruction - Beaufort Sea
40	Evaluation of Mechanical Properties of Saline Model Ice
41	Evaluation of the Properties of Michel's Model Ice
46	Ice Reconnaissance - Beaufort Sea, April 1972
47	Ice Chipper Evaluation Test
50	Ice Thickness Measurement
51	Ice Movement Beaufort Sea 1972/73
52	Measuring the Crushing Strength of Ice

53	Count of Ice Islands in the Beaufort Sea, 1972
54	Ice Geology - Southern Beaufort Sea
60	1973 Summer Ice Study Beaufort Sea
66	Ice Crushing Tests 1973/74

E. Vehicles

7	Cross-Country Vehicle Study
21	Large Wheeled-Low Pressure Vehicle
38	Testing of the Effects on Terrain by Types of Vehicles
48	Study of Vehicular Traffic on the Mackenzie Delta Tundra
49	Study of Arctic Transportation Equipment - Mackenzie Delta Area
56	Preparation of Specification for Large Arctic Truck

F. Others

24	Arctic Clothing Research
39	Submarine Pipeline Study Offshore Mackenzie Delta
42	Survey of Gravel - Mackenzie Delta
45	Arctic Clothing Research - Phase II

- The Prairie Regional Oil Spill Containment and Recovery Advisory Committee (PROSCARAC) of the Canadian Petroleum Association has recently published "A Feasibility Study of Air Sparging Systems for The Prairie Region", a report on the use of air-bubble barriers in oil spill control. For further information contact: Canadian Petroleum Association, 1500 - 633 - 6th Ave. S.W., Calgary, Alberta, T2P 2Y5.

- The Federal Activities Branch of the Environmental Protection Service has released a discussion report entitled, "A Study of Environmental Concerns of Offshore Oil and Gas Drilling and Production". This publication is available upon request from: Publications Coordinator, Environmental Impact Control Directorate, Environmental Protection Service, Ottawa, Ontario, K1A 1C8.

- The proceedings of the Canada-Venezuela Oil Sands Symposium, held in Edmonton from May 30 to June 4, 1977 is now available from The Canadian Institute of Mining and Metallurgy, Suite 400, 1130 Sherbrooke Street West, Montreal, Quebec, H3A 2M8. Copies are $45.00 for CIM Members, $60.00 for non-members and $35.00 for students. Postage and handling is $2.00 additional per copy.

- The University of Toronto/York University Joint Program in Transportation have released the report, "A Statistical Analysis of Oil Spills in Canada", research report No. 50. This report is available for $5.00 from: University of Toronto, Room 219, 150 St. George Street, Toronto, Ontario, M5S 1A1.

The following reports are available from the U.S. Department of Commerce, National Technical Information service, Springfield, Virginia, 22161; telephone (703) 321-8543. Most reports are also available on Microfiche at $3.00 each (U.S.A. Price). Canadian buyers add $2.50 to each paper copy and $1.50 for each microfiche report.

"Equipment to Neutralize Aircraft Fuel Spills". L.R. Munroe. Civil and Environmental Engineering Development Office, Tyndall Air Force Base, Florida. January, 1978. 40 p. AD-A053 862/9SL $4.50

"Petroleum Degradation in Low Temperature Marine and Estuarine Environments". R.W. Traxler. Rhode Island University, Kingston. January, 1978. 16 p. AD-A053 952/8SL $4.00

"Performance Testing of Oil Mop Zero Relative Velocity Oil Skimmer". M.K. Breslin. Mason and Hanger-Silas Mason Co. Inc., Leonardo, New Jersey. April, 1978. 30 p. PB-280 232/0SL $4.50

"Assessment of Treated vs Untreated Oil Spills (Interim Report)". University of Rhode Island for U.S. Department of Energy. June, 1978. HCP/W4047-02 $15.00

"Coast Guard Response to Oil Spills -- Trying to do too Much with Too Little". United States Coast Guard, Washington, D.C. May, 1978. 86 p. PB-280 911/9SL $6.00

"Oil Spill and Oil Pollution Reports: August 1977 - October 1977". P. Melvin, H. Ehrenspeck and E. Sorenson, California University. January, 1978. 291 p. PB-281 114/9SL $11.00

"Environmental Planning for Offshore Oil and Gas. Volume III: Effects on Living Resources and Habitats". J. Clark and C. Terrell. Conservation Foundation, Washington, D.C. March, 1978. 247 p. PB-281 444/0SL $9.50

"Hydrodynamics of Diversionary Booms". W.E. McCracken. Mason and Hanger-Silas Mason Co. Inc., Leonardo, New Jersey. April, 1978. 57 p. PB-281 282/4SL $5.25

"The Effects of the Water-Soluble Fractions of No. 2 Fuel Oil in the Early Development of the Estuarine Fish, "Fundulus Grandis"". V.V. Ernst, J.M. Neff and J.W. Anderson. Texas A & M University, College Station. 12 p. PB-281 426/7SL $4.00

"Effects of Oil Slicks on Sea Clutter". J.Z. Busch and J.W. Crispin. Bendix Corporation, Ann Arbor, Michigan. 106 p. AD-312 980/6SL $6.50

"Interactive Effects of Temperature, Salinity Shock and Chronic Exposure to No. 2 Fuel Oil on Survival and Development Rate of the Horsehoe Crab, Limulus Polyphemus". R.B. Laughlin and J.M. Neff. Texas A & M University, College Station. 1977. 10 p. PB-281 473/9SL $4.00

UPCOMING CONFERENCES

From October 25-28, 1978, the School of the Environment at The Banff Centre will be offering a seminar on Environmental Law in the Regulatory Process. Organized with the co-operation of Alistair R. Lucas, Professor of Law at The University of Calgary, the seminar will provide a unique opportunity to investigate the rapidly-expanding field of legislation as it relates to administrative tribunals, review panels and commissions of inquiry. Specific sessions will focus on:

Environmental Requirements - legislation, rules, policy guidelines; the rulemaking process; environmental impact assessment.

Environmental Evidence Before Tribunals - onus of proof; discovery; handling expert witnesses; panel evidence; tactical considerations.

Environmental Review Processes - review panels; statutory tribunals; public inquiries.

In addition to Alistair Lucas, the seminar will be conducted by top-flight resource people, including Francis M. Saville, partner in the law firm of Fenerty, Robertson, Prowse, Fraser and Hatch of Calgary, Alberta; Reginald J. Gibbs, McLaws and Company, Calgary, Alberta; and Andrew R. Thompson, Director of the Westwater Research Centre at The University of British Columbia, Vancouver, B.C.

The seminar is designed for government lawyers, corporate counsel and lawyers in private practice, concerned with energy, environmental or resource development matters.

The seminar fee is $420, which is all inclusive of single occupancy accommodation, meals, tuition, and teaching materials. Complete details and registration information are available from:

John R. Amatt, Manager
School of the Environment
The Banff Centre
Box 1020
Banff, Alberta
TOL OCO

Telephone: (403) 762-3391, ext. 310
Telex: 03-826657 Arts BNF

The Centre For Professional Advancement is offering two courses on "Oil Spill and Hazardous Materials Control Technology". The first will be held October 16-18 in San Francisco and the second, November 13-15 in Central New Jersey. The courses are intended for industrial managers and government personnel assigned the direct responsibility for response to non-recurring discharges of oil to provide information on the alternatives available for spill prevention, response and cleanup. For further information contact the Centre for Professional Advancement, P.O. Box H, East Brunswick, New Jersey, 08816 or Telephone (201) 249-1400.

The Spill Control Association of America announces the third in a series of regional seminars designed to bring spill control expertise from industry and government within easy reach of those concerned with effectively handling spills of oil and hazardous materials.

Speakers will include representatives from the U.S. EPA, U.S. Coast Guard, the states of California, Oregon and Washington, as well as spill control contractors and manufacturers of specialized spill control equipment.

The two-day seminar will:

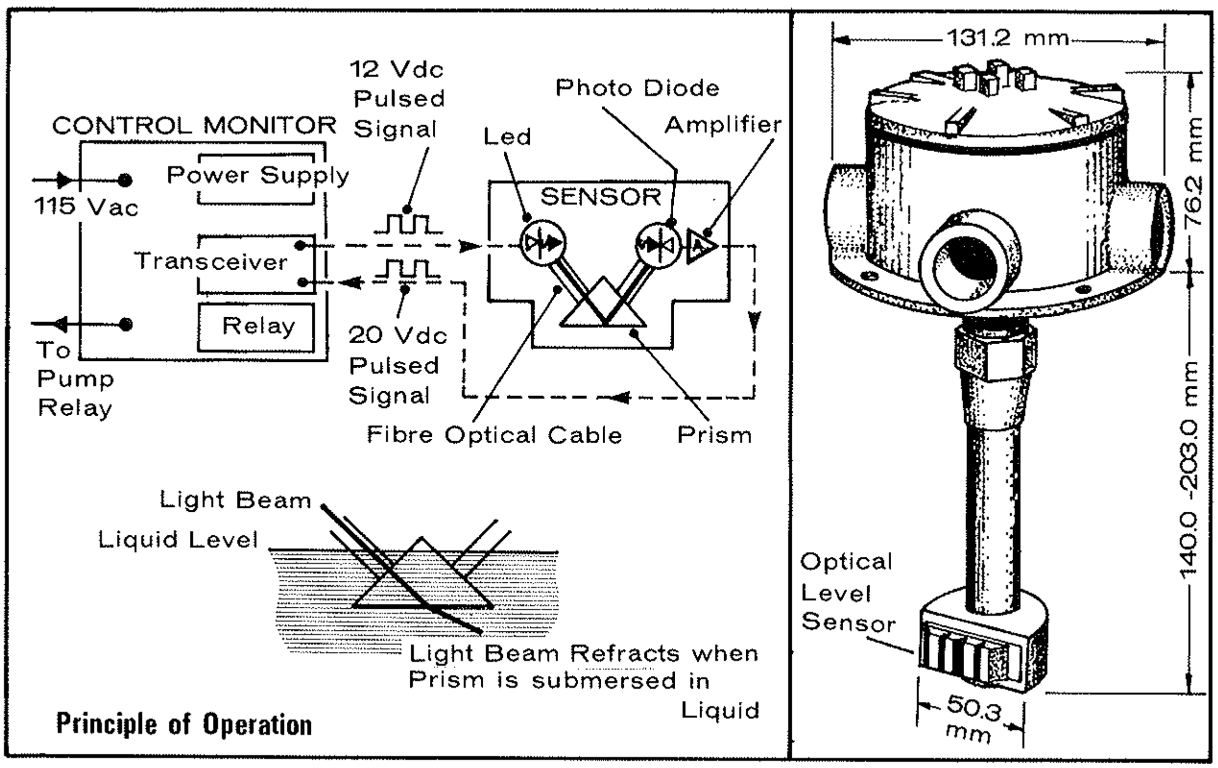
1. Review current federal and state regulations, including enforcement procedures and disposal requirements;
2. Discuss the implications of the recently promulgated hazardous materials regulations;
3. Analyze practical training and prevention methods;
4. Focus in on the special problems relating to inland and harbor spills with emphasis on disposal of recovered material;
5. Present useful information about available equipment and measures that can be taken before expert help arrives; and
6. Consider the role of the spill contractor.

The cost for the two-day program including hospitality suite and a luncheon is $90.00 per person (governmental employees $60.00). The hotel room charges are to be paid by individual registrants. The number of registrants will be limited to 150. Ample opportunity will be provided so that each attendee may fully participate in the question and answer session slated after each topic is covered. For further information contact SCAA at 17117 W. 9 Mile Road, Suite 1515, Southfield, Michigan, 48078 or phone (313) 559-8866.

NEW PRODUCTS

Honeywell of Canada has developed and has initiated the marketing of an optic liquid level sensor intended to provide overfill protection for petroleum tank trucks and bulk storage tanks. The unit employs an optic sensor system arranged in a manner that when the prism of the unit is immersed in a liquid with a refractive index of greater than 1.4 the unit is activated. Honeywell also markets a number of accessories for mounting this device in a variety of situations. For further information contact:

Honeywell Limited,
740 Ellesmere Road,
Scarborough, Ontario,
M1P 2V9 or
Telephone: (416) 491-1300.

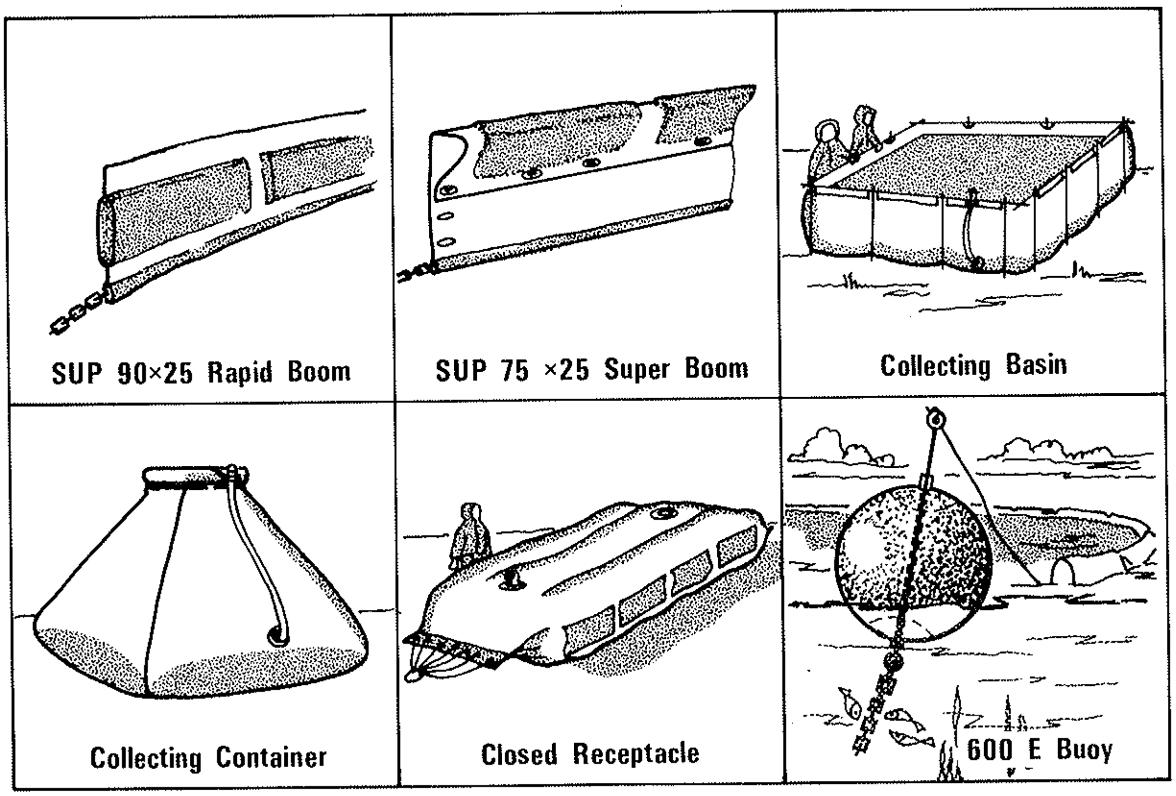


HONEYWELL LIQUID LEVEL SENSOR

Tampella Textile Mills of Tampere, Finland manufactures a number of items for oil spill control as illustrated below. The booms are constructed of PVC-coated fabric and floatation consists of PE-foam. Chains are used for bottom weights. The collection containers are constructed of reinforced plastic sheets and are specially coated to resist petroleum products. The buoys which are intended for use in anchoring or marking booms are constructed of fabric-coated urethane. The Canadian distributor of these products is:

Rent-A-Tarp Ltd.,
1160 Barmac Drive,
Weston, Ontario,
M9L 1X5

Telephone: (416) 745-1667.



TAMPELLA Oil Spill Control Products

WHY CLEAN UP OIL SPILLS?

Submitted by: Donald Mackay
Department of Chemical
Engineering & Applied Chemistry
University of Toronto
Toronto, Ontario.

In their more philosophical moments those who study oil pollution often agonize over the issue of whether or not oil spill cleanup is always necessary. The purpose of this essay is to suggest that although in many cases the need for cleanup is obvious there are situations, particularly in remote Arctic regions, when the reasons cannot be expressed in economic or ecological terms. Perhaps the over-riding imperative for oil spill cleanup lies in an emerging public attitude to environmental contamination which is only dimly perceived at present.

THE ENVIRONMENTAL IMPACT OF OIL

Let us first clarify the diverse impacts which oil releases may have on the environment. First is the large catastrophic spill exemplified by the "Torrey Canyon", "Arrow", "Amoco Cadiz" or Santa Barbara incidents in which thousands of tons of oil were released resulting in local devastation of ecosystems, substantial cleanup efforts and expense, and publicity.

A second category is the very much larger number of smaller incidents which cause less damage. In many such cases, it is difficult to quantify the damage economically. A third category is the chronic continuing discharge of oil, usually from industrial operations, which results in the exposure of ecosystems to oil concentrations which may be sub-lethal but can have profound effects on the biotic community.

A worrisome and poorly understood possible impact of oil releases is long term contamination by slowly or non-degradable components which could cause subtle and unexpected ecological disturbances and even human health effects. There is presently no hard evidence for such effects - but then neither was mercury a problem in the 1950s. The prudent course of action is to minimize il discharges, a policy of prevention which few would contest.

We are concerned here with the first two categories, since the third is more properly regarded as an effluent control problem. In particular, we examine the incentives for cleanup which apply if oil is spilled in remote areas such as the Arctic when there is no obvious economic damage.

THE OBVIOUS CASES

We can dismiss the obvious cases in which oil pollution is directly damaging and the need for remedial action is clear. If a leaking storage tank contaminates ground or well water, the leak should be stopped, and alternative water supplies arranged for the victims. When a pipeline ruptures on agricultural land the oil should be destroyed or removed by established procedures and the land restored to productivity. A resort beach contaminated by oil should be cleaned up and the resort owner compensated for loss of income. The fisherman whose lobsters or fish are tainted or killed deserves compensation. The boat owner should have his oiled vessel cleaned. In these cases, the source of the problem is obvious, the damage obvious and few would contest the moral obligation to compensate. In most cases petroleum companies do clean up and compensate, partly in response to regulations, partly on moral grounds and partly to avoid adverse publicity.

THE LESS OBVIOUS CASES

But there are more subtle cases. If oil is spilled in a remote Arctic ocean far from human habitation there may be some death of plankton, fish and birds but these biota may have been "born to blush unseen" by human eyes. If they are of no economic value, is their death really a problem? Other examples are oil spilled on the remote Alaskan tundra or in the St. Lawrence down river from the massive injection of Montreal sewage, or in the middle of the Atlantic Ocean where there is no fishing and where it is even difficult to find or track the oil. Should efforts be devoted to clean up spills in these areas? The answer is not obvious.

We can dismiss some arguments that are occasionally advanced:

1. The oil has intrinsic value as a fuel and should be recovered.

Since oil costs about $15 per barrel and the clean up can cost $1,000 a barrel, the oil's intrinsic value is negligible.

2. The oil causes an economic penalty of $X, thus there should be compensation of about $X and cleanup, prevention and preparedness costs of the order of $X are justified.

This may be valid in a few obvious cases but in an area such as the Beaufort Sea the expenditures on oil pollution prevention greatly exceed the value of the natural resources exploited. The Berger Report (Vol. II) speculates that the annual value of marine resources exploited in the entire Canadian Beaufort Sea Region is about $460,000. About $12 million was spent on the Beaufort Sea Project. The Canadian Federal Government will spend about $5 million in the Arctic Marine Oil Spill program, a larger amount for Eastern Arctic Marine Environmental Studies, and industry has been required to spend some millions in support of oil pollution equipment and studies. Elementary economics would suggest that it would be far better to give the money to the fishermen. Is it wise to spend $100 to save $10 damage? Similar arguments can be advanced for the environmental expenditures on the Trans Alaska Oil Pipeline or for present and future expenditures on elucidating the environmental impact of operations in offshore Alaska. There have been glaring examples of small quantities of oil spilled in remote areas which have done negligible economic harm but which have incurred high cleanup costs. Obviously economics is not the criterion by which oil pollution is judged. An ironic aside here is the frequent claims that oil for example in the Labrador Sea will damage fishing. When Canada devotes effort to avoid this occurring it does so with a commendable unselfish generosity. Most fishing is by foreign vessels!

3. The oil will cause ecological disturbance.

Most evidence suggests that oil spills have a localised disruptive effect which lasts a few days or weeks in the water column, and possibly a few years in marine sediments or shores. The ecosystem probably restores fairly rapidly and no irreversible changes are evident. Some would argue that we should not allow oil to modify ecosystems. We do modify ecosystems in farming, fishing, hydroelectric schemes, mining, forestry and urbanization. We accept some degree of ecological disruption and indeed the "green and pleasant lands" are rarely the original ecosystem; they are a man-made modification. It is inconceivable that oil could disrupt ecosystems to the extent that is done in overfishing, desertification through poor soil maintenance, by lake acidification, by stripmining or clear-cutting forests.

A valid concern is extinction of a species. There is a compelling case that we should, by careful control of operations, avoid depleting a species to an endangered level. But this must be recognised as a selfish concern. We are concerned about the extinction of whales because we want future generations to see them, not because we are sympathetic to whales - otherwise we would not kill them with such enthusiasm! Any endangered species must play a minor or even negligible part in the functioning of whole ecosystems. Their low numbers dictate a small influence.

4. Oil spills result in the cruel and tragic death of marine animals and birds.

This aspect receives greatest publicity. The oiled bird, beloved of T.V. documentaries, is a tragic sight. Yet deaths from oil spills are few compared to organised death from fishing and hunting. Is the duck or goose more joyful at the prospect of being shot by the hunter than killed by oil? Is the baby seal grateful for its death at the end of a club rather than under an oil spill? We have a conveniently inconsistent attitude towards the death of wildlife.

5. Oil spills contain carcinogens and other toxic compounds.

There is no conclusive evidence that oil accumulates in food chains and has a significant responsibility for cancer by ingestion of oiled food. Most exposure to oil-based carcinogens probably comes from air borne particles from combustion. Even more comes from smoking.

6. Oil spills are aesthetically unpleasant.

If the oiled area is of aesthetic appeal, the oil would certainly be cleaned up. But should we be concerned about a remote Arctic area? There is little concern about unsightly smoldering town dumps swarming with vermin and insects. These sites receive negligible attention by the CBC compared to oil spills.

THE DILEMMA

If a spill is of oil with little intrinsic value, causes little economic loss, has only a temporary or slight ecological effect, poses no risk to endangered species, has a negligible effect on human health and is in a seldom frequented area, why is there so much concern? This question is often raised by the petroleum industry which suspects that it is penalized by over-zealous government officials in being forced to stockpile equipment which may not be used, undertake expensive biological baseline and monitoring studies, and contribute to research programs. Funds used on Arctic oil spill research could perhaps by spent more effectively in installing sewage treatment facilities in Montreal.

SHOULD WE CLEAN UP SUCH SPILLS?

Before attempting to answer this question, let us digress to examine a change in social attitude which has occurred in the last two centuries.

SOCIAL ATTITUDE TO THE ENVIRONMENT

The industrial revolution brought a significant improvement in the quality of life. The workers who swarmed into Dickens' grim factories did so because they left a rural life of even more pitiful squalor with a short life expectancy, and in which mothers could expect to see few of their children survive to maturity. They left an environment where survival was the purpose of life. The common man had little time to sympathise with his fellow humans or with nature. Slavery and child labour were accepted since the victims were not much worse off than the average.

By devising heat engines, mechanical technologies, industrial and agricultural chemicals, improved communications and electronics about one quarter of the world's population has managed to create a high standard of living in which it can afford the luxury of eliminating slavery, taking pity on the poor, improving work and health conditions, abolishing child labour and even abolishing capital punishment. As the pressure for survival lessened we have become more sensitive, possibly even more civilised. We have time and money with which to appreciate the beauty of nature and wildlife, visit remote areas and become indignant about environmental degradation. Simultaneously, our capacity to destroy environments has increased, as exemplified by super-tankers and offshore wells. Perhaps the environmental revolution was the inevitable clash of the increased capacity to destroy with the increased sensitivity for environment, complicated in this case by the realization that oil exploitation is largely controlled by multi-national corporations whose reputation for single-minded pursuit of profit and corporate growth began with Rockefeller and can still be felt in the Petroleum Club in Calgary.

We are apparently experiencing a changing social attitude in which greater value is assigned to individual welfare, to wildlife and to ecosystems. We are less tolerant of personal and corporate abuse of privilege. Those of us who are privileged to teach, see youth's changing attitude quite clearly. There is less emphasis on material possessions and money and more on sensual experience (in the true sense of the word). There is sympathy for wildlife, for conserving life styles with less material and energy consumption and more recycling. Concepts such as solar or wind power, growing one's own food or leading a PEI Ark existence are attractive. There is enormous respect for the Inuit and Indians who epitomised this conserving life style many centuries ago. This respect is reinforced by a deep sense of guilt about past maltreatment of

Native Peoples which leads in many cases to a distorted attitude to the near sanctified North. Technological activities such as Arctic pipelines which threaten that lifestyle are symptomatic of a non-conserving energy-hungry society and are repulsive. Justice Berger is their hero in articulating the value of nature over technology, the caribou over the compressor stations and the trapper over the Bay St. financier.

They see a petroleum industry opening in the Arctic for the benefit of corporate technostructures, to feed an energy-gluttonous society, misguided in seeking a life style of material gain. Only a few claim that the petroleum industry should stay out of the Arctic. Most realise that the affluence which enables them to question society's motives will depend on exploration in the North. But when industry operates in the Arctic it must abide by a devastatingly simple principle; that it be minimally disruptive of the existing social and ecological system, that it leave the environment as it found it uncontaminated by oil, that it strive to avoid spilling oil, and if oil is spilled, it has an obligation to clean it up as much and as soon as possible to leave the environment close to its original condition. It is irrelevant that the oil may coat a remote biologically nonproductive rocky shore. The mere knowledge that the oil is there causes anger, concern and distress. Economic and other arguments are quite incidental, the oils continued presence is simply unacceptable - it ought to be cleaned up!

In many respects, this emerging attitude to the value of the environment parallels the already developed attitude toward the value of human life and health in industry. The Victorian employer could argue that it was not economical or necessarily desirable to spend money on making working conditions safer or healthier. Surely accidents and industrial disease were the prices paid for industrial prosperity? Attitudes changed slowly and only the most reactionary would now value wealth above human welfare. Perhaps we are seeing a similar change in that society now values environmental and social welfare above corporate wealth.

One trend is certain. Any group which fails to perceive the profound change in social attitude and which rigidly adheres to outdated values is doomed to disaster. Beaufort Sea drilling would have come to grief but for some fast and perceptive environmental and social footwork. It is clear that if the Petroleum Industry is to operate in the Arctic in an orderly manner without controversy it must be very sensitive and responsive to changing social attitudes and values. The Arctic Gas lesson is obvious.

SOME IMPLICATIONS

If we accept the emerging principle of oil as an unacceptable contaminant then oil spill cleanup strategies become more understandable.

Primary emphasis should be on prevention by high quality engineering. Operations should be arranged in time and space to avoid exposing sensitive components of the environment to oil contamination.

Since it is impossible to eliminate spill risks entirely we must seek to understand the fate and effects of the oil as completely as possible. This necessitates studies of ocean and atmosphere dynamics, oil slick trajectories, weathering, and toxic effects on biota at all levels. It is essential to identify sensitivities and design cleanup measures to reduce impacts and hasten restoration. Measures such as burying oily debris near shore which sweep the problem "under the rug" are unacceptable. Technology which can make shorelines oily can surely clean them.

CONCLUSIONS

In conclusion, as we become more affluent and more sensitive (and possibly more civilised) a new principle may be emerging that it is a legitimate requirement that industry minimizes its effect on the environment, especially in relatively pristine areas such as the North. Industry should plan its activities to leave the environment close to the condition in which it was found. The occasional oil spill is inevitable, but there remains the obligation to do the utmost to restore the environment as soon as possible. Of course, a reasonable economic perspective must be maintained. It would be stupid to spend excessively on cleanup. After all, it is the unfortunate public which ultimately pays, either in taxes or at the gas station.

The costs of cleanup are part of the cost of doing business in the Arctic in a socially acceptable manner, just as occupational health measures are now regarded as part of the cost of employment.

The primary reason that oil spill cleanup is required is that society regards an oiled environment as offensive. There may be additional economic, aesthetic or ecological incentives for cleanup, but they are incidental to the basic simple imperative. The oil should not have been spilled in the environment: if it is, it should be removed.

ACKNOWLEDGEMENT

This manuscript was prepared over a period of time and in various forms. Many individuals (most of whom would prefer not to be named) have contributed by criticism and suggesting changes. I am very grateful to them.

AMOP EXPERIMENTAL OIL SPILL PLANNING UPDATE

Submitted by: Dr. D.E. Thornton
Research and Development Division
Environmental Emergency Branch
Environmental Protection Service
Environment Canada
8th Floor
9942 - 108 Street
Edmonton, Alberta
T5K 2J5
Canada

Telephone: (403) 425-6932

Notice was given in the last edition (May-June, 1978) of this Newsletter that an exercise is underway to identify studies requiring the discharge of oil in an arctic or sub-arctic marine environment.

The notice included an invitation for readers to submit study suggestions. In addition, a similar invitation has been directly distributed in Canada and abroad to over 150 persons active in the arctic or oilspill field.

An Experimental Oilspill Planning Committee has been formed to select the highest priority studies from an oilspill countermeasures point of view and to develop an integrated program of oil discharges.

The first meeting was held at the end of August to discuss the committee's mandate, objectives, study selection criteria, and scheduling. After a review of the potential marine oilspill threats in the Arctic (and Labrador Sea) and the outstanding information and technological gaps, the Committee discussed the projects identified by the members themselves. These were categorized into two groups:

Core Studies - those which the committee judged would alone justify the discharge of oil into the environment.
Secondary Studies - those which would provide useful supplementary information if incorporated into the experimental design, but would not warrant additional oil discharges.

The preliminary core study titles identified at this time are (in random order);

Burning in meltpools.
Field testing of dispersant effectiveness.
Oil in pack-ice, behaviour and fate.
Shoreline clean-up methods.
Burning against an obstacle (boom, ice edge).
Burning in East Coast ice.
Long term fate and effects of oil in arctic estuaries.

At the meeting, 14 secondary studies were tentatively ranked into high, medium and low priority groups.

Since the first meeting, a number of studies have been received from persons and groups outside the Committee, and more are expected.

The second Committee meeting is scheduled for October 18 and 19, 1978, when additional studies will be added to the list. If you have any promising study suggestions, please inform me before the meeting. Readers contributing, or merely interested in more details about the planning exercise, will be included on the distribution list for copies of the minutes of the committee meeting and working documents.

BLOWOUT (AND OIL SPILL) PREVENTIVE REGULATIONS

Submitted by: M.K. El-Defrawy
Head, Drilling and Completion Engineering Section
Oil and Gas Engineering Division
Department of Indian and Northern Affairs
Ottawa, Ontario
K1A 0H4

The new Canada Oil and Gas Drilling Regulations, which are to be promulgated in the very near future, do require each Operator to present an Oil Spill Contingency Plan prior to the undertaking of any drilling program on Canada Lands under the jurisdiction of Department of Indian and Northern Affairs or Department of Energy Mines and Resources. The purpose of such a contingency plan is to satisfy the Government Authorities that there are acceptable procedures that would be implemented in case of emergency in order to contain and clean-up any oil spilled either from surface sources (e.g. from storage tanks) or subsurface sources as a result of a blowout condition.

The new Regulations further require a Blowout and Major Rig Fire Contingency Plan (Section 79) that explain to the satisfaction of the Federal Authorities that re-gain of control over the well being drilled or the drilling of a relief well to kill the original blowout could be achieved in an acceptable period of time in order to minimize danger to the environment or waste of natural resources. In spite of all such "corrective" measures, the main features of the new federal Regulations are the "preventive" measures that are designed to reduce to a minimum the possibility of such a polluting blowout incident in the first place. The Drilling Regulations deal in detail with such items as prediction of abnormal formation pore pressures, design of drilling fluid programs and casing strings, cementing procedures, multiple BOP stacks and/or diverter systems, protection of BOP's and wellheads, qualification of supervisory drilling personnel, constant drilling fluid pits surveillance system... etc.

The following discussion is aimed at further explaining each of the aforementioned "line of defence" against the possibility of a well blowing out of control, in order to demonstrate that the proposed Canada Oil and Gas Drilling Regulations are among the most cautious in the world.

Section 75, 89, 105, 122 and 123 list the data required from the Operator as to the prediction of formation pore pressure, procedure to be followed to continuously monitor these parameters while drilling and the technology to be employed to ensure that formation pore pressure is always overbalanced while drilling the well. The hydrostatic pressure of the drilling fluid is considered as the first line of defence against blowouts. Therefore, the drilling regulations require the Operator to take all necessary measurements to employ a drilling fluid of adequate density and to continuously monitor this fluid in order to have advance warning about increasing formation pore pressure, penetration of hydrocarbon bearing horizons, water bearing strata or other formations that constitute possible danger to the drilling program. The Operator is required to utilize the most up-to-date monitoring equipment which should be sensitive enough to detect any change in the volume of the active drilling fluid system as well as drilling fluid parameters in addition to maintaining a reserve drilling fluid volume of adequate properties for use in case of emergencies.

The second line of defence is the blowout prevention system and the Drilling Regulations stipulates in detail the design criteria for such a system as well as the diverter systems which could be used at the top portion of a well to guard against high pressures at shallow depths. The working pressure rating of the BOP system is required to exceed 50 percent of the maximum anticipated formation pressure in the case of an onshore well (and 75 percent in the case of an offshore well). Section (60) requires a control system with an accumulator that is capable of activating the blowout prevention equipment in a very short time period and of performing closure and opening of the BOP elements in one continuous sequence of operations without recharging the accumulator system. The design of such a BOP system exceeds the requirement of many other international regulations.

Realizing that the equipment is only as good as the people utilizing it, the Federal Authorities require that all supervisory drilling personnel be knowledgeable in the "Kick Control Technology", when it is prudent to shut-in a well and when it is dangerous to do so and the proper operation of blowout prevention equipment. The Regulations require the Operator to present certificates that such supervisory drilling personnel have achieved a satisfactory rating at a well-control school at least once each three years.

The third line of defence is the casing that is installed in the well to protect the portion of the borehole that has been completed prior to penetrating deeper formations. The casing design criteria listed in the Drilling Regulations are based on the proven engineering principles and are buttressed with the rigorous safety factors which provide for one of the most conservative, that is, the safest design used anywhere in the world. We are not trying to penalize the Oil and Gas Industry by enforcing such regulations but it is rather designed to meet the difficult conditions prevailing in the hostile climate of the Canadian Arctic and the areas offshore the east coast. As an example, the conductor and surface casings are required to withstand excessive freeze-back pressures which are associated with permafrost (22 kilopascals per metre of depth). The intermediate casing is also designed so as to ensure that the casing at the top of the well can withstand full bottom pressure in case of the worst situation where a kick is taken and the drilling equipment (offshore units) is forced off location due to weather conditions for a long period of time. The Drilling Regulations further stipulate an elaborate function and pressure testing procedure for all the aforementioned control equipment, including BOP systems and casings. This way, the actual conditions and pressure limitations are continuously known and the drilling operations are always modified to adapt to any indicated changes in the specifications or pressure rating of the equipment.

Such a conservative casing design coupled with an elaborate BOP system (including the blind-shear ram) renders the occurrence of a polluting blowout incident to be a remote possibility. It is the expectation therefore that in the worst conditions, a penetration of high-pressure zone would result in an underground blowout condition that could adequately be handled either from the same location or by drilling a relief well.

However, with the high level of technical supervision provided by Headquarters in Ottawa as well as the Regional offices in the Field, all drilling operations are very closely and continuously monitored to ensure that each well has enough protection to guard against all possible hazards including the least damaging condition of an underground blowout situation.

OIL SPILL MODELLING: PROBLEMS AND PURPOSES

A background paper prepared for the Oil Spill Modelling Workshop*
Toronto, November 7 & 8, 1978.

Submitted by: Donald Mackay
Department of Chemical Engineering
and Applied Chemistry,
University of Toronto
Toronto, Ontario
Canada M5S 1A4

Phone (186) 978-4019

"I often say" Lord Kelvin asserted more than a century and a half later, "that when you can measure what you are speaking about and express it in numbers you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind: it may be the beginning of knowledge, but you have scarcely, in your thoughts, advanced to the stage of science...."

"In the space of one hundred and seventy-six years the Lower Mississippi has shortened itself 242 miles. That is an average of a trifle over one mile and a third per year. Therefore, any calm person who is not blind or idiotic, can see that in the Old Oolitic Silurian Period, just a million years ago next November, the Lower Mississippi River was upward of one million three hundred thousand miles long. By the same token any person can see that seven hundred and forty-two years from now the Lower Mississippi will be only a mile and three quarters long. There is something fascinating about science. One gets such wholesale returns of conjecture out of such a trifling investment of fact."

Mark Twain

* Participation in this workshop will be by invitation only to enable effective communications on the topic at hand. A list of the invited participants appears at the end of the article. Should anyone wish to provide input, this can be achieved via one of the invitees or by contacting Don Mackay.

INTRODUCTION

The quotations from Lord Kelvin and Mark Twain highlight our dilemma. We have to be quantitative about oil spills without becoming ridiculous. In this background review, I have tried to set out the advantages and disadvantages of modelling, categorised them according to purpose and outline their applicability. In doing so, I hope to have established some objectives for modellers in general and the Workshop in particular.

ADVANTAGES

The ability to express physical phenomena quantitatively lies at the heart of scientific progress. When such expressions are simple (e.g. PV = n RT) they are called "laws". When they are complex (as is inevitable in expressing any real environmental processes mathematically) they are termed "models". Such models usually consist of a set of equations which are conveniently processed by a computer. Often the complexity of the equations preludes immediate insightful prediction of the behaviour of the system. There are many examples of "strange" system behaviour. Models permit predictions to be made faster, they enable more data to be accepted and processed, they are less subject to human judgment error and they can be used (with some risk!) by those who don't understand them fully. They can be used to validate (or otherwise) hypotheses and thus contribute to scientific progress. Models have had many documented benefits in areas such as economic linear programming, critical path scheduling and in systems design. The partnership between the modeller and the computer is immensely powerful when used properly in pursuit of a clear objective.

Yet oil spill models are in some disrepute. It is often claimed that they are not useful, they are expensive and they can rarely (if ever) be validated. Perhaps some of the disrepute arises from the fact that there should be several types of oil spill models, each with its own objective. In many respects models are like vehicles, each has its area of applicability. To misuse a vehicle (e.g. a bus for single family use) is as counter-productive as using a trajectory model for biological prediction. Dissatisfaction is guaranteed!

Before examining categories of oil spill models, let us examine briefly the breakdown of modelling activity into:

1. Input Information Required
2. Computing or calculating procedures
3. Output

These coincide with the three workshop groups proposed for the November meeting.

INPUT

This can include weather, water currents, tides, topography, type of oil (including its physical and chemical behaviour) and biological data.

Such data are usually provided by meteorologists, oceanographers, petroleum engineers and biologists.

COMPUTING

This is basically application of the laws of physics and chemistry in forms such that equations are generated which describe the time space and composition behaviour of the oil. Empirical relationships are very frequently used. Computing techniques are important as are the types and capacity of the computing equipment.

This is usually done by an engineer or physicist with some mathematical flair.

OUTPUT

The data produced are usually in the form of an unassimilable mass of numbers. Only some can be selected for assimilation, preferably in visual display form as graphs, histograms, overlays and maps, perhaps in time series. The output should also contain some estimate of likely error. This task is usually that of the individual responsible for computing. Too often, insufficient effort is devoted to rendering the data into a readily assimilable form. For example, the On-Scene-Commander at an oil spill leads a stressful life and has no time to wade through masses of data. He needs the key information to be transmitted rapidly otherwise he will ignore it and move on to other pressing matters such as keeping T.V. crews away from oily birds.

EXISTING MODELS

I estimate that there are some 20 spill models which have reached a stage of completion and probably as many again under development. Few of these are actually published in complete detail and many are location-specific. Stolzenbach (1) of MIT has reviewed the characteristics of some 15 models and is not very enthusiastic about any of them. Spaulding (2) of the University of Rhode Island has reviewed a number of models and has assembled a rather advanced but as yet unpublished model. Notable among other existing models are Slicktrac (unpublished in detail by Shell), Oilsim (unpublished in detail by Norwegian government), the API-Kolpack model (unpublished), the Mackay-Leinonen model (funded and published by EPS and undergoing further development), the AES model (funded by AMOP/EPS and undergoing further development) and various unpublished or developing models which are specific to locations in the St. Lawrence, the East and West Coasts and the Beaufort Sea.

In summary, it appears that spill modelling is in the same immature development stage as oil spill cleanup equipment design was in some years ago with every backyard inventor "doing his own thing". Perhaps maturity will eliminate many of the minor or ineffective efforts and a few sound models will survive and become established.

PURPOSE OF MODELS

I suggest that there are at least 5 different types of oil spill models. They obviously overlap and have common elements but each has a clear and separate purpose. Surely it is better to have a good model which accomplishes one narrow objective well than an all-embracing model which displeases everyone.

The models are presented in Table 1 along with some requirements and comments relating to Input, Computing and Output and present status. Examination of that Table suggests the impossibility of having one "super-model". Instead, we need a number of specific models operating in concert with different users and time pressures.

WORKSHOP LOGISTICS, OBJECTIVES AND QUESTIONS

Having stated this admittedly prejudiced viewpoint - largely to provoke discussion, we can now set down some objectives for the workshop and suggest questions for discussion. It is expected that each group will discuss the whole area in general but they are requested to concentrate in addition on their particular topic - input, computing or output. The chairman is expected to guide and control discussion and the rapporteur will synthesise the decisions into a final statement to be presented to all attendees.

Assignments will be made by the organizing committee to each group and although some flexibility or group to group movement is acceptable it is hoped that the groups will remain substantially intact. There will be ample opportunity for the expression of individual opinion at the final session.

A transcript will be taken of the final session for processing into a publication, subject to the approval of individual contributors.

The following objectives and questions have been assembled to provide some initial impetus for discussion. Additional questions are enthusiastically invited.

OBJECTIVES AND QUESTIONS

Objective: Better coordination of the various spill modelling efforts.
Question: Is this necessary? How can it be done?
Objective: Coordinate model development to meet operational needs.
Question: What kinds of models do we need? How can coordination be achieved? By whom? What benefits can we expect?
Question: Is it desirable and feasible to work towards the establishment of a set of "standard" Canadian models which would undergo continuous development, would be freely available to all users and whose use would be desirable in, for example, Impact Statements? Non-standard models would be undesirable just as non-standard toxicity tests are undesirable.
Question: Is it acceptable to use a model for regulatory purposes (e.g. Impact Statements) when the details of the model assumptions and procedures are not published?
Objective: Identify gaps in present knowledge about spill processes, environmental data acquisition, output formats, etc.
Question: What are these gaps? How can they best be filled? By whom? With what priorities?
Objective: Identify likely future developments in areas such as remote sensing data input, computation data presentation, biological modelling.
Question: What are these developments? When will they occur? Are they worth pursuing? By whom? How?

Objective: To validate models.
Question: Can and should models be validated? How? By experimental or accidental spills?
Objective: Set reasonable objectives regarding accuracy.
Question: What accuracy is needed? What can be accomplished?
Objective: Establish user education procedures.
Question: How do we teach prospective users? In workshops or "spill games" analogous to "war games"?
Question: Finally, what can be achieved in canadian spill modelling and in what time frame? What actions can and should be taken to ensure orderly and economical development? How can interested parties (including those abroad) cooperate in modelling?

REFERENCES

1. Stolzenbach, K.D., Madsen, O.S., Adams, E.E., Pollack, A.M., Cooper, C.K. "A Review and Evaluation of Basic Techniques for Predicting the Behaviour of Surface Slicks", Report No. 222 prepared for National Oceanic and Atmospheric Administration, U.S. Department of Commerce by the Dept. of Civil Engineering, Massachusetts Institute of Technology, Cambridge, Mass. 02139

2. Cornillon, P., Spaulding, M., "Environmental Assessment of Treated versus Untreated Oil Spills", prepared for Environmental Control Technology Division U.S. Dept. of Energy, by College of Engineering, University of Rhode Island under Contract No. E(11-1)4047.

LIST OF INVITEES

Committee	Organization	Committee	Organization
Peter Blackall	EPS	D. Wilcox	Shell
K. Evans	Gulf	D. Mackay	IES/U of T
R. Fern	IOL	A. Telford	APOA
S.L. Ross	EPS	I. Lissauer	USCG
D. Thornton	EPS	A. Ages	DFE
C. Ross	EPS	A. Lasday	API
M. Ruel	DINA	M. Spaulding	U of Rhode Island
N. Snow	DINA	K. Pilkington	APOA
A. Redshaw	DINA	J.Galt/C.Barrientos	US NOAA
G. Greene	EPOA	T. Beck	APOA
A. Milne	DFE	D. Cormack	U.K. (Warren Springs)
T. Munn	IES/U of T		
H. Sahota	AES	M. Sydor	DFE - IWD
E.C. Jarvis	AES	C. Kerr	Princeton Univ.
H. Snyder (or designate)	CCORE/NORDCO	J.W. Miller	Oceanographic Inst. of Washington
B. Coupal	U. of Sherbrooke	J. Henderson	Oceanographic Inst. of Washington

TABLE 1
TYPE OF MODEL

Characteristics	Real Time Spill Trajectory	Environmental Impact Assessment Scenario	Research (Physical)	Site Specific Biological	Whole Ecosystem Model
Purpose	To facilitate countermeasures, possibly in "game" as well as actual spill form	To provide an assessment of likely impacts of a proposed development	To obtain and validate scientific findings and plan experiments	To provide an assessment of likely ecological effects of developments	To provide an overall, long term assessment of impact and hazard for a lake or sea
User	On-scene-commander actual and training	Proponents and reviewers of the development	Research scientist	Biologist/ Ecologist	Environmental Scientist/Planner
Program Accessibility and Speed	Accessible in remote regions, results available in 1 hour without consultation with developer. Must thus be simple and robust and easily used	Several days delay acceptable with user able to consult with programmer. Fair complexity acceptable but should be usable by several groups	Available only to a few individuals or even the programs alone. Long delay acceptable. Any degree of complexity acceptable	As research model	As research model
Environmental Data Input	Real time wind, current tidal weather data and local geography and bathymetry	Historical wind current, tidal weather data ie monthly averages	Usually several selected "typical" conditions	As Research Model	Average weather and other conditions
Oil Type	Amount and composition of actual spilled oil. Properties must be "looked up"	Estimate of the oil or oils likely to be spilled and range of amounts and times of spill	Specific oil and amount selected	As Research Model	Estimates of annual amounts spilled and average properties
Output	Fast visual display readily assimilable cathode ray tube or computer graph preferred	More complex and slowly assimilable data acceptable but preferable converted into visual form in report eg. overlays	Complex tabulations acceptable. Can be connected to visual form for reporting at leisure	As Research Model	Simple mass balances, prefer in visual form for report
Status	Several exist	Several exist	A few exist	Very few	Very few

FIELD TRIALS - OPERATION PREPAREDNESS
ST. LAWRENCE RIVER
LISBON BEACH
JUNE 19-23, 1978

Submitted by: N. Vanderkooy
Regional Environmental Emergency Coordinator
Environmental Protection Service
135 St. Clair Avenue, W.
Toronto, Ontario
M4V 1P5

Phone: (416) 966-6462

1. BACKGROUND

In 1976 the Operations Preparedness - St.Lawrence River was established as a Joint Canada-United States programme. The objectives of this study were to identify ecological sensitive areas which may be adversely affected by a major oil spill, and to determine resource requirements to deal with such eventualities.

The operation Preparedness programme was initiated under the auspices of the Joint Canada-United States Marine Pollution Contingency Plan, with the co-operation of Canadian and United States agencies, including:-

- Canadian and United States Coast Guards
- U.S. Environmental Protection Agency
- New York State Department on Environmental Conservation
- New York State Department of Transportation
- St. Lawrence Seaway Development Corporation
- St. Lawrence Seaway Authority of Canada
- Ontario Ministry of the Environment
- Ontario Ministry of Natural Resources
- St. Lawrence Eastern Ontario Commission
- Environment Canada.

The programme consisted of a number of projects to examine the entire river system from Wolfe Island to Cornwall, Ontario, for the purposes of identifying:

1) potential sites where recovery operation may be initiated in the event of a major spill
2) ecological sensitive areas which will require special protection
3) strategic locations of recovery equipment, including supporting materials such as communications, sorbents, etc.
4) potential disposal sites, and
5) effective operating procedures to control an oil slick in the St.Lawrence river.

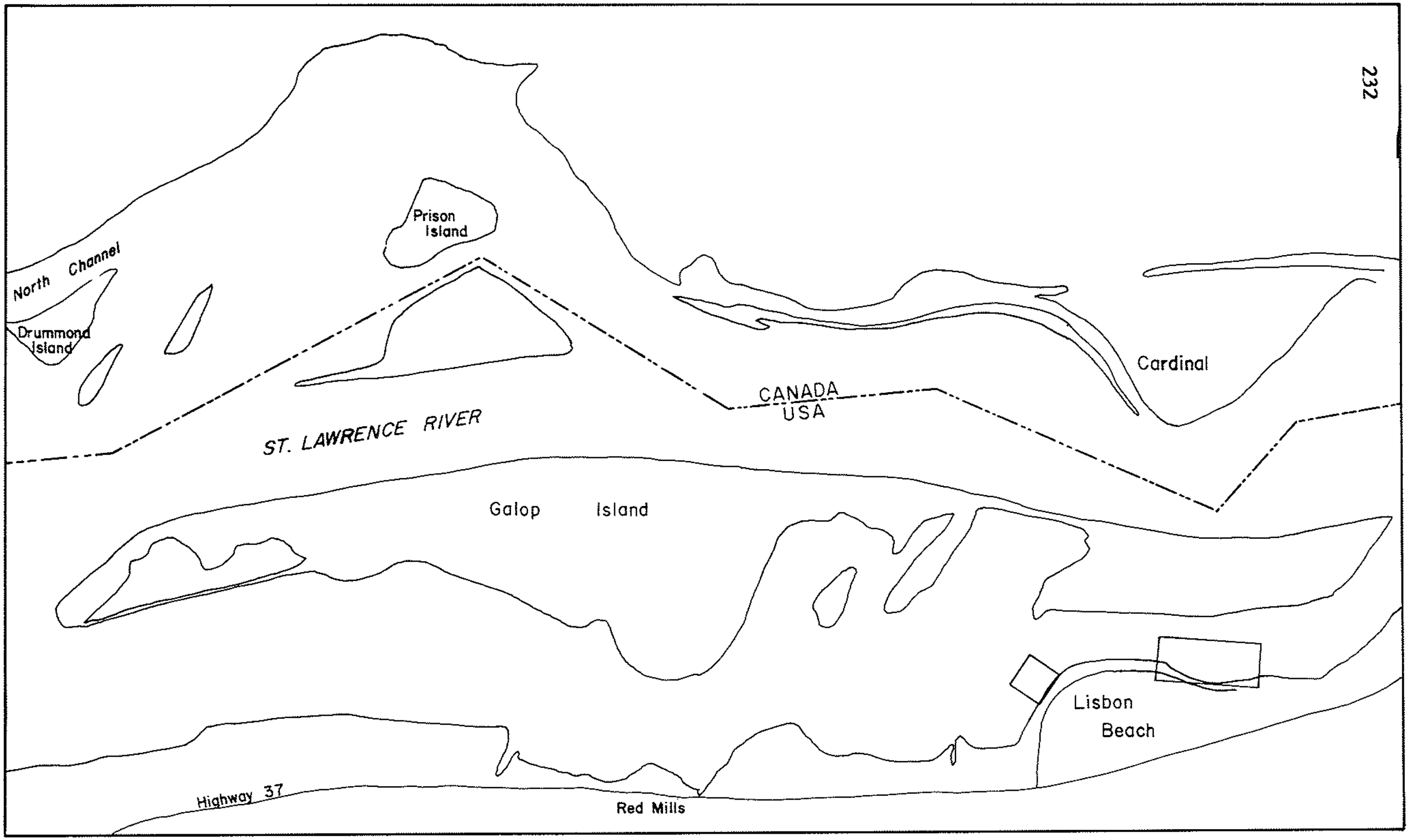


FIGURE I. TEST SITES AT LISBON BEACH

.25 .5 .75 0
Miles

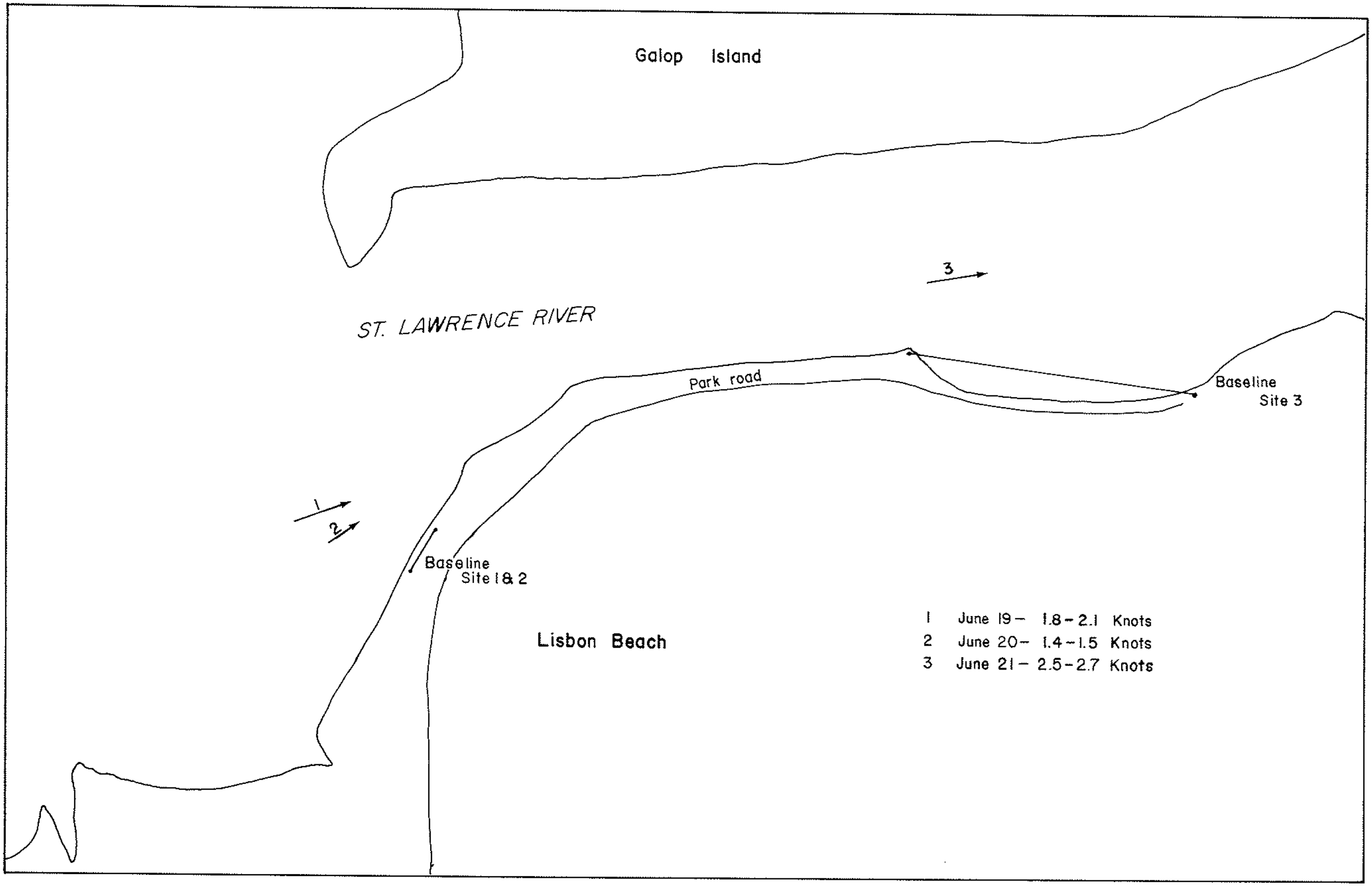


FIGURE 2. TEST SITES AT LISBON BEACH

2.0 INTRODUCTION TO THE FIELD TRIALS

During the 1976 Nepco spill incident at Alexandria Bay, and the 1974 Imperial Sarnia incident at Whale Back Shoal, it became evident that significant quantities of oil accumulated in the Channel between Gallop Island and New York State mainland; for that reason this area including Lisbon Beach was identified as a potential oil spill recovery site. (See Figures 1 and 2).

It was agreed that the field trials in July of 1978 should be conducted at Lisbon Beach. The objectives of the trials were three-fold:

1) determine any correlation between the results of the boom evaluation trials conducted in the St.Clair-Detroit rivers in 1974-1975, and the St.Lawrence field trials.
2) evaluate "new" barriers which were not considered and/or available during the 1974-1975 trials
3) develop operational deployment procedures at the Lisbon Beach recovery site.

2.1 TEST METHOD

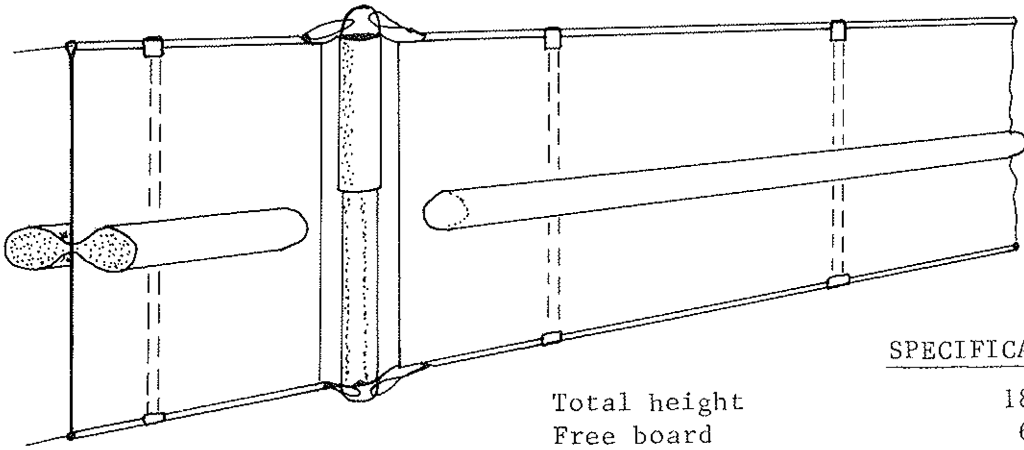
Similar testing procedures to the St.Clair River trials were employed at the Lisbon Beach N.Y. trials, and are summarized below. (These procedures are described in the EPS report, "Evaluation of Oil Spill Barriers and Deployment Techniques for the St-Clair-Detroit River System".)

2.1.1 BARRIER SELECTION

The initial step in the barrier selection involved the gathering of manufacturers' literature. The information was reviewed and compared with the data collected for the St.Clair-Detroit trials.

In order to attain the first objective, it was agreed to re-test the Hurum Marine 18" and 24" booms, and the American Marine Co. 25" Optimax boom. (Unfortunately due to the mechanical breakdown of the trailer neither the Hurum 24" nor the American Marine, Optimax arrive in time for the testing programme). Two additional barriers were selected for the testing phase of the programme which were the Bennett ZOOOM boom and the Tampella, Guard SUP 75 x 25 boom. These barriers are listed in Figures 3, 4, 5 and 6.

FIGURE 3 FLEXY II OIL BOOM



SPECIFICATIONS

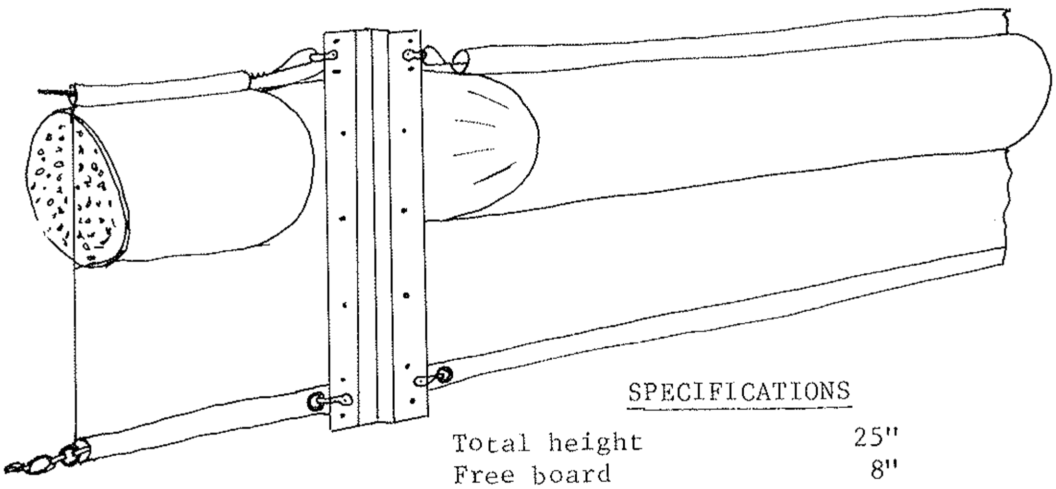
Total height	18"	24"
Free board	6"	8"
Draught	12"	16"
Section length	50'	50'
Weight	1.5 lb/ft.	2.6 lb/ft.
Floatation	2" *	3" *
Floatation Material	Ethafoam	
Barrier Material	PVC coated nylon	
Tension	½" steel cables top & bottom	
Ballast	lead weights	
Price: June, 1978	$11.25	$12.60 /ft

* larger floatation available.

DISTRIBUTOR:

Hurum Shippers & Trading
Board of Trade Building
300 St. Sacrement St.
Montreal, P.Q.
(514-847-5211)

FIGURE 4 OPTIMAX OIL BOOM



SPECIFICATIONS

Total height	25"
Free board	8"
Draught	17"
Section length	100'
Weight	2.5 lb/ft.
Floatation	6" Ø - 7ft. long
Floatation Material	Ethafoam
Barrier Material	vinyl impregnated nylon
Tension	steel cable top- chain bottom
Ballast	galvanized chain

DISTRIBUTOR:

American Marine Canada
P.O. Box 1660
Kingston, Ontario
(613-389-3118).

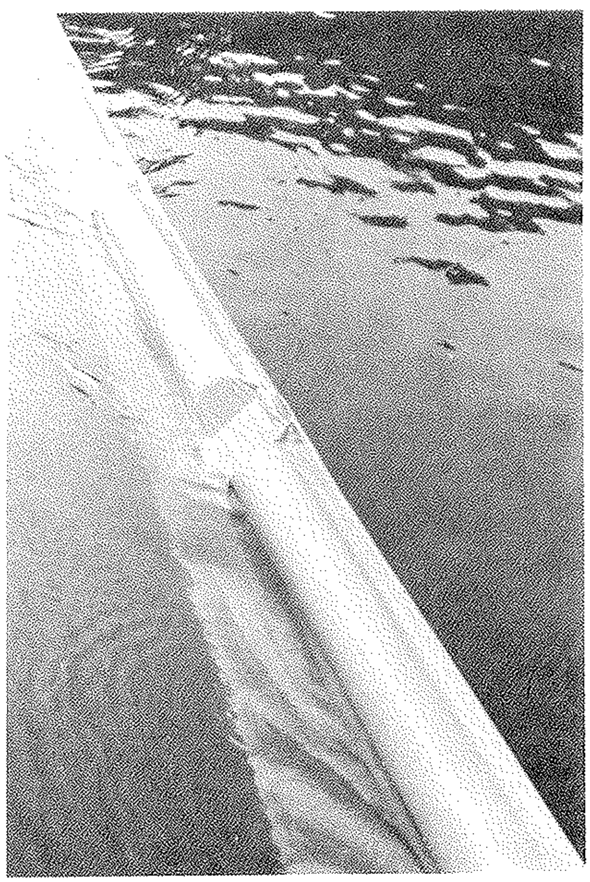
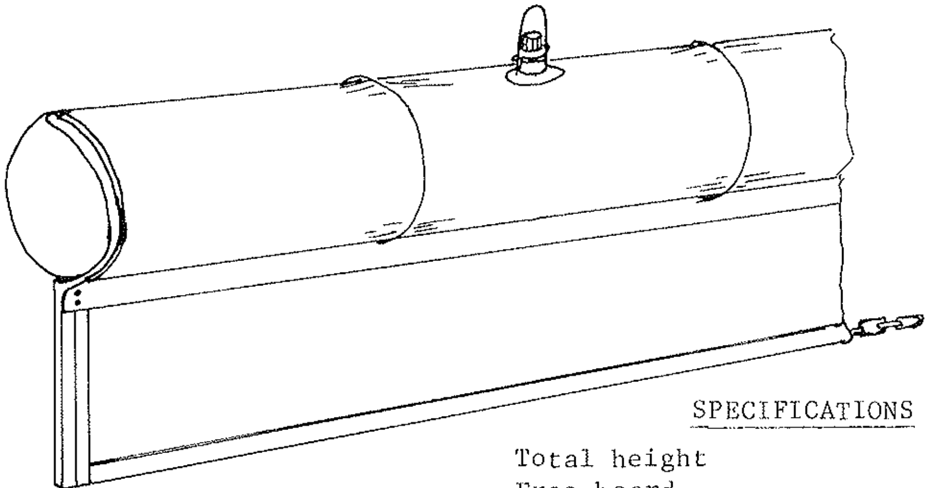


FIGURE 5 ZOOOM SERIES 12 OIL BOOM



DISTRIBUTOR:

Bennett Pollution Controls Ltd.
11a Charles Street,
North Vancouver, B.C.
(604-929-5451)

SPECIFICATIONS

Total height	30"
Free board	10"
Draught	10"
Section length	100'
Weight	1.8 lb/ft.
Floatation	12"
Floatation Material	air
Barrier Material	polyurethane coated nylon
Tension	chain - bottom
Ballast	galvanized chain
Price: June, 1978	$23.65/ft

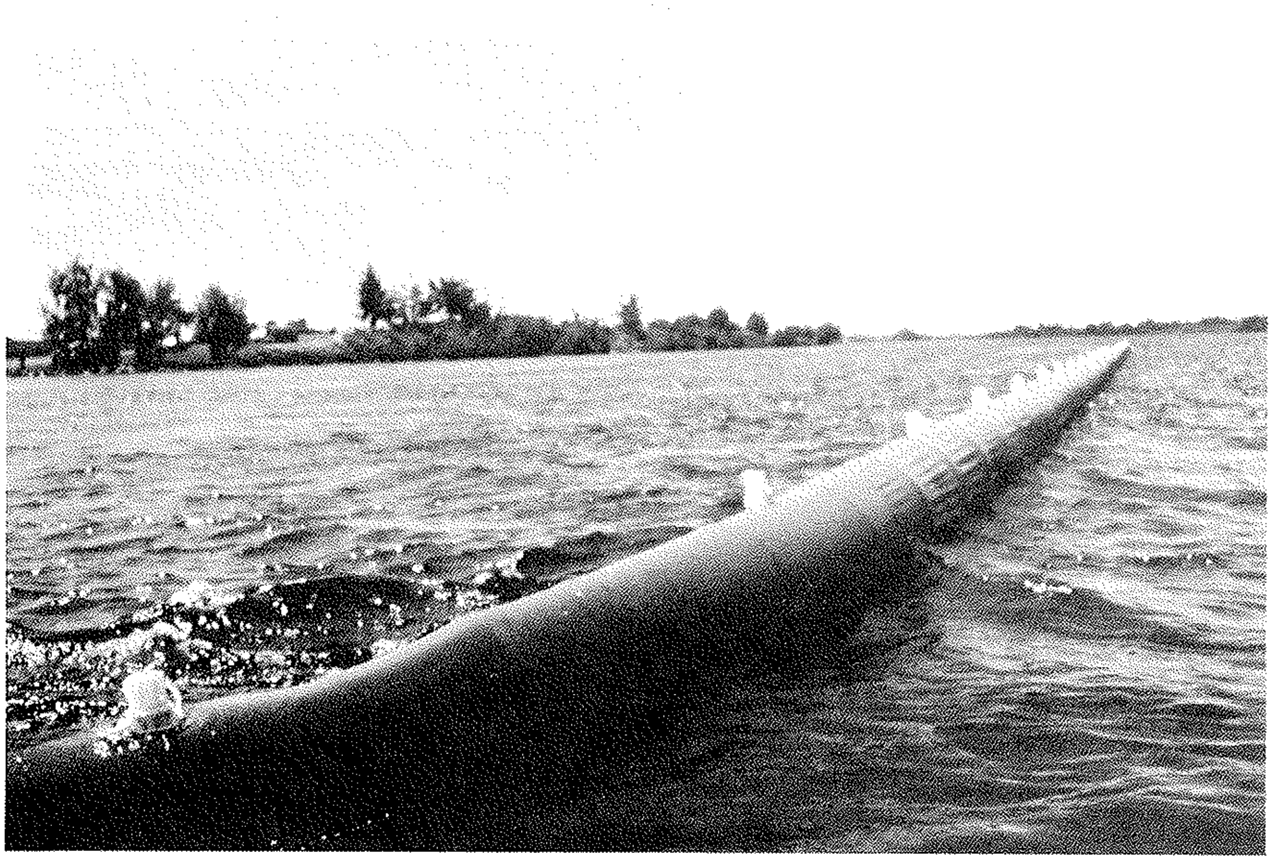
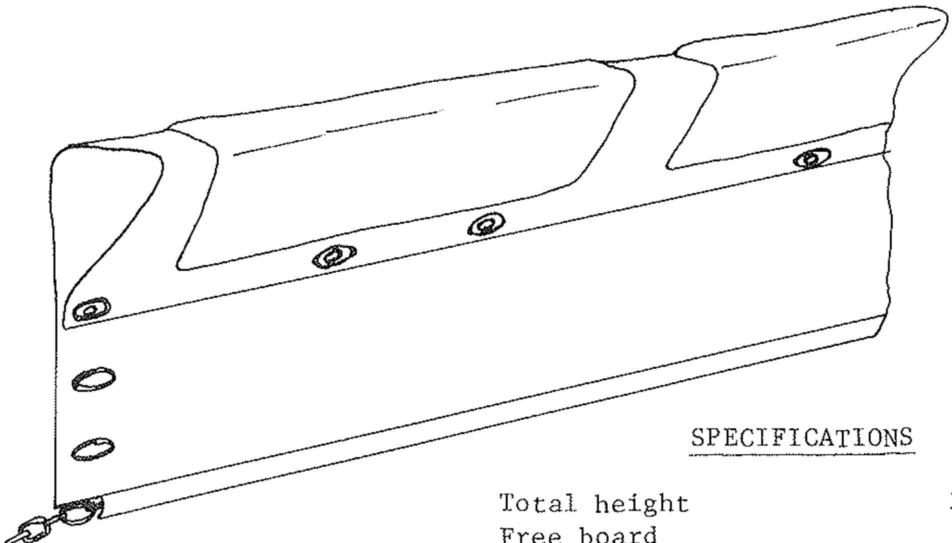


FIGURE 6 GUARD SUP 75X25 OIL BOOM

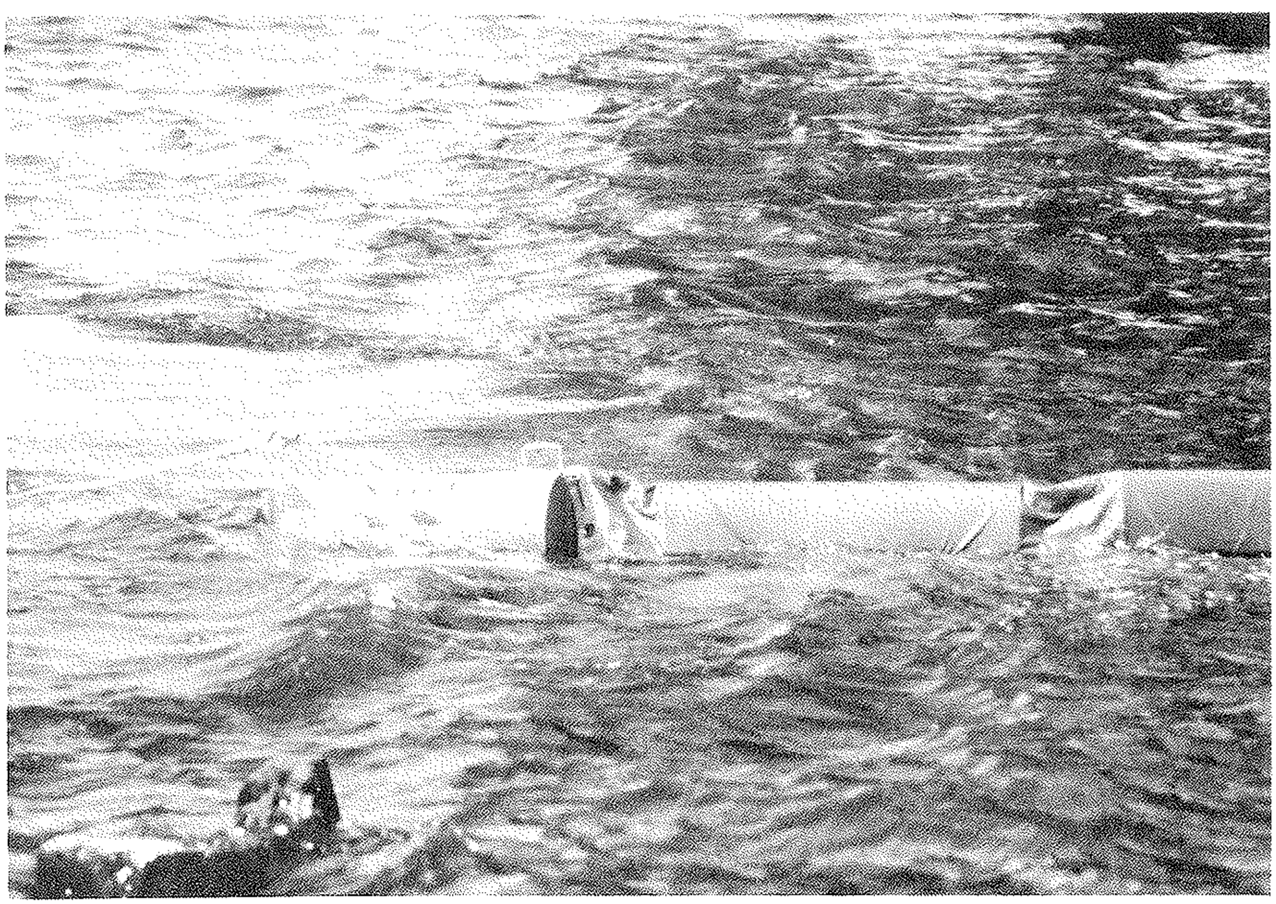


SPECIFICATIONS

Total height	30"/47"
Free board	6"
Draught	24"
Section length	82'
Weight	1.6 lb/ft.
Floatation	polyethelene
Floatation Material	polyethelene
Barrier Material	PVC coated nylon
Tension	chain - bottom
Ballast	galvanized chain
Price: June, 1978	$16.50/ft.

DISTRIBUTOR:

The Tarp Shop
1160 Barmac Drive
Weston, Ontario
(416-745-1667)



2.1.2 DEPLOYMENT PROCEDURES

Figure 7 is the schematic of a typical layout at the Lisbon beach test site. Based on the St.Clair-Detroit River study, 61M (200 ft.) lengths of barriers were considered ideal for the test for the following reasons:

1) ease of handling on shore and in water
2) obtained an optimum angle across the currents.

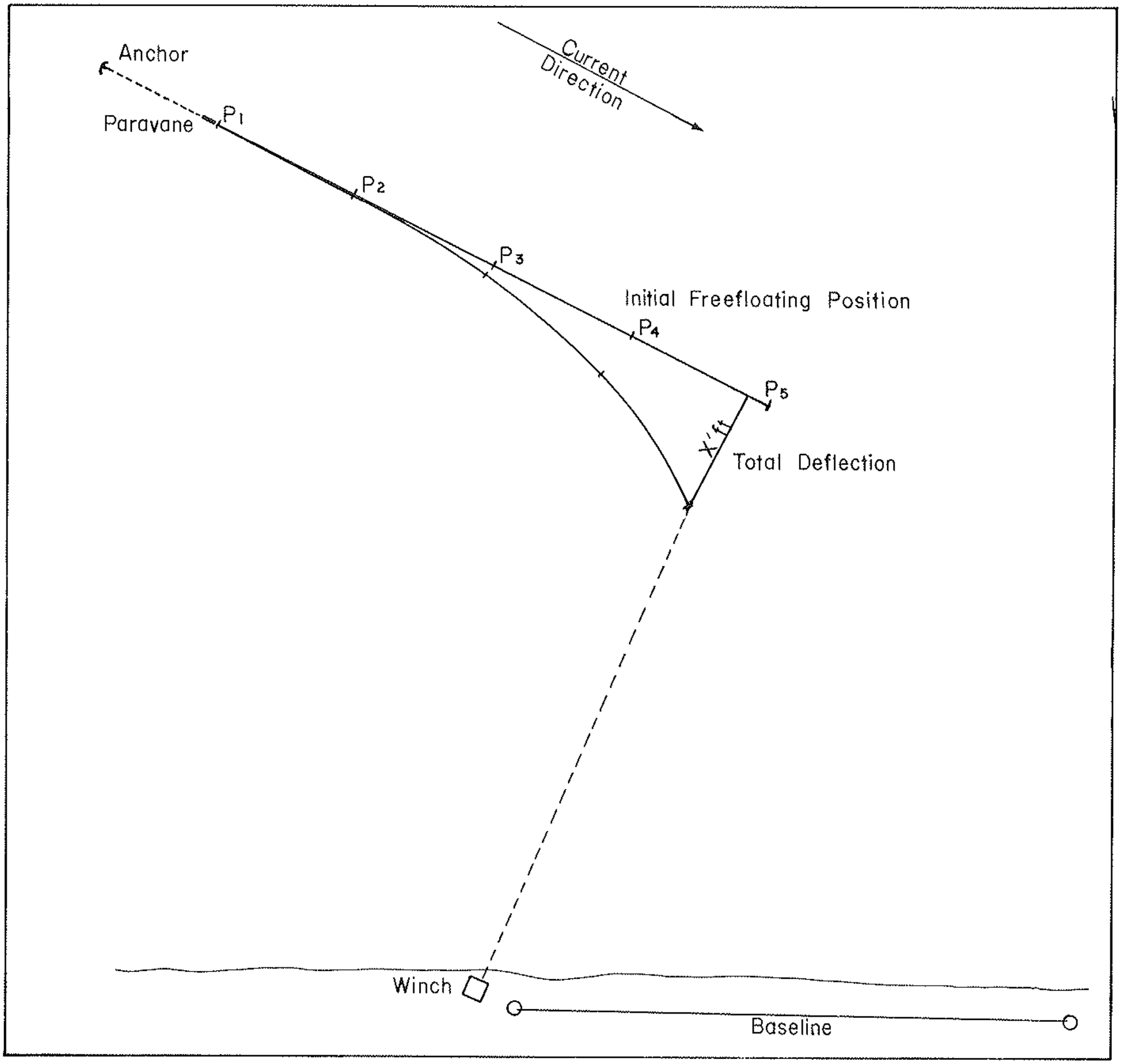


FIGURE 7. TYPICAL TEST LAYOUT

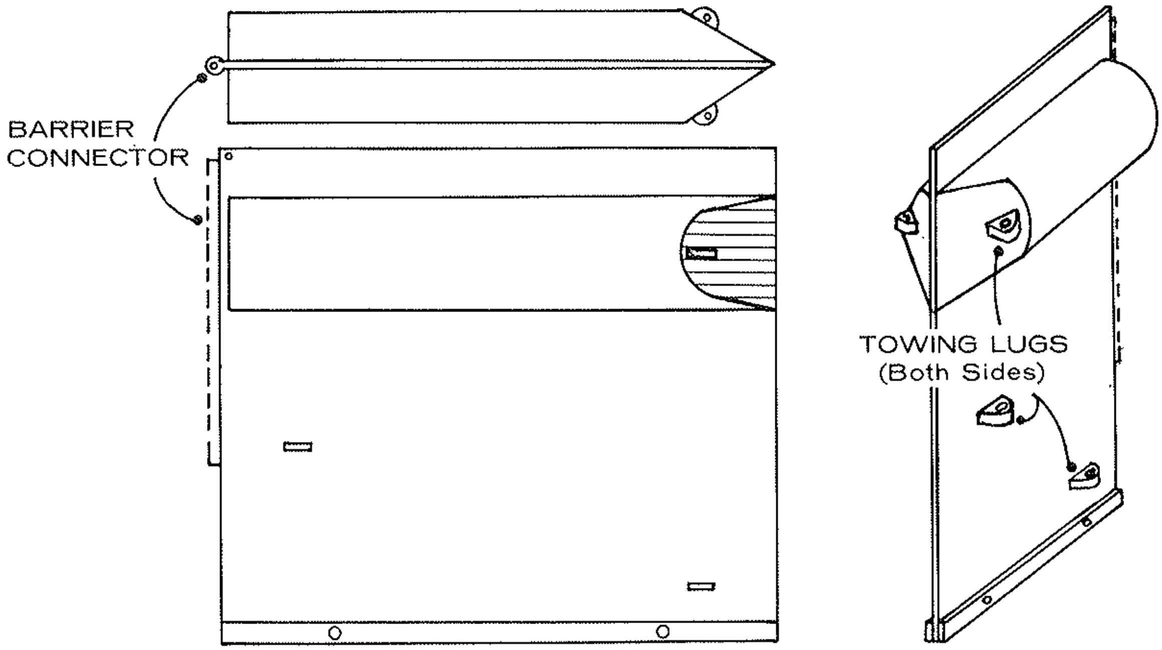


FIG. 8 - SCHEMATIC OF A PARAVANE

Paravanes such as the one shown in Figure 8, were used during the testing phase to provide additional buoyancy and stability at the upstream and downstream ends of the barrier.

Each test barrier was connected to the paravanes and anchored approximately 50m (165 ft.) offshore and was allowed to float free. The barriers initial position was plotted by triangulation using two Wilde T.1 theodolites. Sightings on the barrier were taken, and angles recorded every 7.5m (25 ft.). The configuration and the position of the barrier were then plotted.

The downstream end of the barrier was connected to a cable and was pulled towards shore in increments of 5m (15 ft.) to 10m (30 ft.). An electric winch mounted on a truck was employed for this purpose. The barrier was allowed to stabilize for 10-15 minutes each time it was pulled in an increment. The position of the barrier was plotted by triangulation. Observations and measurements were made on:-

1) current conditions
2) the ability of the barrier to remain upright along its entire length (stability)
3) the ability of the barrier to traverse the currents (deflection)
4) the ability of the barrier to deflect oil across the currents. During the Lisbon beach trials sawdust and peatmoss were used to simulate oil.

2.1.3 APPLICATION OF SAW-DUST/PEATMOSS

Saw-dust and peatmoss were used as an oil simulant to determine the deflection ability of the barrier. Each time the barrier was pulled towards shore several increments, and remained stable, an application of saw-dust or peatmoss was placed upstream of the test-barrier. Observations were made and photographs taken of the movement of the material to determine if the saw-dust/peatmoss dispersed into the water column, and if the material passed underneath the barrier.

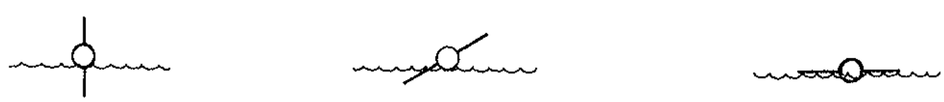
3.0 OBSERVATIONS ON BARRIER PERFORMANCE

3.1 Currents

The currents were measued using a Mead HP-302 velocity meter. Background data were collected at the Lisbon Beach test site; the currents were 1.8 to 2.1 knots on day 1 (June 20, 1978) and 1.4 to 1.7 knots on day 2 (June 21, 1978). The current vectors are shown on figure 2.

3.2 Stability

Visual observations were made on the test barrier with respect to their ability to stay upright. When the barrier remained upright 0° to vertical) it was considered to be stable and conversely if the barrier rotated about its axis (30° - 90° to vertical) it was considered to be unstable (see below).



0° to vertical   30° to vertical   90° to vertical

Figure 9, 10 and 11 summarize the observation on the angle to the vertical. All test barriers were considered to be stable. The Flexy #2 which was exposed to the highest current (2.1 knots) had a 30° angle to the vertical for the lower 6m (20 ft.) of boom.

FIGURE 9.
Configuration of FLEXY STANDARD NO. 2, 18", at Galop Island Test Site, June 19, 1978.

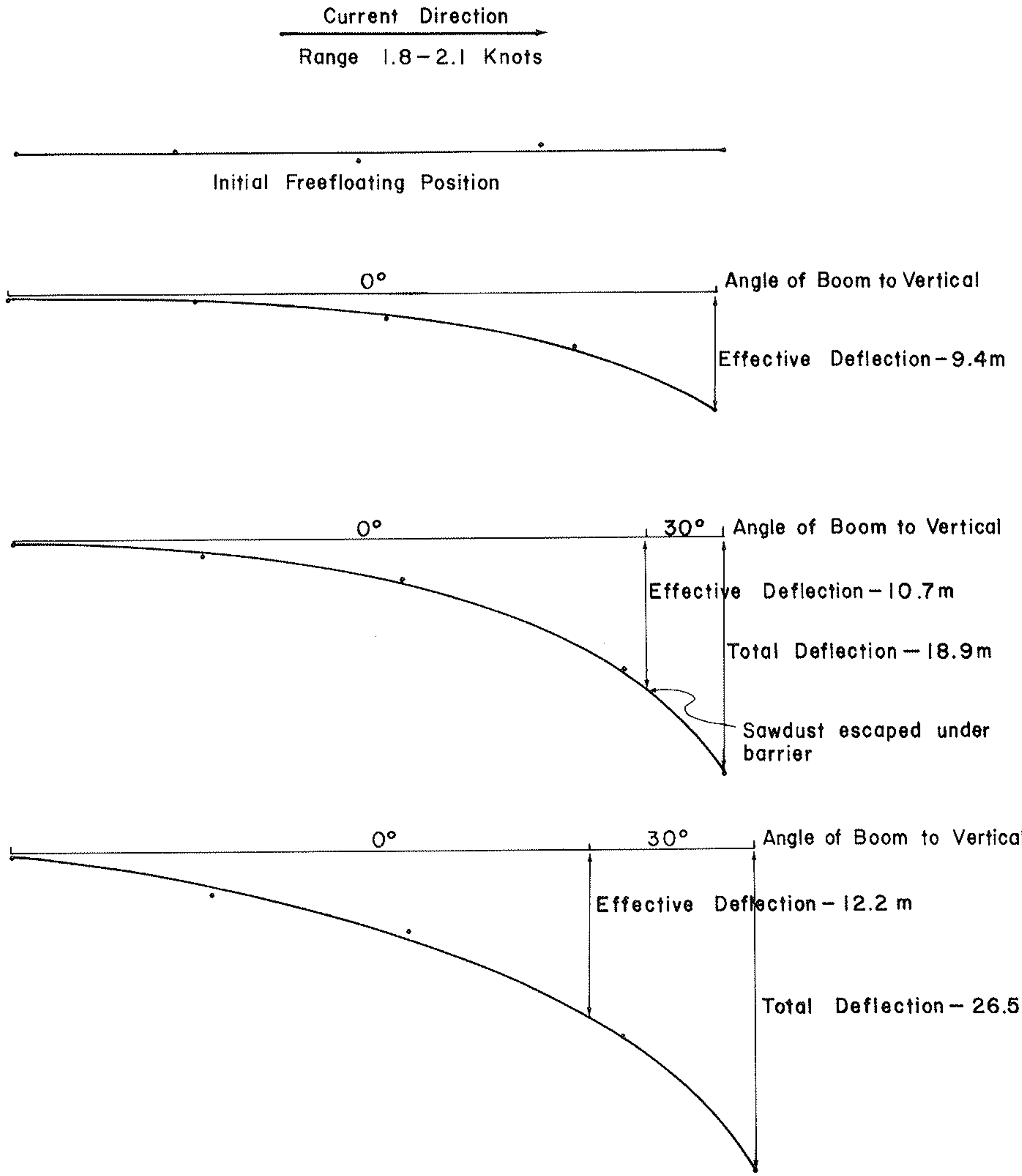


FIGURE 10.
Configuration of GUARD SUP 75X25 SUPER, at Galop Island Test Site, June 20, 1978.

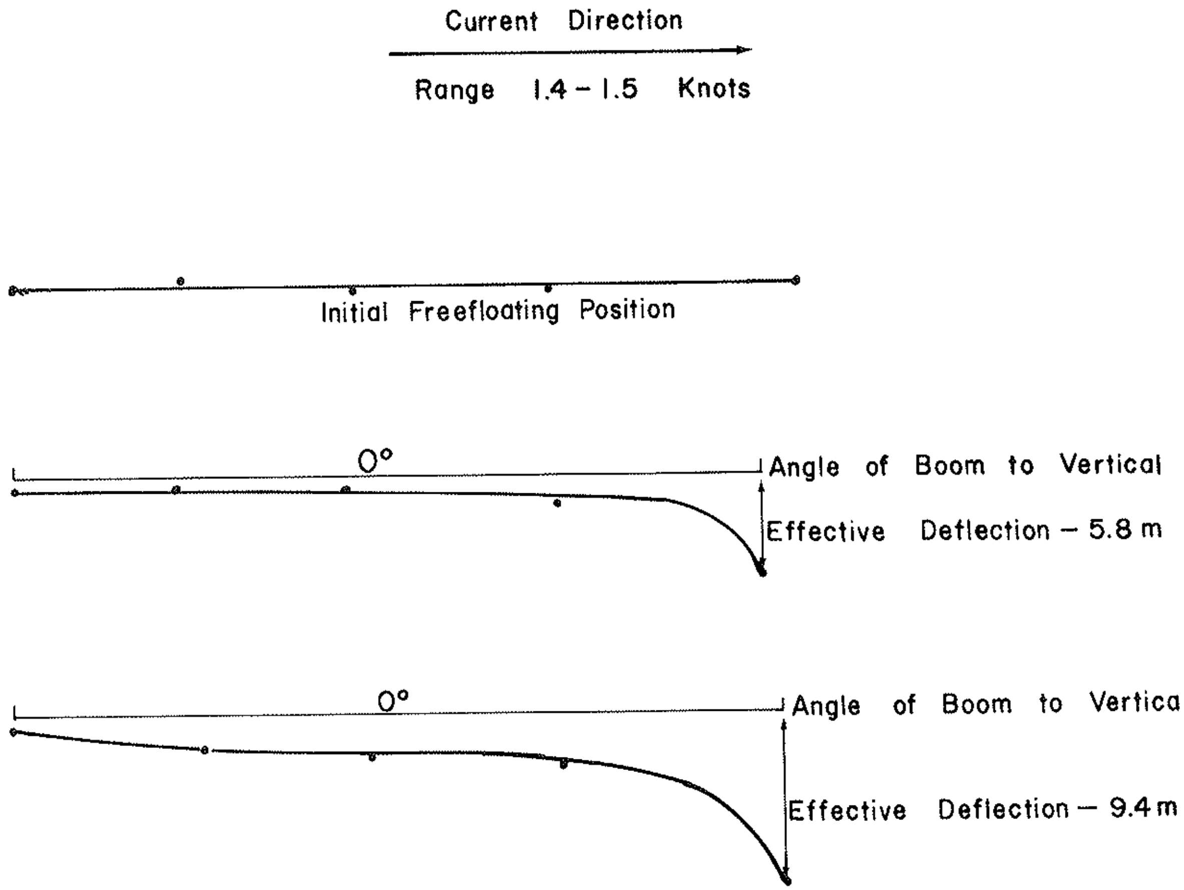
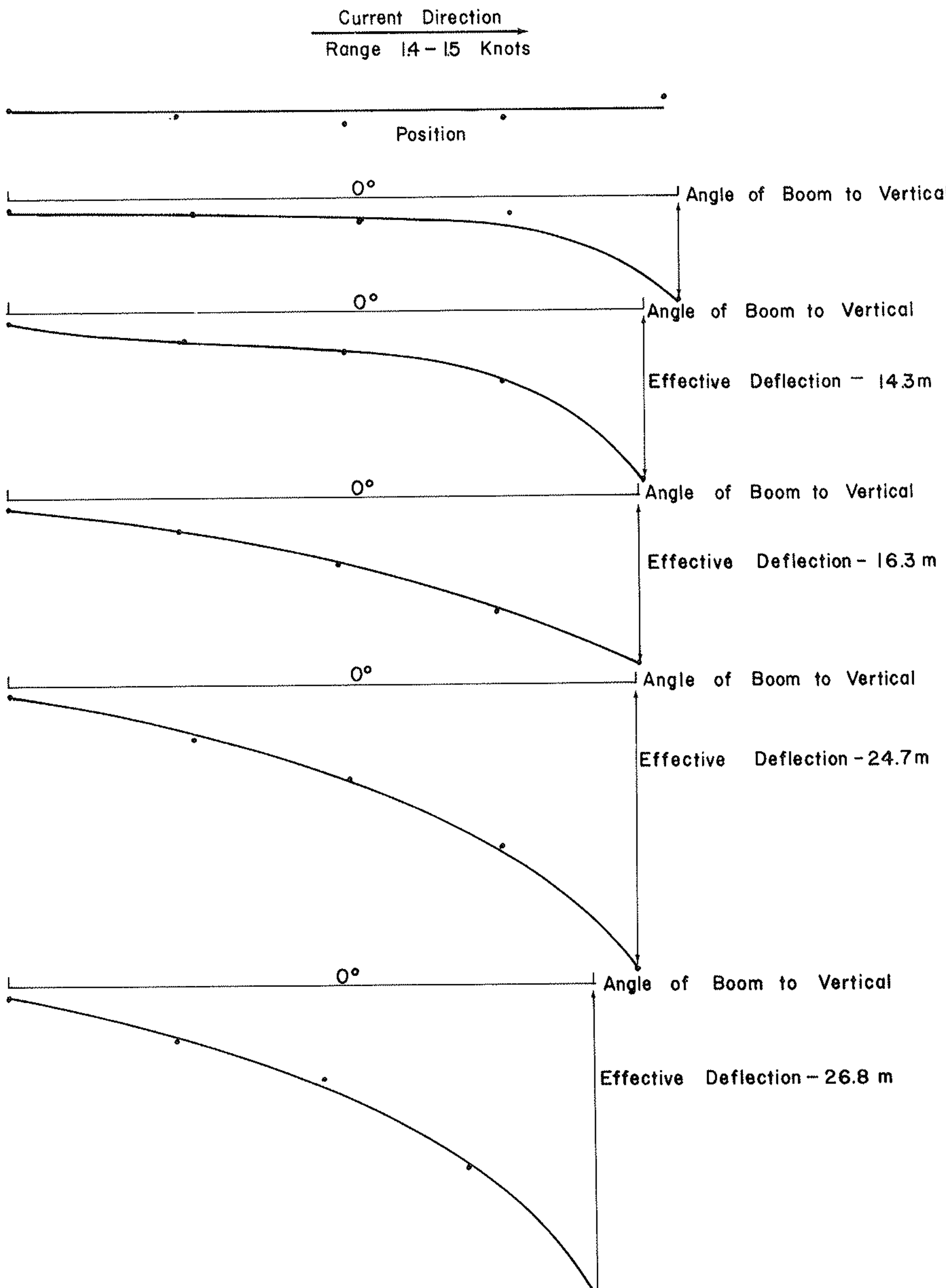


FIGURE 11.
Configuration of ZOOOM SERIES 12, 30", at Galop Island Test Site, June 20, 1978.



3.3 DEFLECTION AND EFFECTIVE DEFLECTION

The ability of a barrier to deflect a free floating slick across the current, provides an indication of the efficiency of that barrier.

The Flexy Standard #2, 18" was the first barrier to be tested and the results are summarized in figure 9. This unit was deployed at the time when the currents were the strongest (maximum 2.1 knots). A maximum deflection of 26.5m (87 ft.) was realized after the boom was pulled in 3 increments with an estimated effective deflection of 12.2m (40 ft.). Saw-dust was applied after the boom was pulled in 2 increments, and it was noted that the saw-dust escaped underneath the downstream part of the barrier which resulted in an effective deflection of 10.7m (35 ft.) (see figure 9). This performance is a marked improvement over the same unit which was tested in Sombra where it obtained a maximum deflection of 14m (50 ft.), and an effective deflection of 1.5m (5 ft.) under 1.8 knot current.

The test results for Guard SUP 75 x 25 are summarized in figure 10. Modification to the barrier was made to connect it to the paravane. After the barrier was pulled in towards shore for the second increment, a deflection of 9.4m (31 ft.) was attained and the barrier was considered to be stable (see figure 10). Subsequent attempts to pull the barrier further noted that the Guard SUP 75 x 25 barrier was approximately 45cm (18") deeper than the paravane it was connected to. The connection to the paravane was a makeshift connection, and it was felt that this may have reduced the stability of the barrier.

The ZOOOM was tested the second day of the evaluation programme under current conditions of 1.4 and 1.7 knots. This barrier performed well. A maximum of 26.8m (88 ft.) of effective deflection was realized. (See figure 11). All the peatmoss was completely deflected each time an application was placed upstream of the barrier.

4.0 SUMMARY AND CONCLUSION

There is no apparent relationship between the results of the Flexy Standard #2, 18" barrier tests at Sombra 1975, and these at Lisbon Beach 1978, with a maximum deflection of 14m (45 ft.) and 26.5m (87 ft.) respectively. It was unfortunate that the American Marine OPTIMAX boom was not at the Lisbon test site to verify the results of the Flexy Standard #2, 18" boom. It was felt that the OPTIMAX barrier would also have demonstrated an improvement at the Lisbon site.

The discrepancy also points out the need to conduct site specific tests with several barriers before selection process can be completed.

The results of the Lisbon test do confirm some of the observations made during the St.Clair-Detroit River trials with respect to:-

i) the importance of tension members and/or the ability of the fabric and the floatation collar to absorb the tensile forces acting on a barrier,
ii) the importance of reserve flotation to resist the downward pull caused by the currents, to improve the barriers stability.

All three barriers tested at Lisbon Beach contained the above mentioned characteristics.

It was unfortunate that we were unable to complete the development of operational deployment procedures for the placing of the barrier in a cascading formation. Preliminary plans are underway to conduct a mobilization at the Lisbon site later this Fall. This exercise will be conducted under the direction of the Captain of the Port of Buffalo, US Coast Guard.

5.0 ACKNOWLEDGEMENTS

It must be pointed out that completion of these field trials would not have been possible without the dedicated support of the Operation Preparedness Team. Specifically, the Canadian Coast Guard who provided most of the hardware, test equipment, vessel support and helicopter support; the US Coast Guard provided work crews and vessel support; St. Lawrence Seaway Authority assisted with additional equipment and work crews; New York State Department of Conservation and the Ontario Ministry of the Environment staff worked hard and assisted in the actual data collection.

A LETTER OF CONCERN ON CHEMICAL SPILLS

Submitted by: D.P. McCracken
Planning Officer
London-Middlesex County Emergency Planning
London, Ontario.

As a Municipal Emergency Planning Officer I (and many others) are more concerned with non-petroleum hazardous chemicals as they seem to pose the greatest immediate threat to life. The exception to this general feeling is the case of L.P.G.'s which pose a considerable threat if involved in an accident. Most of Canada is in a non-maritime environment, and the greatest threat probably comes from industrial chemicals, and the greatest spill threat is probably in the land transportation mode.

The recent incidents in the U.S.A. have taken a considerable toll in life and property, and as I am of the opinion that their industrial and transportation regulations are quite stringent, I believe the happier Canadian experience is due more to good fortune than good management.

We are aware of and encouraged by the development of the new Canadian National Code under the guidance of the C.T.C. This should improve the transportation of these goods and ensure better labels, placards and emergency information.

However there appears to be a dearth of information on this whole matter of inland spill incidents i.e., the hazards, clean-ups procedures availability of testing kits, long term effects etc. As the initial reaction to a spill incident rests with municipal (or other local forces) it is most important to have this reaction technically correct, and complete and at least ensure that it is not counterproductive. There is perhaps still a tendency in some areas to "flush away" such spills, and remove the immediate local effect. This action of course may not remove all the local threat, and in any event transfers the action down-stream as it were. The eventual result is probably a residual local hazard and a chemical contamination at the maritime system. In larger urban centres with immediate access to Environmental offices this is less likely to occur than in smaller centres, or rural areas. The P.C.B.'s in the lower Great Lakes appear to be a case in point. It is noted that the environment degrades petroleum products in some 5 to 15 years but P.C.B.'s and other man-made products appear to have a much greater resistance to natural degradation.

I feel there is a need for articles to inform municipal forces on this matter. Such articles/analysis should be in layman's language insofar as is possible. Local initial emergency response is by Fire, Police, Engineering teams. These persons are highly trained in their everyday tasks, but one cannot expect them to also have a great understanding of biology and chemistry as well.

"RED RIVER RUN"
A SPILL PREPAREDNESS EXERCISE IN MANITOBA

Submitted by: B.H. Mansfield, P.Eng.
Chief, Contingency Planning Division
Environmental Emergency Branch
Environmental Protection Service
Fisheries and Environment Canada
Place Vincent Massey
Hull, Québec

Phone: (819) 997-3800

A) Summary

A one-day field exercise for oil spill preparedness in southern Manitoba was held on September 6, 1978 near Winnipeg. This activity was a cooperative Federal/Provincial/Industry exercise of existing reporting/alerting and communications arrangements, regionally-available spill equipment and of the designated oil industry, contractor and government personnel concerned with oil spills in the area.

The exercise involved a simulated spill of 6000 barrels (252,000 U.S. gals./954 cu. metres) from a ruptured trans-provincial pipeline belonging to the fictitious "ManSask Pipeline Co. Ltd". The site of this simulated spill, and of subsequent downstream equipment deployment activities, was chosen to be representative of a realistic spill scenario in the area. This scenario involved a variety of special concerns such as sensitive biological, social and historic areas, together with potential impacts on municipal and industrial water intakes and on recreational shorelines within and downstream of a National Park. Consequently, there was a substantial requirement for on-scene coordination and for input from a large number of agencies and their representatives. Additional Government resources were placed on standby alert during the exercise, but were not called upon.

The exercise involved about ten months of planning, expenditures of nearly $10,000 and participation by approximately 100 people as players, referees or observers. A consensus of opinion expressed at the post-operation debriefing the next day indicated that the exercise had been successful in reaching its objectives of preparedness evaluation and practice. It was felt that with some minor adjustments and improvements, a satisfactory state of readiness and cooperation exists for minor and medium-sized oil spills in southern Manitoba.

A formal exercise report is to be prepared by the Exercise Red River Run planning committee.

B) Details:

1. Planning and Participants:

Planning of the exercise over a ten-month period involved many agencies and individuals. Principal among these were Capt. Chris Beckett and Mr. John Mytz of the Canadian Coast Guard (who served as Exercise Coordinator and On-Scene Commander respectively), Mr. Bill Willis of Emergency Planning Canada, Mr. Hamish Gavin of Fisheries and Environment Canada, Mr. Grant MacLeod of the Manitoba Department of Mines, Resources and Environmental Management, Mr. Jack Miller of the Manitoba Emergency Measures Organization, Mr. Bill Jarvis representing Winnipeg Pipeline Co. Ltd, as well as the oil industry's Manitoba Oil Spill Cooperative, and Mr. Tom Johnson representing Gest Ltd, the contractor who is custodian and operator of the Cooperative's spill equipment trailer.

The organizing committee's planning effort resulted in the advance issue of an exercise paper which outlined administrative details, spill scenarios, area maps, sequential operations flow charts and communications arrangements. The scenarios highlighted major event sequences and narratives, action responsibilities and taskings for operational and support groups. An outline of proposed debriefing procedures and topics was also provided in the paper.

Agencies participating in the exercise included operations, administration and advisory personnel from:

a) oil and pipeline companies in the Manitoba Oil Spill Cooperative;

b) regional coast guard, air administration and public affairs agencies of the federal Dept. of Transport;

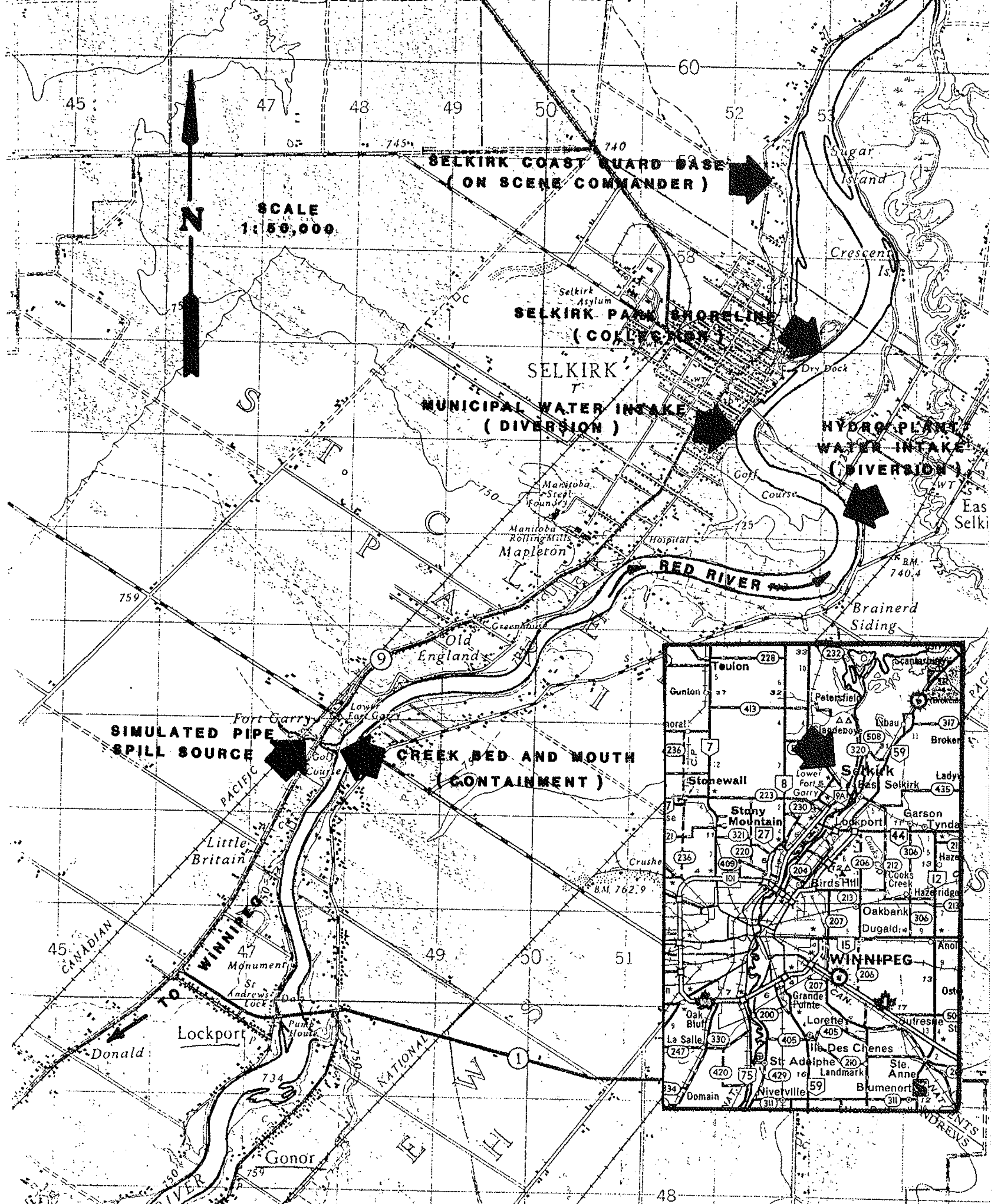
c) federal and provincial government agencies for environmental protection, resource management, and emergency measures/planning;

d) federal agencies providing water data and weather information, parks management, police and legal advisory services.

In addition to the exercise participants who were involved as players, guest observers and two four-man teams of umpires plus a coordinating referee were present. Observers included interested representatives from oil companies, municipalities, provincial and federal governments. Two representatives from the Environmental Protection Agency, Regions V and VIII which border the Red River in the U.S., were also present. The umpire teams were mixed groups of oil company and government representatives who have specific interests and experience in the conduct and evaluation of spill response operations and exercises. The assignments of the umpire teams were to observe specific field operations and evaluate the efficiency and effectiveness of these operations. The coordinating Referee accompanied the Exercise Coordinator to witness the general performance of operational activities and to evaluate the overall response capability.

FIG.1 - EXERCISE "RED RIVER RUN"

(SHOWING MAIN ACTIVITY AREAS)



2. The Site, Scenario and Field Operations:

The location of the simulated spill and the major response activities was near Selkirk, Manitoba, as shown in Figure 1. A dry creek bed which passes through Lower Fort Garry, a National Historic Park of archeological importance, was the channel identified as receiving the initial impact of the crude oil pipeline spill, and which led to eventual oil pollution problems on the Red River. Hypothetical response operations were simulated in the creek bed through motions of stopping the spill source, selecting a dam site within the creek bed in the park area, building an imaginary dam to contain remaining oil and runoff and conducting simulated skimming, storage and trucking disposal operations at this site using some equipment actually delivery to the site.

Actual field deployment of booms was carried out at four locations further downstream as shown in Figure 1. Further expected oil runoff was handled by the Spill Cooperative's Contractor crew by deploying a containment boom at the creek mouth. Hypothetical slicks at municipal and industrial water intakes were diverted by Coast Guard boom deployments in 1 knot currents at two selected sites in the Red River. A major oil containment, recovery and disposal operation was established downstream at Selkirk Park, using the industry cooperative's "OSCAR" (Oil Spill Containment and Recovery) equipment, including booms, various skimmers, pumps, hoses, boats and other ancillary equipment. Disposal was simulated through inquiries and arrangements made with truckers, refineries and land disposal authorities. Additional Coast Guard resources at Parry Sound and Thunder Bay, Ontario were placed on "Yellow Alert" status during the exercise, but were not called upon.

The entire scenario reflected a gradual escalation of the response from an initial pipeline company involvement, through an industrial spill cooperative response stage, to an eventual joint operation involving both industry and government resources under the coordination of a government Coast Guard On-Scene Commander.

The Coast Guard Base at Selkirk served as the eventual Command Headquarters, communications center and preliminary debriefing area. Supplemental communications support was provided by a mobile communications relay truck of the Manitoba Emergency Measures Organization. This agency also provides the 24/7 initial reporting and alerting network for emergencies in the province of Manitoba. In this exercise, the alerting "fanout" reached all appropriate municipal, provincial and federal agencies with the necessary information and update reports, within the necessary timeframe.

Other arrangements and support which contributed to the running, evaluation and documentation of the exercise included road traffic control by the RCMP at potential problem areas, provision of buses for observers and the media, a media center (hosted by media relations officers) and ready access for media representatives to key individuals in the exercise to assist in public relations matters, coordination assignments for details such as administrative support of the exercise and the command center, for resource coordination, for observers and the media, for medical and rescue requirements, and for liaison with Selkirk municipal officials and other interested parties. Shell's colour videotape coverage of field operations provided additional immediate information at the debriefing session to all participants and observers who were not able to witness each of the response operations. Movie coverage by a government film crew will contribute to the documentation, training and public information needs in industry/government spill preparedness, and will supplement the formal exercise report to be prepared by the Exercise Planning Committee, under the coordination of Capt. Beckett.

4) <u>Results, Conclusions and Recommendations</u>:

Total cost of the exercise has been estimated at $10,000, including some $5800 in equipment costs. Media coverage of the exercise by newspapers, television and radio was substantial, accurate, and almost entirely positive. Nearly all participants and observers appeared to be involved during the exercise and were satisfied that "Red River Run" had been worthwhile. A general consensus at the debriefing session concluded that the operation:

a) had proceeded smoothly and provided an opportunity for "hands-on" experience and exercise of assigned duties and responsibilities under a simulated emergency spill situation

b) had successfully exercised the reporting/alerting network, the communications facilities and the specialized spill equipment available in the area

c) had identified minor improvements required in equipment, communications, inter-agency coordination/support and in decision-making functions

d) subject to some small modifications in (c) above, had demonstrated a satisfactory oil spill response capability and state of preparedness for a spill of this magnitude in southern Manitoba.

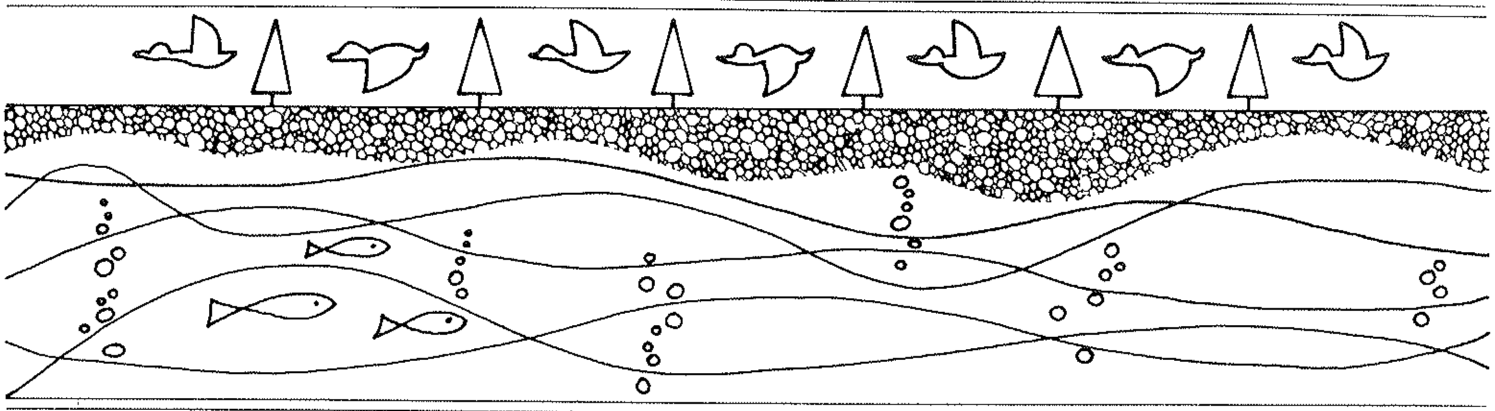
Recommendations for improvements made by the players, referees and observers at the debriefing focussed on some minor equipment additions to the OSCAR trailer (eg. wheel chocks, plywood sheets for culvert barriers, an underwater weed-cutter and mechanical brush cutter, and two portable temporary-storage tanks to supplement the existing pit liner). Questions of designated safety supervision and of refueling practices for hot engines/ generators were also raised. Improvements in preparedness to address the problems and needed arrangements for disposal of recovered oil and oiled materials were identified. It was also recognized that the exercise introduced some artificial factors that were not dealt with on this occasion, but would be handled in a real spill. This related to strong north winds which were actually overcoming current effects and which would have likely driven the oil upstream or held it above the point where the OSCAR trailer was deployed. Some agencies identified some needed improvements in internal and inter-agency alerting and information networks and communications procedures. More attention to record-keeping and logging of event sequences was suggested for better continuity and documentation/ cost purposes. The need for a further detachment of the On-Scene Commander from the operational details in order to focus more on the overview and on major decisions, suggests that the OSC needs some form of Operations Coordinator to handle these duties. Some potential legal conflicts and problems in trespass and liability were identified by the Justice observers as areas for needed future study. A recommendation was also made to involve more personnel in response operations for future exercises, to increase the value and benefits of "hands-on" training opportunities.

In summary, the exercise was a valuable experience in evaluating and improving the regional state of spill preparedness by both industry and governments. The results demonstrated the benefits of a continuous, ongoing effort in developing and exercising contingency plans, establishing channels of communication and cooperation within companies and agencies, and between agencies and governments at the regional, national and international level.

SPILL TECHNOLOGY NEWSLETTER

An informal newsletter published bi-monthly by the Environmental Emergency Branch, Environmental Protection Service, Ottawa, Canada.

VOLUME 3 (5) ISSN 0381-4459 September-October 1978



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Spill Technology Newsletter

EDITORS

Dr. S.L. Ross & Mr. M. Fingas

Research and Development Division
Environmental Emergency Branch
Environmental Impact Control Directorate
Environmental Protection Service
Department of Fisheries and The Environment
Ottawa, Ontario
K1A 1C8

Phone: (819) 997-3921

The Spill Technology Newsletter was started with modest intentions in 1976 to provide a forum in Canada for the exchange of information on oil spill countermeasures and other related matters. The interest in it was such that we now have almost 2,000 subscribers in Canada and around the world.

To broaden the scope of this newsletter, and to provide more information on industry and foreign activities in the field of oil spill control and prevention, readers are encouraged to submit articles on their work and views in this area.

INTRODUCTION

Our apologies for being so late in getting this issue to you. One of the reasons is that, as a result of a recent zero-base budgeting exercise in our Department, we have lost some efficient typists and word-processing units that were employed to prepare the newsletter. Also affected by this loss will be the publication of EEB technical reports. There will be some delays in getting these reports out to you; it is hoped, however, that once the new system (no longer within our Branch) is organized and operating at peak-level the reports will be completed and disseminated as efficiently as before.

Also, as a result of a government-wide austerity drive to reduce spending, the Arctic Marine Oilspill Program (AMOP) has been cut by about 50% for the next fiscal year which begins on April 1, 1979. The implications of this situation will be discussed in further detail in subsequent newsletters.

Now, in this issue we are fortunate in having articles from two individuals whom we have been hounding for years to contribute to the newsletter. The first is Captain Mike Garnett, who without question is the world's leading expert on major tanker oil spills. Mike, who was the on-scene-commander for the Torrey Canyon spill, has been actively involved in every major oil spill since then. His article here, which was recently presented at an API conference in the States, discusses the poor state-of-the-art in combatting the world's major oil spills. Much is to be learned from this definitive essay, especially by those, as indicated in the paper's introduction, who "do not actually attend spills, but retain responsibility".

The second individual who has finally found the time to submit a short article for the newsletter is our own Commander, Bob Beach, the manager of EEB's National Environmental Emergency Centre in Ottawa. Bob's submission discusses the various information systems used by the Branch. Thank you, Bob.

Finally, you will recall in the last issue, Dr. Mackay wrote an article on "Why Clean Up Oil Spills", and we asked for comments on it. Well we have one here, written by Dr. Eric Levy of the Bedford Institute of Oceanography, who takes exception to almost everything Dr. Mackay had to say. Again, any comments?

UPCOMING CONFERENCES

- The Banff Centre, School of the Environment has announced a series of seminars on various topics:

Environmental Implications of Northern Development.............January 7-12, 1979
Land Use Planning Workshop..February 4-10, 1979
Social Dimensions of Environmental Planning
--Seminar I at Banff, Alberta..February 25-28, 1979
--Seminar II at Cantrakon, Quebec...March 7-10, 1979
Resource Management and the Environment...........................March 25-31, 1979
Environmental Impact Assessment Workshop...........................April 16-22, 1979
2nd Canadian Conference on Public Participation...................May 2-5, 1979
2nd Annual Banff Wilderness Seminar...................................July 5-15, 1979

For further information on any of these seminars contact:

John R. Amatt, Manager
School of the Environment
The Banff Centre
P.O. Box 1020
Banff, Alberta T0L 0C0
Phone: (403) 762-3391, ext. 310
Telex: ArtsBanff 03-826657

REPORTS AND PUBLICATIONS

- The American Petroleum Institute has published a 23 page technical paper entitled "Fate and Effects of Polynuclear Aromatic Hydrocarbons in the Aquatic Environment". The paper is a review of research which has been done in various parts of the world. The paper (Publication No. 4297) is available from the Publications and Distribution Section of the American Petroleum Institute, 2101 L Street, North West, Washington, D.C., 20037, for $3.00 (U.S.) per copy.

- In February 1979, "Nautical Review" will highlight the problems of pollution giving particular emphasis to the equipment that is currently available to combat major disasters. For further information contact Alan Gondron at: Advertisement Department, Lloyd's of London Press Limited, Sheepen Place, Colchester, Essex, C03 3LP, England; Telex 987321 Lloyd's G.

- Applied Science Publishers of London has recently released the report, "Developments in Biodegradation of Hydrocarbons - 1". The book is priced at 16.00 pounds.

- The Canadian Petroleum Association has published a "Study into the Reclamation of Five Oil Spills in Alberta". The report is available in very limited quantities, however, a field manual on this topic of land restoration after an oil spill will be published next year. For further information contact: The Canadian Petroleum Association, 1500 6300-6th Avenue, South West, Calgary, Alberta, T2P 2Y5.

- The Environmental Emergency Branch has released two new publications: the titles and abstracts of which appear below. These publications may be obtained upon request from:

Publications Coordinator,
Environmental Impact Control Directorate,
Environmental Protection Service,
Ottawa, Ontario.
K1A 1C8.

Selection Criteria and Laboratory Evaluation of Oil Spill Sorbents: An Update (EPS 4-EC-78-8)

Twenty-one oil spill sorbents were laboratory tested via immersion in three different petroleum products aged for one and seven days.

The synthetic sorbents generally exhibited higher initial and maximum capacities with foam synthetics having the highest capacities. Potential reuse was also much greater for the synthetics than for other sorbents.

During a 48-hour immersion test, the particulates and fibres exhibited the least change, the foams some structural weakening, and fibrous mats the most apparent alteration.

Several synthetic sorbents reacted with the diesel oil, changing from discrete particles to a homogeneous immiscible layer at the oil/water interface.

A statistical anaylsis shows that there is no significant difference between initial and maximum capacities for most sorbents. There is, however, a significant decrease in sorption capacity with the reduction of the oil layer thickness from 2.5 mm (diesel) and 5 mm (crude) to 0.1 mm for both oils, as well as a concurrent increase in water pickup.

The Impact and Cleanup of Oil Spills On Canadian Shorelines: A Summary (EPS 6-EC-78-1)

The structure of Canadian shorelines is described in terms of 10 basic types: rock surfaces, cliffs, coarse sediment beaches, sand beaches, intertidal coarse sediments, intertidal sand, intertidal mud, marshes, backshore areas and man-made structures. The expected impact of oil and cleanup strategies for each type of shoreline are presented.

● The following reports are available from the U.S. Department of Commerce, National Technical Information Service, Springfield, Virginia, 22161, telephone (703) 321-8543. Most reports are also available on Microfiche at $3.00 each (U.S.A. Price). Canadian buyers add $2.50 to each paper copy and $1.50 for each microfiche report.

"The AMOCO CADIZ Oil Spill. A Preliminary Scientific Report." W.N. Hess, NOAA, Boulder, Colorado. April, 1978. 355 p. PB-285 805/8SL $12.50.

"Mechanical Dispersal of Oil Stranded in the Littoral Zone." E.H. Owens, Louisiana State University, Baton Rouge. February, 1978. 14 p. AD-A058 187/6SL $4.00

"Marine Accident Report - Grounding of M/V Dauntless Colocotronis in Mississippi River Near New Orleans, Louisiana on July 22, 1977." National Transportation Safety Board, Washington, D.C., July, 1978. 25 p. PB-284 333/2SL $4.00

"Crisis Science: Investigations in Response to the Argo merchant Oil Spill." A.M. Pollack and K.D. Stolzenbach, Massachusetts Institute of Technology, Cambridge. June, 1978. 330 p. PB-285 646/6SL $12.00

"The Behaviour of Centrifugal Pumps Operating with Heavy Oils." K. Pantell, Southhampton University, England. November, 1977. 25 p. N 78-29450/1SL $4.00

"Managing Oil and Gas Activities in Coastal Environments." W.L. Longley, R. Jackson and B. Snyder, RPC Incorporated, Austin, Texas. June, 1978. 75 p. PB-283 677/3SL $5.25

"OHMSETT 'High Seas' Performance Testing: Marco Class V Oil Skimmer." G.F. Smith and W.E. McCracken, Mason and Hanger-Silas Mason Company, Incorporated, Leonardo, New Jersey. May, 1978. 49 p. PB-283 390/3SL $4.50

"Oil Pollution Control Mechanisms. Statues and Regulations." Mississippi-Alabama Sea Grant Consortium, Ocean Springs, Mississippi. April, 1978. 74 p. PB-284 737/4SL $5.25

"The Biological Effects of the Water-Soluble Fractions of a Number 2 Fuel Oil on the Plankton Shrimp, 'Lucifer Faxoni'." W.Y. Lee, K. Winters and J.A.C. Nicol, Texas University, Austin. 19 p. PB-283 319/2SL $4.00

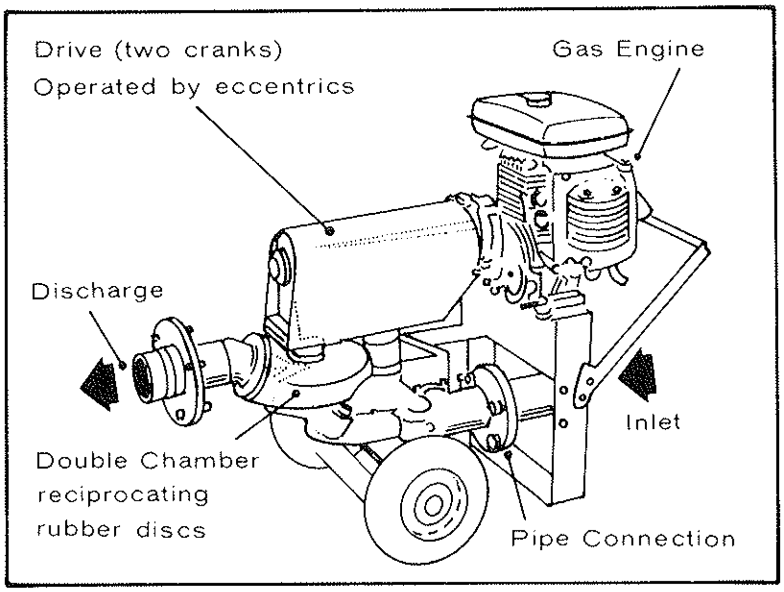
"Report of Study of Tanker Safety and Pollution Prevention Requirements for United States Tankers in Domestic Trade." Office of Merchant Marine Safety, United States Coast Guard, Washington, D.C. June, 1978. 196 p. AD-A057 607/4SL

"Environmental Assessment of an Active Oil Field in the Northwestern Gulf of Mexico, 1976-1977." W.B. Jackson, National Marine Fisheries Service, Galveston, Texas. December, 1977. 756 p. PB-283 890/2SL $21.50

"Oil Spill Removal Techniques and Equipment. Volume 2. 1976 - July 1978 (A Bibliography with Abstracts)." M.F. Smith, National Technical Information Service, Springfield, Virginia. September, 1978. 84 p. NTIS/PS-78/0960/1SL $25.00

"Chemical Immobilization, Baseline Hematological Parameters and Oil Contamination in the Sea Otter." T.D. Williams, Pacific Grove, California. August, 1978. 33 p. PB-283 969/4SL $4.50

NEW PRODUCTS



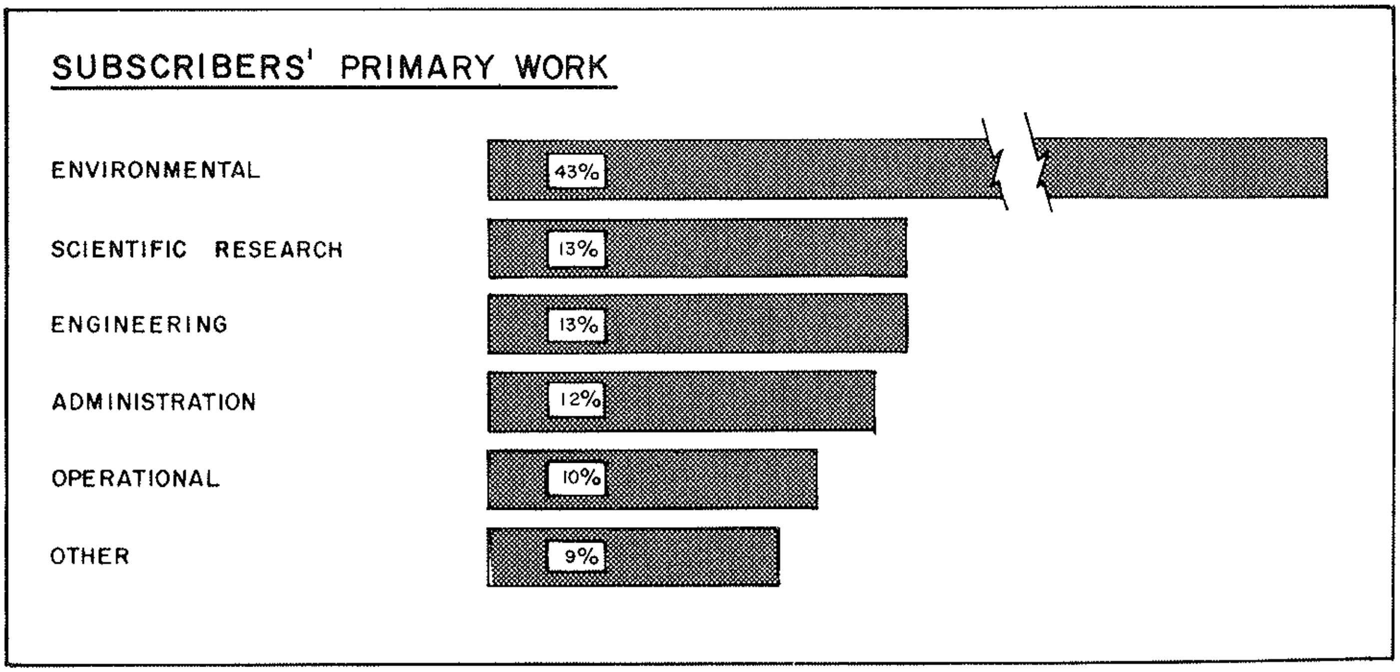
KOMLINE-SANDERSON Dualdisc Pump

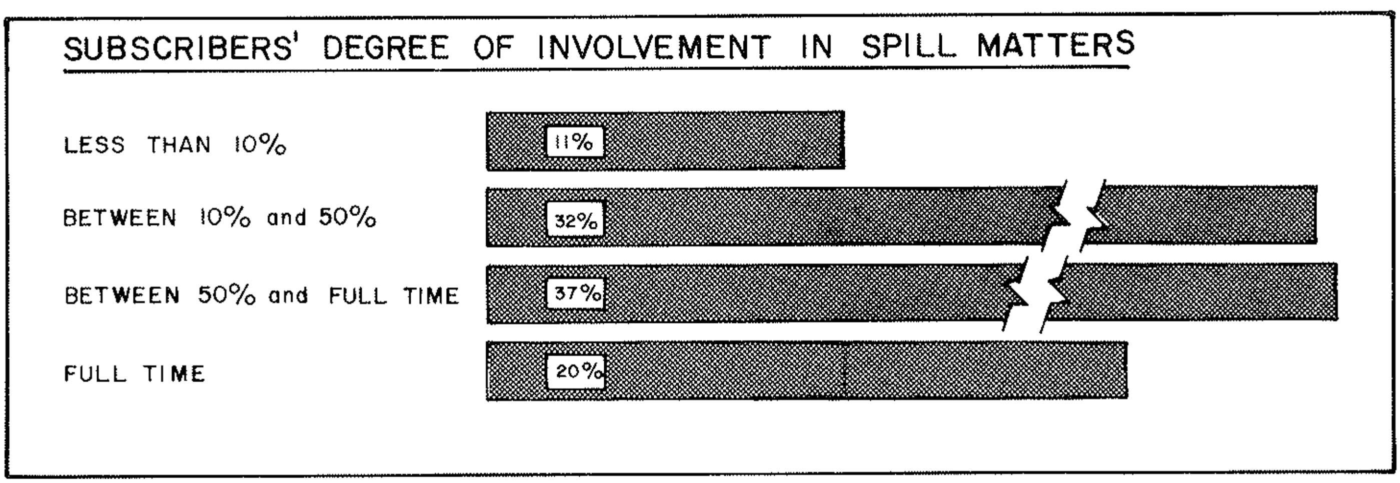
Komline-Sanderson has recently introduced a new pump which appears to have application for moving oil. The pump known as the "Dual disc" uses two flexible discs working in opposition to each other to create suction, discharge, and induced flow action. The pump can pump slurries and up to ½ inch solids, and is self-priming. For further information contact: Komline-Sanderson, Brampton, Ontario, L6W 1W1, or phone (416) 453-5330.

ANALYSIS OF THE SPILL TECHNOLOGY NEWSLETTER READERSHIP

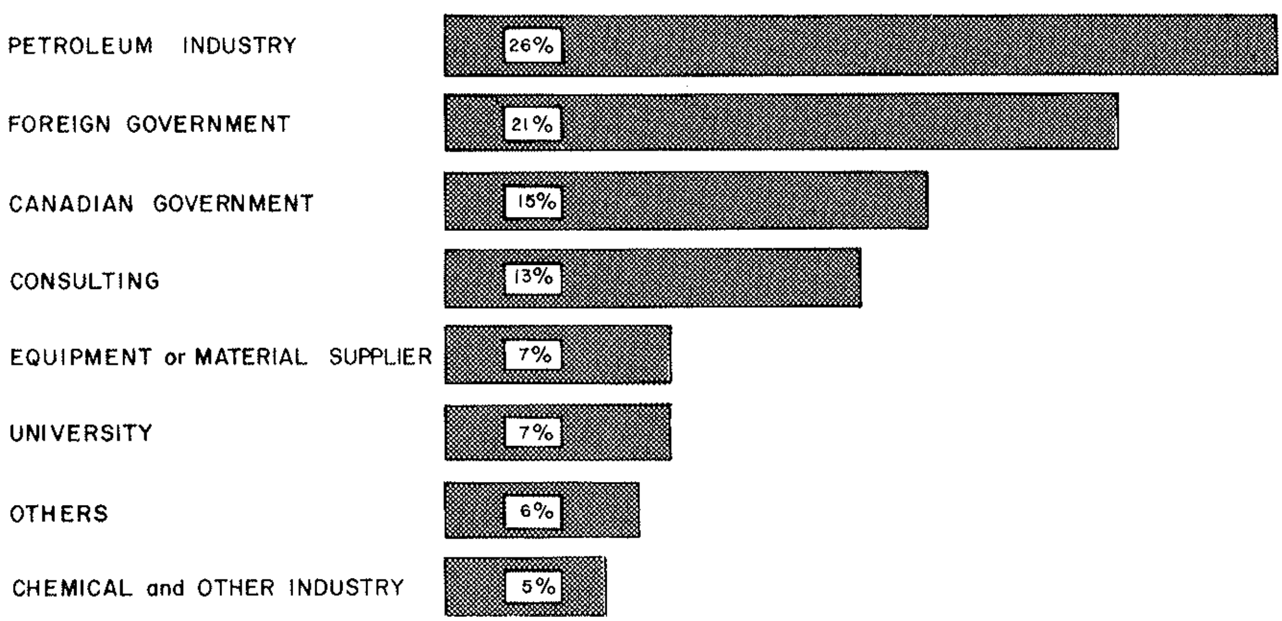
Submitted by: M.F. Fingas
Co-Editor Spill Technology Newsletter

We attached a questionnaire to the May-June issue of the Newsletter and have analyzed those which were completed and returned. The most significant result to us was the circulation of each copy of the Newsletter: An average of 4.6 readers per copy. The rating of various sections of the Newsletter indicated that most individuals found every section useful or moderately useful. The section dealing with length of articles, frequency of issue, etc. indicated that, on balance, most respondents felt that these items were "OK". The bar graphs which appear below summarize the results of the remainder of the questionnaire.

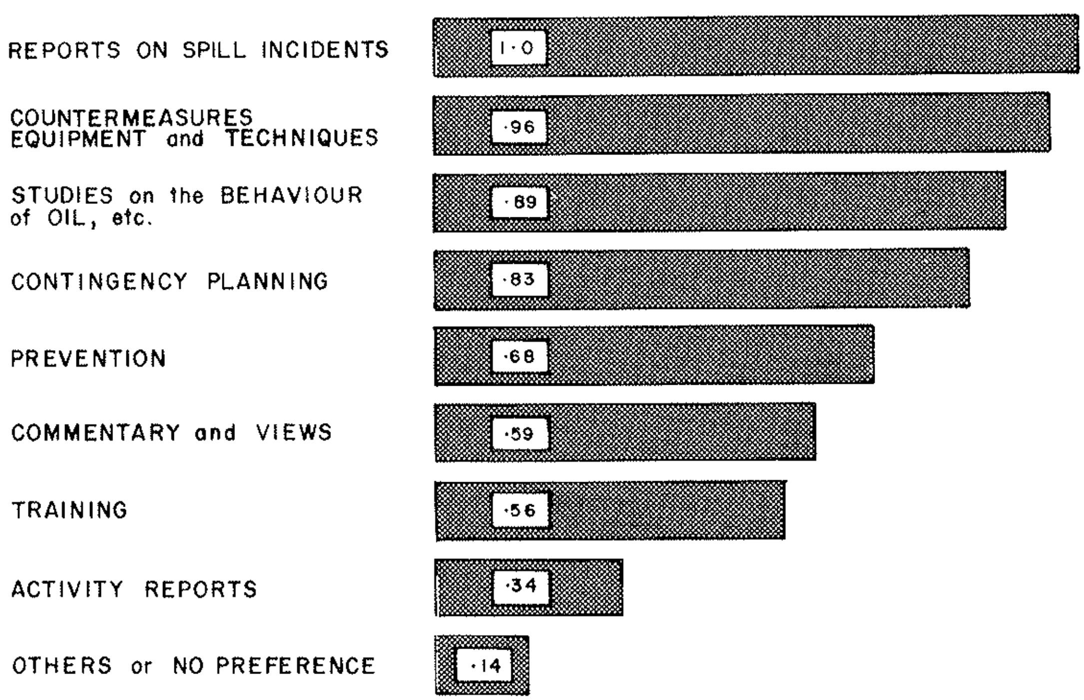




SUBSCRIBER EMPLOYMENT BY SECTOR



RELATIVE PREFERENCE for VARIOUS TYPES of ARTICLES



AMOP EXPERIMENTAL OIL SPILL PLANNING UPDATE

Submitted by: D.E. Thornton
Research and Development Division
Environmental Emergency Branch
Environmental Protection Service
Environment Canada
804, 9942 - 108 Street
Edmonton, Alberta
T5K 2J5

Telephone: (403) 425-6932

It was reported in the last two editions of this Newsletter, Volumes (3) 3-4, that a planning exercise is underway to identify studies requiring the discharge of oil in an Arctic or sub-Arctic marine environment. Both articles included an invitation for readers to submit study suggestions. In addition, a similar invitation has been directly distributed in Canada and abroad to over 250 persons active in the Arctic or oilspill field.

An Experimental Oilspill Planning Committee has been formed to develop an integrated program comprising the studies of highest priority from an oilspill countermeasures viewpoint.

So far, over seventy responses have been received from people and groups not represented on the Committee, and two comittee meetings have been held. As a result of the second meeting, a very preliminary draft of the program design is nearing completion.

The draft document includes a very brief background regarding the oilspill threat in the Arctic, the study selection criteria, and general experimental design considerations. The main body of the document consists of draft project descriptions for the five high-priority (core) studies identified by the Planning Committee. Each project description includes an objective, background, rationale, draft experimental requirements, a listing of studies necessary prior to initiation of the field discharges, and a summary of secondary studies which could be integrated with the core projects with little or no environmental penalty.

A very brief summary of the core projects follows. In each case, the project title indicates the main thrust(s) of the study.

1. Oil and Gas Under Beaufort Sea Ice: Behaviour, Fate and Countermeasures (Burning)

Phase 1 (Spring, 1980): This first phase is primarily scientific and involves the discharge of 0.3 - 1 m^3 (about 2 to 6 barrels) of oil in low concentrations (initial average thickness of about 1 mm) onto the surface of melt pools on landfast ice a few miles offshore in the Beaufort Sea. The primary purpose is to examine oil concentrating mechanisms such as wind or current herding and other natural processes, and to evaluate prototype incendiary aids deployed from the ice surface.

Phase 2 (Spring, 1981): The second phase requires the discharge of 2 - 6 m^3 (about 10 - 40 barrels) of oil (and gas, in a realistic volume ratio for blowouts) beneath landfast ice.

After the oil has surfaced, the primary objective is to deploy and evaluate incendiary aids, mostly from aircraft, under as realistic conditions as possible. An important additional objective is to verify laboratory results on the behaviour of oil and gas discharged under simulated sea ice.

2. Oil in East Coast Pack Ice: Behaviour, Fate and Countermeasures

Phase 1 (Feb. - May, 1980): The first phase is largely exploratory, and involves the discharge of a total of 2 - 6 m^3 (about 10 - 40 barrels) of oil in low concentrations (average thicknesses of oil 0.1 - 0.5 mm) under a variety of conditions in the pack ice in Davis Strait or the Labrador Sea. A vessel will be used as an operating base in the pack ice. The primary objective is to examine small-scale, short-term processes such as oil entrainment into ice edges, emulsion formation, migration of oil through porous ice, etc.

Phase 2 (Feb. - May, 1981, at the earliest): Contingent upon the results obtained during the first phase, a larger volume of oil will be released, perhaps 25 - 65 m^3 (about 150 -400 bbl.), to examine relatively long-term, large-scale processes such as spreading amongst the pack and release of oil from melting ice near the pack edge. Countermeasures techniques currently under development (mechanical equipment, aerial application of dispersants, *in situ* burning) would also be tested on parts of the oil discharge.

3. Oil on Arctic Shorelines: Behaviour, Fate and Countermeasures (Spring 1980 - 82).

It is proposed to discharge 10 - 20 m^3 (about 50 - 100 bbl) of oil probably on the east coast in a test bay with a variety of shoreline types present (high priority will be given to sand, gravel and cobble beaches, mudflats and rocky shorelines). In addition to monitoring the fate of oil on the shoreline, promising cleanup and protection techniques requiring minimal logistical support will be evaluated. The techniques will be selected from a variety being examined in a quasi-laboratory study which is currently underway.

4. Oil on Cold Water: Countermeasures (Summer 1979 - Summer 1981)

A controlled evaluation of the performance of selected mechanical devices is planned for cold water and cold weather conditions. The equipment will include a variety of skimmers and booms currently under development by AMOP, and the associated support systems. The studies will also include an evaluation of the effectiveness of dispersants selected after the completion of ongoing laboratory testing. A series of discharges is contemplated, each involving 2 - 10 m^3 (about 10 - 50 bbl.) of oil.

5. Oil in Arctic nearshore Environments: Fate, Effects and Countermeasures (Summer 1979 - 1982)

An attempt will be made to select three similar bays, probably on the east coast, which have a fairly low energy wave environment, and which have a high biological productivity. Prior to any oil discharges, one year of baseline information will be obtained for each bay. One bay will remain uncontaminated and serve as a control, and the other two will each be contaminated by 10 - 20 m^3 (about 50 - 100 bbl.) of oil. Dispersants will be used in one of the two contaminated bays. A comprehensive chemical and biological sampling program will be followed for at least the subsequent three years.

Two additional, lower-priority studies on simulated subsea oilwell blowouts received some support from the committee - one relating to the fate and behaviour of oil from blowouts in deepwater (greater than about 200 m); and another regarding the assessment of on-site countermeasures for blowouts in shallow water.

In the middle of December the draft program design, and summaries of it, will be circulated to interested parties and feedback solicited. During the following few months, attempts will be made to further identify groups or agencies interested in participating in such a program and to define their potential involvement.

A final report, including the overall program design, is scheduled for completion by the end of February, 1979. Thereafter, sites will be selected and very detailed experimental designs will be prepared for the program components which receive financial support. At that stage, the core projects will be submitted individually to the regulatory bodies for the formal review and approval process.

A REPLY TO "WHY CLEAN UP OIL SPILLS?"

Submitted by: E.M. Levy
Chemical Oceanography Division
Atlantic Oceanographic Laboratory
Bedford Institute of Oceanography
Dartmouth, Nova Scotia B2Y 4A2

Editors Note: This article was submitted as a response to the article "Why Clean Up Oil Spills?" which appeared in the July-August issue of this newsletter.

Occasionally an article is published for apparently no other reason than to generate some interest in a Journal or to "stimulate" the reader either by putting forth an argument which raises a variety of questions but does not answer them, or in which an extreme position is taken on some controversial issue without having adequate data to support this stance and at the same time deliverately ignoring existing data which support a contrary position. Such dissertations deserve only a quick perusal, at most, and the scientific community is perhaps best served by taking no further notice of them. Whereas I usually successfully resist the urge to respond to such papers, a recent article by D. MacKay "Why Clean Up Oil Spills?" has provoked (stimulated, if you prefer) me sufficiently to draw attention to the fallacies of some of his arguments pertaining to spills in "remote areas such as the Arctic when there is no obvious economic damage".

1) No one would consider if "oil costs $15 per barrel and clean-up can cost $1000 a barrel", that clean-up would be a paying venture. The same argument could go as follows: Since the soil that might be recovered is not worth the price of the soap at existing prices, it is not worth washing one's socks. This superficial economic equation is a gross oversimplification of the oil spill/clean-up situation because it has neglected the most important factors. "Economic penalty" enters the equation and even this factor is only one of the many considerations (and probably not the overriding one) in deciding whether to clean up a spill (or if, or when, to wash one's socks). "Elementary economics", as MacKay has applied them to the oil clean-up problem do not take into account the social, environmental, asthetic and other aspects of the problem. While it might seem economically sensible to give the $12 million spent on the Beaufort Sea Project and the EAMES and AMOP funds directly to the fisherman, if the Canadian Federal Government were to adopt this philosophy, there would be no investment in programs with small immediate but potential long-term return, no effort at job creation, etc. Should production of oil in these areas become a reality the resources invested in these programs will prove to be a trifle if even a single massive clean-up problem is avoided by having conducted the environmental studies beforehand.

If an economic agrument is to be made, it should be based on the costs of prevention rather than clean-up or the intrinsic value of the oil. It is difficult to imagine a situation where the adage "an ounce of prevention is worth a pound of cure" applies more than to the oil spill prevention/clean-up problem.

2) Ecological disturbance. This is a subject on which there is an abundant literature. The statements,

> "Most evidence suggests that oil spills have a localized disruptive effect which lasts a few days or weeks in the water column, and possibly a few years in marine sediments or shores. The ecosystem probably restores fairly rapidly and no irreversible changes are evident."

are not only a gross injustice to the existing body of knowledge on the subject of oil spills but are a misrepresentation of the facts.

Whereas the literature is not free from conflicting information, it is fair to say that the evidence not only "suggests" that oil spills have a "disruptive effect", this has been clearly demonstrated. Further, while what is meant by such vague terms as "a few days", "a few years" and "fairly rapidly" could be the subject of prolonged debate, recovery takes much longer than implied by these statements. Indeed, the recovery potential of oiled northern environments was specifically addressed by a recent symposium* and while there is no doubt that recovery does take place the rate at which it occurs is dependent upon many factors, the prime one being the energy condition of the environment. Complete recovery, whether defined as restoration of conditions that existed before the spill or the return to a condition identical to that of an equivalent but un-oiled environment, takes several years, possibly decades, if it occurs at all. Based on follow-up studies on the effects of the Torrey Canyon spill, the West Falmouth and other spills, the general concensus was that recovery time is something in excess of 15 years. Therefore, MacKay's comment that "the ecosystem probably restores fairly rapidly" is true if he means on a geological time scale but if, as stated in his previous sentence, "fairly rapidly" means only a few days, weeks or years his statement is clearly in conflict with existing data.

Should we be concerned about changes to ecosystems by careless handling of oil, when what appear to be comparatively minor oil-induced changes are super-imposed upon much larger ones which have already occurred from unwise land management, etc.? We might equally logically (or illogically) argue that since the number of people killed in the careless use of automobiles is insignificant compared to the numbers that have already fallen victim of famine, bacterial infections, wars, etc. over the course of history that we need not be concerned about automobile safety. If, as the author states, our only concern over endangered species is to preserve them so future generations of humans can see them, then it would obviously be much more appropriate to collect as many of these creatures as possible and place them in museums as soon as possible. Just think what wonderful collections of extinct creatures would now exist for our enjoyment if prehistoric man had had such foresight! To state that a small number of certain species of animal "must play a minor or even negligible part in the functioning of the whole ecosystems because their low numbers dictate a small influence" demonstrates the author's lack of understanding of ecosystems. We need only to consider the importance of small numbers of predators which keep herbivores in balance with their environment and what happens when this balance is disrupted by eliminating the predators to appreciate the fallacy of this argument. A species which is few in numbers but widely dispersed is in a less precarious situation insofar as oil pollution is concerned than one such as the Thick-billed Murres which are in very densely populated colonies during the nesting season.

* Journal of Fisheries Research Board of Canada, Special Issue, Volume 5, May, 1978.

4) It is true that the oil-soaked bird "beloved of T.V. documentaries is a tragic sight". So is the seabird that has been soiled with an amount of oil which is hardly apparent on a casual inspection but which is nevertheless sufficient to lead to the bird's slow and painful death by exposure and/or starvation under winter conditions. These victims of oil are certainly much more pitiful than the former which has at least had the benefit of a comparatively quick demise. Further, we have not even the crudest estimate of the numbers of birds so affected and which perish unnoticed at sea. Therefore, such a direct and forceful statement as "deaths from oil spills are few compared to organized death from fishing or hunting" is meaningless without statistical data to support it.

5) "Should we be concerned about a remote Arctic area?" Of course! Should a spill there be cleaned up? This is a much more difficult question and there may not be an obvious answer. In some instances it might be advisable to leave the oil to natural cleaning processes if there appears to be sufficient energy available to carry out the cleaning in an acceptable period of time, in some cases it might be necessary to disperse floating oil to protect colonies or even entire populations of seabirds, in other situations clean-up with absorbents, burning or even manual pick-up as was used in France might be the best approach. A best guess can only be made after considering as many as possible of the relevant factors, and each incident must be considered on its own. In all cases the Native people must be considered and I would hope that they would be given every opportunity to contribute to the decision-making process. After all it's their backyard!

The author's concern that the CBC might not have given equal time to "unsightly smoldering town dumps swarming with vermin and insects" should be addressed to the CBC or the CRTC. This is a completely different problem and is irrelevant to the oil spill debate.

6) That the Inuit and Indians epitomised a conserving lifestyle for many centuries is a pure myth. In actual fact, they exploited their environment and its resources to the maximum extent they could (and still do) within the limits of the technology available to them. With the white-man's technology (firearms, snow-mobiles, communications, permanent housing, etc.) and social programs (food, medicine, etc.) mass death from starvation, exposure and disease has become a thing of the past and I doubt if there is an Inuit or Indian in Canada who would want to go back to the "old" way of life.

As the author has pointed out, the industrial revolution and subsequent changes in social attitudes has resulted in an affluent society. Since people are now able to spend less time worrying about their own next meal and how to avoid becoming the next meal of some other creature, we have had time to think about wealth vs human welfare (provided there is no reduction in the former), environmental and social welfare vs corporate wealth and other "really big problems". It has also provided the idle time required to write "stimulative" articles ...and to reply to them!

Oh, by the way Professor MacKay, "Should we clean up oil spills?", and may I ask, "Why, or why not?"

EQUIPMENT UPDATE

Submitted by: L.B. Solsberg
Environmental Emergency Branch
Environmental Protection Service
Ottawa, Ontario, K1A 1C8

Telephone: (819) 997-3470

January 22, 1979 has been selected as the starting datefor an additional phase of equipment evaluations. For this series, Arctec Canada Limited of Ottawa will combine with Eastern Marine Services Limited of Musquodoboit Harbour, Nova Scotia to test out five devices on behalf of the Environmental Emergency Branch in Arctec's test basin. Included in the program are machines which display three different but effective (if past experience proves correct) approaches to skimming oil.

Oil Mop Pollution Control Limited of Mississauga, Ontario is providing a very interesting prototype originally labelled the Stationary Oil Skimmer (S.O.S.). It now exists as a self-propelled catamaran about two metres in length, is operated via a remote control package and features two 22-cm strands of polypropylene rope mop as its means of oil collection. In addition, it houses on-board transfer capability.

Morris Industries of North Vancouver is shipping an improved diesel/hydraulic control assembly and the MI-30 and MI-2 oleophilic disc skimming systems to Ottawa. The January program follows evaluation work that took place at the Oil and Hazardous Materials Simulated Environmental Test Tank (OHMSETT) in Leonardo, New Jersey in October, 1978 as well as field trials in Quebec City during October of 1977. The current piece of work is aimed chiefly at examining further refinements incorporated into the Morris units.

The third oil recovery machine is the four-metre prototype of a system to be sent in from Denville, New Jersey called the LPI. It was developed by a team of three men headed by Alexander Ivanoff. The United States Environmental Protection Agency has examined two versions of the skimmer and were instrumental in securing a unit for the Ottawa tests. The LPI operates on the principle of an advancing, non-rotating, inverted plane. It is envisioned that this product will contribute to a better insight and greater understanding of the capabilities of this generic type of skimmer. More specifically, it will allow the test team to prove out several theories which arose as a result of the skimmer tests conducted in Quebec City in October, 1976.

The Ottawa project also includes the evaluation of a unique transfer system, Komline-Sanderson's Dualdisc pump (see New Products section). It will be examined as well as the practical pump/separator combination which Offshore Devices Incorporated of Peabody, Massachusetts features as part of thir skimming barrier package. The intention is to test out Offshore's double acting diaphragm pump in conjunction with two variations of their oil/water gravity separator.

Other work this fiscal year has centred around a number of quite different skimming principles. Western Canada Hydraulic Laboratories Limited of Port Coquitlam, British

Columbia is the primary force behind the engineering evaluation of a double, contra-rotating drum skimmer. It was originally developed for the Canadian federal government as a prototype device referred to as the Oil Spill Containment and Recovery vessel (OSCAR). On the other hand, Morrow Engineering Limited of North Vancouver has been working on an ultrasonic skimming method developed by John Koblanski who resides in that city.

Arctec, through another contract in which the firm studied the performance of weir skimmers, was able to determine that a fine tuning capability in the hydroadjustable component of a weir skimmer is crucial in maximizing the performance of such devices. Their tank tests also revealed that even under ideal conditions, shear properties of the oil and water layers result in water passing over the weir lip even when it is set above the water phase, i.e. in the oil alone.

Other investigations the Branch is conducting, with the encouragement of the Canadian Coast Guard, are concerned with identifying equipment which allows the processing of spilled bunker and other viscous products.

A REVIEW OF RECENT MAJOR OIL SPILLS INCLUDING THE AMOCO CADIZ

Submitted by: M.J. Garnett
International Tanker Owners
Pollution Federation Limited
Plantation House
31-35 Fenchurch Street
London EC3M 3DX, United Kingdom

Editor's Note: This paper was presented at an API Conference held in Florida during October. Permission for reprinting was obtained from the Author and from API.

INTRODUCTION

Widespread opinion during and after the Amoco Cadiz spill was that the overall response to the incident was no better than that at the time of the Torrey Canyon 11 years before, almost to the day. It is apparent to anybody who was actively involved in either of these incidents that if there is another such spill in 11 years time, similar comment will be made. Major spills such as these will always be beyond the response resources required and that can be brought to bear in a timely manner. One can only do what is humanly possible and if this is done from a properly prepared basis with intelligence, enthusiasm and professionalism, then any damage will be minimised or mitigated, and certainly money will not be wasted as has always been the case in the past.

The main difference between the Torrey Canyon and the Amoco Cadiz was that in 1967 virtually no-one knew anything about the problems of oil pollution, its clean-up, etc. whilst in 1978, there was no excuse for people not knowing or in fact doing enough to have had positive effect. It must be pointed out that this is equally true for the Eleni V, Tsesis, Venpet/Venoil and inumerable other oil spills at which we have been on site over the years.

Society has been ill-prepared by both government and industry to swallow the unacceptable truth, that oil which is adjacent to the coast will, in all probability, come ashore, and that if it does not, it is because of a natural cause and not because of man's endeavour. In addition, government and industry have either not planned at all, or their plans have been totally inadequate when put to the test. This paper is a positive attempt to enlighten those who do not actually attend spills, but retain responsibility.

BACKGROUND

In all countries, except possibly North America, only government and the oil/tanker industry possess any personnel trained, or in any way experienced, in oil pollution response. Similarly they are the only possible sources of specialised equipment and materials to combat spills. Thus they are the only people who can in any way provide the response necessary. However, the preparation for a national oil pollution contingency plan and response capability calls for a very considerable degree of co-operation between many government departments, local authorities, industry and other interests. Bitter experience must have taught us all by now that in the event of a major spill it is simply impossible to defend all that is threatened. Not every part of a coastline can be afforded the same degree of protection, and attempts to do so are doomed to failure. The nature of the response will be a balanced decision related to the priorities for protection and taking into account the possibility of causing damage to other environments, amenities or industries, etc. from the operation or the oil alone. Priorities for protection can only be established by government after consideration of all the various interests involved. Any decision will be unpopular. Mainly for this reason, it must be accepted that the combating of major spills must be the responsibility of central government, since only they have the authority. Thus the task for industry can only be advisory and giving assistance as and when required. Their normal role should be:

(a) Prior to a Spill

(i) to advise and assist government, both central and local in their planning;
(ii) to assist in training and exercising;
(iii) to undertake research and development of equipment, techniques, etc.

(b) At the Site of a Major Spill

(i) provide any advice required;
(ii) provide any equipment and/or trained personnel who can assist.

It is apparent that in practice the amount of co-operation and assistance offered and given by industry to government varies from country to country, as does the willingness of governments to accept and act on it. However, at the site of large spills, governments seldom welcome assistance or advice and frequently appear to distrust any initiative on the part of industry. This is most noticeable over the provision of equipment and materials where too frequently authorities believe its provision will make money for the company concerned. Of greater importance and significance, however, is that whilst co-operation is often achieved at local levels, this is never true at national level. Only in a spill in South Africa have we found any real co-operation between industry and government, and as a rule government personnel perfer to 'go it alone'. The whole problem is compounded by a mixture of national, departmental and personal amour propre, and the astounding belief of all and sundry that they are the 'experts' at oil pollution clean-up. In fact one can count the number of people on one continent who have sufficient experience to be of value at a large spill on the fingers of one hand. (I would imagine a greater number could be identified in North America).

The lack of ability to implement action at all levels is due to oil pollution being a part-time activity of almost everyone involved, combined with a total lack of experience due to the infrequency of the requirement to combat spills. The shortage is not just at on-scene commander level, but right down to beach clean-up foreman.

One factor which remains common to all spills is that every interested party, viz tanker owner, cargo owner, national and local government, relies on the insurer to pay, and handsomely. That money does not grow on trees and that in the end we all pay seems to be permanently forgotten.

CONTINGENCY PLANNING

Most people's understanding of a contingency plan is simply a list of the names, addresses and telephone numbers of people to be contacted in the event of a spill. We have yet to see a plan that starts with a proper basis, identifying the threat and what is threatened, detailing the best possible defence that can be achieved.

During all previous spill incidents the absence of an adequately prepared contingency plan has resulted, both at the national and local level in a confused command organisation, lack of co-ordination between the various authorities and interests, lack of readily available information on equipment location, and no agreed policies regarding priorities for protection or acceptable clean-up response. The combination of all of this has not only caused a delayed response but also a degree of shoreline contamination and resource damage which could have been avoided.

During a recent incident, a country which had previously been opposed to the use of chemical dispersants was forced to resort to their use since there was no alternative. Delays occurred while the subject of dispersant usage was debated and equipment and materials obtained. In the meantime in this emergency some dispersant spraying was carried out by untrained personnel using incorrect equipment which only served to further compound the problem.

It must be borne in mind that during the planning stage it is essential to establish the framework of an organisation which can be brought together rapidly when an incident occurs to ensure that agreed plans are implemented and that co-ordination between the various agencies, authorities and interests is achieved. Although the organisation (and indeed the whole response) must be geared towards the most probable size of spill, there must also be sufficient flexibility built into the plan to allow for expansion to deal with a much larger or more difficult spill than previously anticipated. In this respect it is important that the contingency plans of industry and government, at both local and national level, are compatible and easy to co-ordinate. Because the vast majority of countries can only be expected to have sufficient specialised material to cope with medium size spills, or to provide a first aid response in the event of a major incident, the availability of additional equipment from outside the country has to be considered.

The existence of a plan too often gives a false sense of security that is then shaken, when an incident occurs, since a spill is never dealt with as effectively as expected. Too frequently those responsible obviously feel that when they have written a plan, they have done all that is necessary. This of course is not true and they have simply taken the first step. The information contained within the plan should therefore be frequently updated.

Exercises, regular training of personnel and testing of equipment are seldom carried out properly to ensure that new personnel are conversant with the techniques and that the equipment is in working order. Recommendations for deployment of equipment contained in the plan are not critically tested to see whether they are practicable at all times of the year, in all weather conditions, etc. Those responsible for controlling or co-ordinating oil spills are not given the opportunity to observe at close quarters incidents occurring in other countries. Consequently, valuable experience is lost and lessons are not learnt with the result that mistakes are repeated. It must be said in all fairness however, that few governments feel able to send their pollution personnel to the other side of the world to view an oil spill, but for many the cost of such experience could be well worthwhile.

CLEAN-UP RESPONSE

As so often stated, each incident is unique, even when more than one occurs in the same area. Many factors, including type and quantity of oil, weather conditions and time of year, alter the nature of the threat posed and therefore the response required. Even during a single incident the response often has to be altered as the situation changes. Invariably those in control have lacked not only a well prepared contingency plan to guide them in their choice of response, but also a basic understanding of the response available. Frequently their failure to appreciate the limitations of the various options has resulted in reliance on a single approach, even when all the evidence points to it being inadequate for the particular circumstances of the incident.

During a recent spill of heavy fuel oil in an area characterised by low sea temperatures the ineffectiveness of dispersant spraying was predicted within 24 hours, and evident from simple laboratory experiments and from the initial spraying operations. This did not prevent the massive use of dispersants by a flotilla of vessels over a period of some 20 days. Absolutely no good was done by the treatment as was apparent from the extent of the shore pollution in relation to the relatively small quantity of oil involved.

In another incident involving a relatively small oil spill, recovery techniques were used exclusively despite adverse weather and hydrographic conditions. In the event, recovery proved to be of little value and extensive pollution of the shore occurred. Had a less rigid approach been adopted and the attempts to recover the oil supplemented by the controlled use of dispersants, no oil need have reached the shore at all.

On many occasions the best course of action is to do nothing (with the exception of surveillance to ensure that no threat develops) as intervention is unnecessary and may do more harm than good. If left, oil on the sea dissipates through the natural processes of spreading, evaporation, dispersion, photoxidation and biodegradation, the rate depending upon many factors, including type of oil, sea state and temperature. There is no doubt that these natural processes are far more effective in removing oil from the surface of the open sea than any man-made techniques.

A recent major discharge occurred hundreds of miles from land and it was predicted that the resulting slicks would dissipate long before reaching any coastline or other sensitive area. Nevertheless a great deal of recovery equipment was deployed to the scene of the incident. The endeavours to recover the oil were thwarted due to the inability of the equipment to work in the prevailing conditions and the fact that the oil dissipated at the same rate that it was being discharged to the sea.

Recovery of oil from the surface of the sea is in many respects the ideal solution as it removes the threat completely and in addition causes no environmental damage. The plain fact is that we have never seen such equipment operating satisfactorily (sufficiently effectively) in wave heights of more than one metre. In addition this equipment needs some form of boom to concentrate the oil at the entrance of the collection mechanism. It is a sad fact that in all recent incidents booms on the high seas have proved impractical, or at the very best ineffective. In one incident in relatively confined waters three booms were used, two of which sank, allowing the oil to contaminate the foreshore.

Recent spills have shown that the best and often the only alternative to leaving the oil offshore alone is to use a chemical dispersal technique, though we have never seen it exploited to its full potential. This is due in part to a lack of understanding by those involved of their purpose and the conditions required for their use.

One of the important lessons learnt from the Torrey Canyon was that in order to be effective, dispersants must be distributed evenly on to floating oil and adequately mixed into the upper layers of the sea. In the case of hydrocarbon solvent based materials and concentrates pre-diluted with sea water, additional mixing to that provided by wave action is required under all but very rough sea conditions. One of the most effective methods of achieving this is through the use of surface breaker boards towed behind the spray vessels, which produce intense sheer mixing at the oil water interface. The turbulent mixing achieved through high pressure water jets and ships propellors has been shown to be inadequate, particularly when dealing with large slicks of oil.

Despite this, most governments have failed to purchase the correct equipment, and in recent spills, naval and other vessels were enlisted to apply dispersant through fire monitors, deck hoses, or by whatever other ingenious method seemed appropriate to the ship's Master. All such methods have one thing in common - massive quantities of expensive dispersant are used to far less effect and with a much greater risk of environmental damage, than would have been the case had the correct equipment been used by personnel trained in its use. The new generation of dispersant concentrates now available, if used undiluted do not require the same degree of mixing as the older type of products, and often the natural movement of the sea is sufficient. This opens up the possibility of aerial application techniques, which potentially offer a quick and effective means of dispersing slicks at sea. It should be borne in mind that these techniques are still in their infancy and have yet to be proven in practice. The opportunity to put them to the test arose during a recent major spill, but regrettably the authorities chose to dilute the dispersant with sea water, thereby reducing its effectiveness. No authoritative conclusion could be reached and an ideal opportunity was wasted.

The usefulness of recovery devices increases enormously when oil is within harbours, estuaries and relatively sheltered waters with little water movement. Sorbents have also proved of some value in these circumstances. The use of booms to protect harbours, rivers, cooling water intakes, fish farms, marinas and other sensitive areas becomes a far more viable proposition. Once again, however, the limitation of the techniques has to be fully realised. Too often the booming schemes devised have been over-ambitious, attempting to totally prevent ingress of the oil into areas rather than trying to minimise contamination in a realistic manner. This has led to booms often being deployed in situations where the effect of waves, currents and even wind was the greatest, rendering the boom ineffective. Even when booms were sensibly located, they were often left unattended (especially at night) with the result that tidal changes or excessive accumulation of oil negated any good effects previously achieved.

Whilst we have witnessed many such occurrences during recent incidents, we have also seen the value of a well-deployed and well-tended boom. In one particular case, a heavy duty boom was deployed in a deflection mode approximately 500 metres upstream of the entrance of a river, the upper reaches of which were of ecological interest and also housed a number of fishing and amenity craft. Although at times the current exceeded 2 knots, the deployment of the boom at an acute angle ensured that the vast majority of the oil that entered the river was deflected to a collection point at the side of the river, preventing contamination of the areas to be protected.

Clean-up of the shore has been the main task in nearly all recent spills. The methods employed have been relatively simple and straight-forward, and quite rightly have not relied on specialised oil spill clean-up technology.

If adequate planning and organisation is considered necessary for efficient clean-up sea it is equally so for beach cleanup. In all previous spills where oil has come ashore, local authorities have resorted to ad hoc clean-up methods with no prior consideration as to the best approach. Whilst mechanical methods have proved efficient on previous occasions, we have too frequently seen them used in situations where they were not at all suited, e.g. on soft, mobile beaches and on any sort of beach where there is only minor pollution. The end result has been the removal of vast quantities of beach material in relation to the amount of oil, causing excessive beach damage and a massive and unnecessary disposal problem.

Manual recovery of oil, whilst often labour intensive, generally results in far more effective clean-up with minimum damage.

Removal of bulk oil from rocky shores may be required on occasions because of amenity usage or concern that the oil will be a reservoir for recontamination of other areas. In such cases reliance is usually placed on vacuum trucks where the necessary access is available or on men with buckets where not.

A variety of other methods and a great deal of improvisation is often required in cleaning contaminated shorelines. We have seen dispersants, hot water, steam, high pressure hosing, sorbents, sand blasting and a wide variety of other methods employed in additon to physical removal. All have their place, often during a single incident. However, the choice of the most appropriate response requires an understanding by those in control of the full consequences of the approach adopted if the affected areas are to be restored to the required pre-spill condition in the shortest possible time.

CONTROL OF OIL SPILL CLEAN-UP OPERATIONS

Wherever the incident occurs, whatever the techniques employed and however good the contingency plans, the success of the clean-up response has always ultimately depended upon the degree and effectiveness of the control of the operation and of its individual components.

It is our experience that one of the main difficulties is that the number of occasions on which spills occur in any one country is rarely sufficient to justify the establishment of a full-time response force, able to maintain a high level of technical expertise and readiness. Because of this, the oil spill clean-up organisation inevitably depends heavily on those whose main duties lie elsewhere.

In all spills which we have attended, several different authorities have been involved, each with its specific responsibility, areas of interest, concerns, capabilities of clean-up etc. Often co-operation was lacking between these various organisations, sometimes to the extent that conflicts arose. The likelihood of overcoming these problems would be greatly enhanced by the appointment of a full-time oil spill co-ordinator who takes overall charge of the clean-up operation during each and every incident and who has the responsibility for co-ordinating the actions of the various organisations and authorities, both at sea and on shore.

Aerial reconnaisance is one of the most important requirements in order to help ensure that clean-up at sea is adequately controlled and that the response remains appropriate as the situation changes. During past spills, aerial reconnaisance has usually been totally inadequate, carried out by inexperienced personnel, with reliance often being placed on pilots of civil airliners overflying the area. This has resulted in inconsistent reports with no distinctions being made between very thin films of oil and heavy rafts of water-in-oil emulsion. Inevitably this has led to confusion and the deployment of resources where least required.

On occasions where aircraft were specifically made available, no attempt was ever made to use them to control clean-up operations and rarely have they had the necessary communication links with surface vessels.

On the shore too, control of clean-up has often been lacking. At a recent spill, clean-up of a sandy beach was entrusted to heavy equipment contractors with no previous experience of beach clean-up. Each machine operator was apparently left to devise his own approach to the problem, with the result that oil was soon spread over much of the otherwise clean beach and in places was ground into the sand to some considerable depth.

Disposal of the collected oily sand was similarly uncontrolled and unco-ordinated, with holes being dug at many positions towards the top of the beach to bury the material and little concern for the long-term effects of such disposal. In this particular case, it was our opinion that the clean-up could have been carried out more effectively with far less physical disturbance to the beach, had the control been stricter.

CONCLUSION

The key to efficient clean-up is the combination of good contingency planning, organisation and control. All are important and no quantity of equipment or high technology will compensate if these are lacking. Regrettably this message seems still to go unheeded in many countries of the world, even among those who have had several major oil spills in the past.

If oil spills are to be dealt with effectively in the future so that damage is reduced and the wastage of money, labour, materials and equipment is minimised, much more effort must be made to learn from previous experience or perhaps from previous mistakes.

The most significant and at the same time unnecessary, failures in the field of co-operation. Co-operation is routine and common for dealing with small spills but rare if not unheard of at national level, and at the scene of major spills. There is no short term answer along the lines of providing a physical response to all major spills from a centralised air transportable strike force with any amount of equipment that can be imagined. Major spills are beyond the capacity even of the most wealthy states, even when such spills are on their own coastlines.

Since it is generally accepted that central government has the responsibility and related authority on such occasions, it is beholden upon them to seek and listen to the advice, and accept the assistance, of industry both prior to and at the site of major spills. Without such co-operation and joint approach the clean-up of any future major spill will be of the same order as the Torrey Canyon and the Amoco Cadiz.

MISSILES OR PARACHUTES - HOW TO TRACK OILED ICE

Submitted by: Mr. P.J. Blackall
Process Development Engineer
Environmental Emergency Branch
Environmental Protection Service
9942 - 108th Street
Edmonton, Alberta T5K 2J5

It has been generally accepted that oil discharged from a subsea oil well blowout, a fractured sea bottom pipeline, or some other source beneath moving ice, will be trapped and held on the underside of the ice. Therefore, it was considered necessary to devise a technique for tracking the contaminated ice, in order to facilitate later cleanup operations.

In the fall of 1977 a contract was awarded to Innovative Ventures Limited, Calgary, to carry out a study, entitled "Evaluation of Ice Movement Buoys for Tracking Oil Spills", as part of the Arctic Marine Oilspill Program. The objective of the project was to review the availability, suitability, and cost of tracking buoys for the subject application. It was also required that recommendations be made on possible ways to improve promising buoys, particularly to ensure a long operating life and an air-droppable capability. In addition to reviewing the various tracking systems and making recommendations for Arctic applications, the project report addressed two subjects.

Firstly, the authors of the report recommend the use of a dual tracking system -one system for tracking large-scale or macro movements and another for small-scale or micro movements. It was suggested that a satellite system, incorporating an Air-Droppable Random Access Measurement System (ADRAMS), be used on a macro scale. This was an already proven technique with the advantages of being remotely monitored and dependable during all seasons and in virtually all weather conditions. On the micro scale it was recommended that a combination of an HF or VHF radio beacon and a radar reflector be used. The advantages of these devices are cited as low cost, high position accuracy, and compatability with typical search aircraft.

It can be envisaged that during a spill incident, satellite trackable buoys would be released at the spill site. For an extended subsea discharge buoys would be deployed every week or two depending upon ice velocity. Between deployments of the large-scale, more sophisticated buoys several smaller micro-scale buoys could be released. This dual system would allow remote tracking of the oil during the dark winter months and also permit the exact location of the contaminated ice prior to and during spring breakup by airborne clean-up crews.

Secondly, the authors of the report suggested the use of a penetrometer for air deployment of both the macro- and micro-tracking systems. This suggestion led the writer to the question posed in the title of this article. Should one use a "soft-drop" system employing a parachute in combination with an ADRAMS buoy, or a "hard-drop" system using a high "g" missile, which can survive high deacceleration? The answer to this question was not immediately obvious and it is worthwhile to explain the advantages and disadvantages of both systems.

The high "g" missile or penetrometer, with appropriate electronics has the advantages of providing a firm mounting on the ice surface and being unaffected by wind drift during deployment and, hence, can be more precisely aimed at target ice floes. Also, the fixed penetrometer orientation on the ice allows for a simple, less expensive antenna configuration. This disadvantages of this system include: the missiles do not float, the missiles would penetrate right through thin ice, and local melting during the spring may result in the device tipping or sinking. In addition, several tens of thousands of dollars are required to develop the penetrometer to a commercial state.

The parachute system has the advantages of being able to float on water or land on thin ice. Also, the system has been fully developed and was recently used successfully in the Canadian Arctic with a success rate of close to 100%. The disadvantages of this system are: the expensive gimbal mounts which allow proper antenna configuration upon landing, regardless of buoy orientation; the potential drift problems during deployment due to wind; and the lack of a firm mounting on the ice.

In light of the success with the "soft-landing" system in the field, it is difficult to favour the "hard-drop" system. An assessment of the cited advantages and disadvantages of both techniques further emphasizes this conclusion.

In summary, it would appear that a dual tracking system combining macro- and micro-scale trackers deployed with the "soft-drop" system is the logical answer for tracking oil-contaminated ice floes in the Arctic.

REFERENCES

"Evaluation of Ice Movement Buoys for Tracking Oil Spills" Goodman, R.H., Innovative Ventures Limited, Calgary, Alberta, March, 1978.

Milne, A.R. and Melling, H., Personal Communications.

INFORMATION SYSTEMS USED IN ENVIRONMENTAL EMERGENCIES

Submitted by: R.A. Beach
Manager, National Environmental Emergency Centre
Environmental Emergency Branch
Environmental Protection Service
Ottawa, Ontario K1A 1C8

Telephone: (819) 997-3742

Three Canadian information storage and retrieval systems are used in dealing with spills of hazardous materials. Two are used in the first stages of the response to a spill and are described below under "Response Systems". The third system is used to record details on hazardous materials spills, largely for analytical purposes, and is described below under "Reporting".

RESPONSE SYSTEMS

When a hazardous material is spilled, the on-scene-commander (OSC), emergency response teams and scientific or technical advisory groups need to know:

1. the chemical and physical properties of the material and its biological effects, and;

2. the nearest or most readily available source of equipment, material and expertise to combat the spill.

In Canada, two multi-purpose information systems are used to satisfy these requirements: the Hazardous Materials System (HAZMATS) and the National Emergency Equipment Locator System (NEELS).

HAZMATS was originally desinged by the Department of Environment (DOE) to support implementation of the Canada-U.S.A. Great Lakes Water Quality Agreement, then expanded to assist in the formulation of a code for the transportation of dangerous goods. It is now being revised to serve the Canadian Contaminants Program in a broader sense, under its enabling legislation, the Environmental Contaminants Act. The system, managed by the Contaminants Control Branch of DOE, currently contains chemical, physical and biological effects data on about 3,700 hazardous chemicals, 1900 of which are cross-referenced with the United Nations' list of dangerous goods.[1] It is envisaged that, with minor modifications, HAZMATS could complement and support the International Registry of Potentially Toxic Chemicals (IRPTC) data base proposed by the United Nations Environment Program (UNEP).

The existing data base contains sixty fields of information (see Table 1), some or all of which are useful to a number of other governmental regulatory departments or agencies, and particularly to spill response organizations.

(1) Recommendations prepared by the Committee of Experts on the Transport of Dangerous Goods, Transport of Dangerous Goods, United Nations publication number ST/SG/AC. 10/1* New York, 1976.

HAZMATS is an interactive system, stored on and accessible through the Department of Energy, Mines and Resources computer network using the System 2000 natural language.

TABLE 1 - HAZMATS DATA BASE DESCRIPTION

1. U.N. Transport of Dangerous Goods Reference Number
2. U.N. Transport of Dangerous Goods Classification Number
3. U.N. Transport of Dangerous Goods Packaging Group
4. (See 410)
5. U.N. Hazard Information Code
6. Disposal Reference
7. Registered Chemical Name
8. Synonyms (Trade Names, Syn.)
9. Physical Phase (At room temp.)
10. Solubility in Water (Text if exact figures not available)
11. Solubility (Decimal numbers, in pph, in water)
12. Specific Gravity
13. Boiling Point
14. Melting Point
15. Vapor Pressure (mm Hg)
16. Decomposition Point
17. Flash Point
18. Sublimation Point
19. Refractive Index (Na, 20^{o}C)
20. Cup (In ref. to flash point)
21. Persistence (In water, in weeks)
22. Persistence Reference Number
23. Chemical Class (Main use)
24. Chemical Origin (U.N. List, Canadian List, U.S.)
25. Aquatic Toxicity Dose (ppm)
26. Aquatic Toxicity Type (K = Kill, TIA = LC50, after 1 day, ...)
27. Aquatic Toxicity Test Organism (Fish, invertebrate, . .)
28. Aquatic Toxicity Test Organism Name Abbreviation
29. Aquatic Toxicity Reference Number
30. Is Aquatic Test Organism Indigenous To Great Lakes
31. Oral Toxicity Dose (mg/kg)
32. Oral Toxicity Type (LD50, LDLO, ...)
33. Oral Toxicity Animal (Test organism)
34. Dermal Toxicity Dose (mg/kg)
35. Dermal Toxicity Type (LD50, ...)
36. Dermal Toxicty Animal (Test organism)
37. Inhalation Toxicty Dose (Vapor = ppm, Dust = mg/kg)
38. Inhalation Toxicity Type (LC50, ...)
39. Inhalation Toxicity Animal (Test organism)
40. Ecological Effect Rating
41. Booz-Allen Rating
42. IMCO Pollution Category for Operational Discharge
43. U.S. Coast Guard Reference Number (CHRIS)
44. OHM-TADS Reference Number
45. Flammability Rating
46. Reactivity Rating
47. Health Hazard Rating
48. Environmental Hazard Rating
49. Phytotoxicity Rating
50. Genetic Aberration Rating
51. Disposal Label (Reference)
52. Inhalation Toxicity Phase (Dust or vapor)
53. Chemical Abstract Number (CAS)
54. Bioaccumulation
55. Environmental Damage
56. U.N. Secondary Risks 1
57. U.N. Secondary Risks 2
58. U.N. Special Provisions 1
59. U.N. Special Provisions 2
60. U.N. Secondary Risks 3

410. U.N. Packaging Number (Reference No.)

The National Emergency Equipment Locator System-(NEELS) was designed to assist government and industry response organizations by standardizing their spill countermeasures inventories and by providing a rapid means for locating equipment in an emergency. Participants in NEELS list their equipment and contact identification inforamtion in the data base under specified fields or Main Information Headings (see Table 2), and the inventory owner is obliged by agreement to keep that information up-to-date.

TABLE 2 - NEELS MAIN INFORMATION HEADINGS (FIELDS)

1. Province/State
2. Place Name
3. Organization
4. Latitude - Longitude
5. Facility
6. Phone Numbers
7. Booms/Fencing
8. Watercraft/Aircraft
9. Skimmers/Pumps/Fittings
10. Hoses/Connections/Portable Tanks
11. Vacuum/Pumper Trucks
12. Special Vehicles
13. Communications Equipment
14. Sorbents/Chemical Treating Agents/Application Equipment
15. Safety Equipment/Special Clothing
16. Generators/Lights
17. Earth Movers/Heavy Equipment
18. Other Equipment and Materials/ Local Resources
19. Disposal Facilities
20. Comments/Control Points

All geographic locations in the data base are identified by latitude and longitude, allowing the system to provide the great circle distance, in nautical miles, between a search datum and each selected inventory location. In the search mode, the user may ask for "all" of the equipment, or a specified "type" of equipment (Main Heading equipment), or a specified "piece" of (Trade name) equipment at the location or locations nearest to the search datum.

The system is interactive (prompts the user with progressive questions), and, in a spill situation, first asks for the latitude and longitude of the spill location. The on-scene-commander may provide this location or, since he should be quite familiar with the resource situation in his own area of responsibility, he may select the location of a major logistics-support center that can support him more completely, or more rapidly, or both, than locations within his own area. This latter option is particularly appropriate for spills in the remote, northern regions of Canada, but it may also be used by the OSC after resources in his own area have been depleted.

In either case, NEELS searches radially from the given locus and prints-out "all", "type", or "piece" information on the nearest location. If there is not enough of the desired equipment at that location, the system may be instructed to search for the next nearest location, then the next nearest, and so on, until the OSC's needs are satisfied. At this point, the logistics support group takes over and, through contact information provided by NEELS, makes arrangements for delivery of the equipment to the spill location or assembly point.

Outside the search mode, NEELS may also be interrogated by industry and government planners to list company or agency inventories across Canada, or in specified areas, to assist in the preparation of contingency plans or in the assessment of existing plans. Predesignated OSC's and leaders of response teams carry bound photocopies of NEELS listings for field checks in their areas of responsibility and for training exercises.

The system specifications were prepared by DOE in close cooperation with the Department of Transport and the Petroleum Association for the Conservation of the Canadian Environment (PACE). An international computer services company, I.P. Sharp Associates Limited, wrote the program using the APL computer language under the modified Sharp APL System. The data base is stored on one of Sharp's computers, free of charge as a public service, and, in an emergency, is accessible 24 hours per day through Sharp's toll-free telephone lines at several key locations in Canada, the United States and overseas, or through the Trans Canada Telephone System.

NEELS has been in operation since 1974 and now contains about 600 inventories at locations across Canada and in some states in the U.S.A. (The Department of Natural Resources, Michigan, U.S.A., participates in the program.) The interactive portions of the system are accessible in either English or French, Canada's two official languages, but inventories are entered in the data base in the language chosen by the inventory owner.

Operational experience shows that the NEELS field structure must be more precise and that special emphasis must be given to chemical and radio-active spill countermeasures equipment. This information is "buried" in the existing structure, but a revision, to be completed in 1979, will highlight these subjects under separate fields or Main Headings.

REPORTING

In Canada, regulations promulgated by federal or provincial agencies now require that virtually every situation involving a spill of hazardous materials be reported. Practical working arrangements among federal and provincial regulatory agencies serve to ensure that most of the significant spills of hazardous materials are reported by the fastest possible means. Passage of the Transporation of Dangerous Goods Act, should close any existing loopholes in mandatory reporting requirements.

The Department of the Environment, through its Environmental Emergencies Program, has been directed by the federal Cabinet to "Implement, making maximum possible use of existing facilities of all agencies, a national system for reporting environmental emergencies and alerting appropriate authorities of the situation". In 1973, a national reporting system was put into operation, in cooperation with several federal and provincial regulatory agencies, for the "real time" reporting of environmental emergencies. As a logical extension of the reporting system, the Environmental Emergency Branch (EEB) developed a national inventory of accidents involving spills of hazardous materials. The program is known as the National Analysis of Trends in Emergencies System (NATES).

NATES was designed to assist federal and provincial regulatory agencies in analysing accident trends and their distribution in order to assess contingency plans, equipment development and requirements, equipment deployment, accident prevention programs, and the effectiveness of laws and regulations. Federal and provincial regulatory agencies contribute their spill information to DOE in the format used by the reporting agency. This information is then transferred to the NATES Coding Form and forwarded to EEB in

DOE headquarters. Quality control checks are made in EEB before and after key punch operations and then the spill data are batch-entered into the data base. For quality control purposes, only EEB may input or update data for the system, but any participating government agency may search the data base.

A NATES user's manual provides guidance on the preparation of the coding forms and on procedures to be followed to perform various kinds of searches, depending upon the type of anlaysis to be conducted. The EEB publishes a comprehensive summary of hazardous materials spills annually in its Spill Technology Newsletter.

The system specifications were prepared by EEB in consultation with potential federal and provincial user agencies. The programming language is APL under the Sharp APL system, and the data base is stored, on-line, on one of the I.P. Sharp Associates Limited computers in Toronto. The system is interactive and is accessible in both English and French through Sharp's toll-free lines or the Trans Canada Telephone System.

NATES has been operational since 1974, but all available accident records as far back as 1968 have been entered in the data base. The current 32 fields of information are now being revised and augmented, primarily to provide more and better data for accident prevention programs. In this revision, the hazardous material spilled will be identified by its United Nations reference number, and the "cause" and "reason" fields will be refined to reduce the number of accidents relegated to the "other" category. This new field structure will be implemented in January, 1979, and, where possible, the existing 6000 records will be amended to incorporate the more detailed information.

HIGH CAPACITY OIL-WATER SEPARATOR

By: Lcdr Myron Hura
Program Administrator for Energy and Environmental Protection Technology
Naval Supply Systems Command
Washington, D.C.

Mr. John Mittleman
Project Engineer
Naval Coastal Laboratory
Panama City, Florida

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INTRODUCTION

REFLECTING ITS INTEREST IN ENVIRONMENTAL QUALITY, the NAVY has been actively pursuing a dynamic and comprehensive pollution abatement program. The overall objective of the program is to develop and institute measures that will permit NAVY ships, shore facilities, and aircraft to comply with pertinent Federal, State, and local environmental regulations. The basic strategy of the program has been to institute source reduction measures before attempting to apply effluent control of "clean-up" techniques to existing source.

A large portion of the NAVY Pollution Abatement Program has been on oily wastes. Thus far, significant efforts have been devoted to quantify, reduce, and control discharges of contaminated bilge, ballast, and tank wasing wastes from ships and oily waste generated at shore facilities. Reference (1) describes these efforts in detail. The high capacity oil-water separator subsequently described was developed under the sponsorship of the Navy Pollution Abatement Program.

DEVELOPMENT OF THE SYSTEM

The current 3,000 gpm oil-water separator evolved from a joint COAST GUARD, MARITIME ADMINISTRATION (MARAD), and NAVY project which was designed to investigate state-of-the-art technologies for processing oily waste. Under this project numerous oily waste separation technologies were evaluated including gravity separation, coalescence, microfiltration, and centrifugation. Following the evaluation, the NAVY elected to continue with the development of gravity parallel-plate coalescer separators. In this category of separators, coalescing plates greatly accelerated natural gravity separation of oil from water by creating a laminar flow regime bounded by a material with a great affinity for oil. Generally, the coalescing plates are arranged horizontally in stacks with only one quater of an inch between the upper surface of one plate and the lower surface of the plate above it. Thus, oil droplets as small as several microns in diameter can rise, according to Stoke's Law, the short distance between plates as the flow passes through the plate stack. Surface tension effects cause these small oil droplets to be captured by the plates and to coalesce into a film of oil which adheres to the plate.

When the film reaches an equilibrium thickness, additonal oil forms large, buoyant droplets which are shed from the plates. These large droplets rise quickly to the surface where they merge with the bulk oil layer which is removed by skimming.

The NAVY Oil-Water Separator Development Program can be subdivided into two categories: 1) the development of low capacity units (10-50 gpm) for processing shipboard bilge waste, and 2) the development of high capacity units (1,000-3,000 gpm) for processing contaminated ballast aboard ship and all types of oily wastes ashore. Reference (2) provides a detailed discussion of the Bilge Separator Development Program.

Under the High Capacity Separator Development Program the Navy obtained two units of parallel-plate design; one to be used for processing ballast on board ships with self compensating fuel tanks, and the other for processing high capacity oily waste picked up from accidental or deliberate spills. In 1974 the deballasting unit was mounted on a barge and connected to the ballast overboard discharge of the USS Koelsch (FF-1049). The unit was operated in conjunction with ship refueling evolutions; thus, it was able to process ballast containing oil concentrations as high as 800 ppm at flow rates up to 1,200 gpm. At no time did the oil concentration in the effluent exceed 15 ppm. Currently, a modified version of the unit is being developed for installation aboard self compensating fuel tank ships, such as DD 963 and FF 1040 Class ships.

While the above testing was in progress on FF-1049, the second high capacity separator was being evaluated at the Naval Coastal Systems Laboratory (NCSL) at Panama City, Florida, to determine its capability of processing oily waste at sites of accidental or deliberate oil spills. During the testing program the separator could not handle oil/water emulsions properly and thus provide satisfactory oil separation under simulated conditions. For this reason, further efforts toward this goal were temporarily halted. It was anticipated that the unit might better lend itself as a solution to contaminated ballast problems associated with Oilers. These ships, after conducting underway replenishment, often take on large volumes of ballast water for their return trip to port. Upon arrival they have to discharge the contaminated ballast prior to taking on a new load of fuel. The deballasting of large quantities of contaminated water in port areas creates a serious disposal problem unless the water can be effectively separated in real time from oil contaminants.

With this new objective in mind, and after minor modifications, the testing of the unit was resumed. During this later testing period, the unit effectively processed contaminated waste ranging in oil content from 0.01 to 20 percent. Following Laboratory evaluation, the unit (OPS-1000) was shipped to the Naval Station, Mayport, Florida, for use in processing oily waste collected from ships and shore facilities. For the past two years the unit has performed satisfactorily under real-world conditions. In view of the relative success of the above units, it was decided to develop a "scaled-up" 3,000 gpm unit based on the same technical principles.

DEVELOPMENT TESTING

During the design of the OPC-3000 Oil-Water Separator several areas of technology required developmental testing in order to provide guidelines for sizing and interfacing components of the final design.

TABLE 1 A SUMMARY OF MAYPORT TEST RESULTS

Alternative	Results	Conclusions
20 micron pleated paper filter followed by coalescing plates and 4-inch thick foam pack	46% solids removal; 25 psi drop across filter; poor overall separation efficiency	No further consideration due to poor separation performance
Leaf filter (diatomaceous earth Coated screen) followed by coalescing plates and 4-inch thick foam pack	99% solids removal; 30 psi drop across filter; excellent overall separation efficiency; short operational life between applications of diatomaceous earth	No further consideration due to excessive maintenance requirements and high supply pressure requirement
Coalescing polyurethane foam filters between coalescing plate stacks	Separation efficiency varies with foam thickness; pressure drop and operational life acceptable	Further tests scheduled to determine interface and maintenance requirements and performance under ballast conditions
Fiberglass filter pack between coalescing plate stacks	Excellent separation efficiency; pressure drop higher than for foam	Futher tests scheduled to determine interface requirements imposed by pressure drop
Woven fiber coalescer used with paper filter following coalescing plate section	Poor sepration efficiency; short operational life; 16% solids removal by woven fiber coalescer	No futher consideration
Stainless steel woven coalescer following coalescing plate section	39% solids removal; poor separation efficiency	No further consideration

In order to give the OPC-3000 adequate flexibility in handling oily wastes other than ballast water, a series of test were run at Naval Station, Mayport, using the OPS-1000 Oil-Water Separator in conjunction with several alternative media for handling the high solids content typical of many oily wastes. These alternatives included:

- Paper filters and diatomaceous earth leaf filters for removal of solids prior to coalescence.
- Foam and fiberglass coalescing media for use between stacks of coalescing plates.
- Fiber and stainless steel wool coalescing elements for tail end polishing.

The scope of tests performed in Mayport and the conclusions that were drawn from these tests are shown in TABLE 1. It was decided on the basis of these tests that additional laboratory tests of the foam and fiberglass packs should be scheduled to define more fully their interface requirements and maintenance characteristics.

The development tests, which were undertaken in order to define more fully the performance of coalescing packs used in conjunction with the coalescing plates, were performed at the Naval Coastal System Laboratory in a model separator with full-size coalescing plates and full-thickness foam packs. The model separator is approximately one foot square in cross section and 20 feet long. The influent flow rate chosen for laboratory tests simulated the full 3,000-gallon a minute flow rate through the proposed separator. The influent characteristics were made to match as nearly as possible expected ballast conditions by mixing oil with water in a centrifugal pump. This mixture was passed through an appropriate length of pipe to simulate the effect of piping anticipated at the Craney Island Fuel Depot site. From these tests, it was confirmed that while the fiberglass exhibited a slightly superior separation efficiency, it clogged very rapidly therby creating a large pressure drop across the fiberglass pack. Coalescing polyurethane foam packs on the other hand, while slightly lower in separation efficiency, were less prone to clogging. In the final design, a 4-inch layer of polyurethane foam was chosen in order to obtaiun satisfactory separation efficiency, to reduce the structural problems associated with a pressure drop across the coalescing pack, and to minimize the maintenance requirements imposed by clogged coalescing packs.

THE OIL-WATER SEPARATOR SYSTEM

PHYSICAL DESCRIPTION

The OPC-3000 Oil-Water Separator is located in the vicinity of the sludge treatment plant at the Craney Island Fuel Depot in Portsmouth, Virginia. The entire oil-water separator system is built on a concrete pad 30 ft x 44 ft in size which lies within a diked-off area 70 ft x 92 ft. The major structures on the concrete pad shown in Figure 1 are:

- The SEPARATOR TANK - 23 feet in diameter, 12 feet high. Installed within the separator tank are horizontal parallel coalescing plates, foam filter packs, oil skimmers, and sensors which give the operator cues as to the status of the separation process. Figure 1 is an overall view of the separator system, and Figure 2 is a cut-away sketch showing the Separator's internal components.

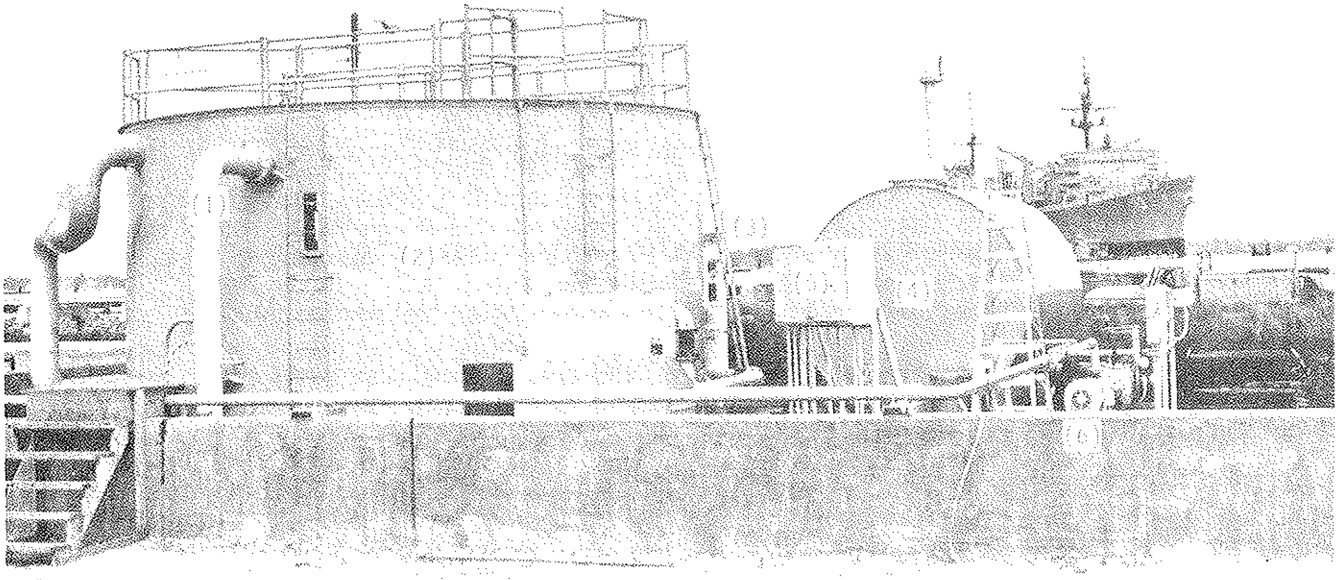

Figure 1. The OPC-3000 Oil-Water Separator System, Craney Island Fuel Depot, Portsmouth, Va.:
(1) Influent Pipe **(3) Oil Monitor Shack** **(5) Control Panel**
(2) Separator Tank **(4) Oil Holding Tank** **(6) Oil Pump**

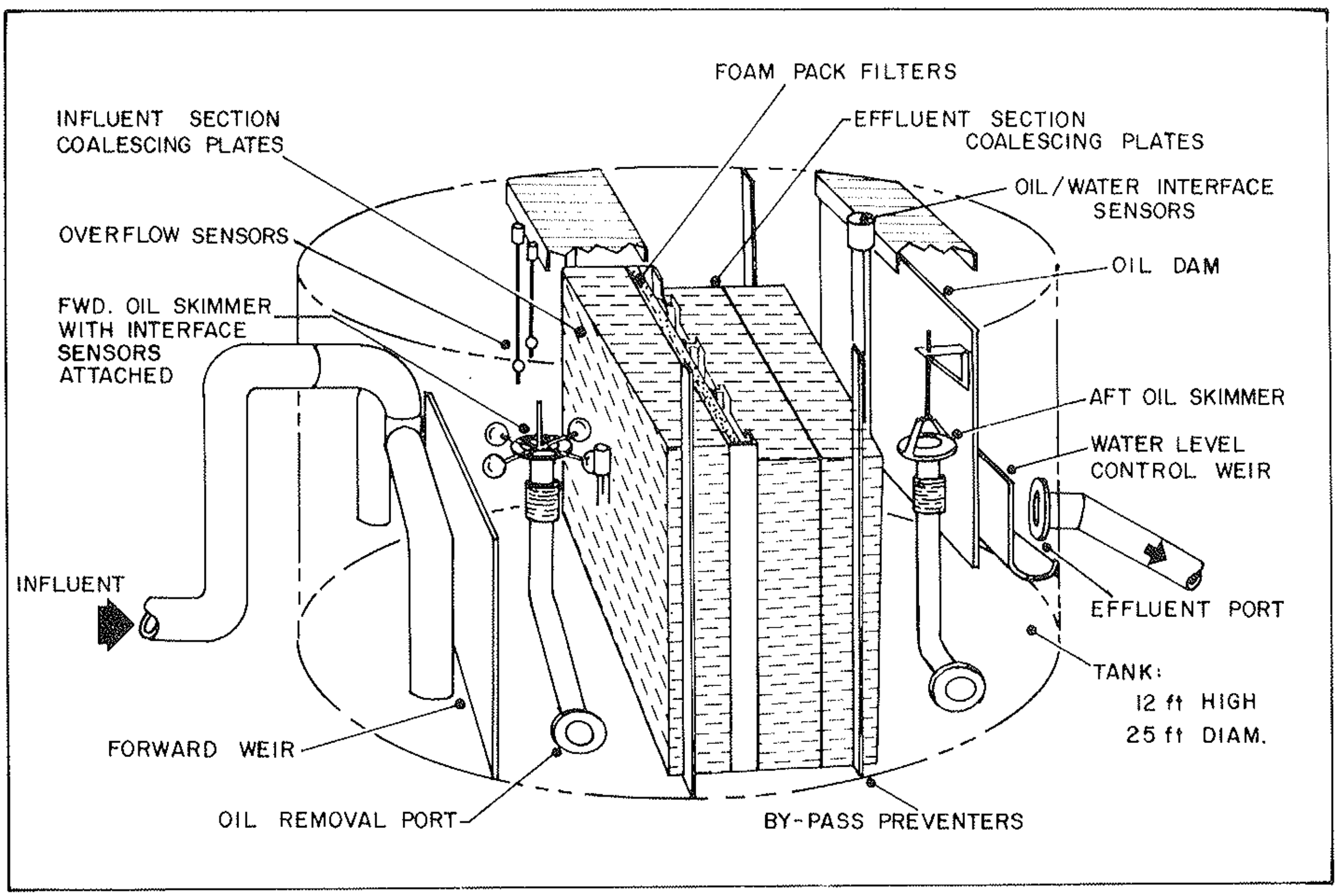

Fig. 2 - The Separator System's Internal Components

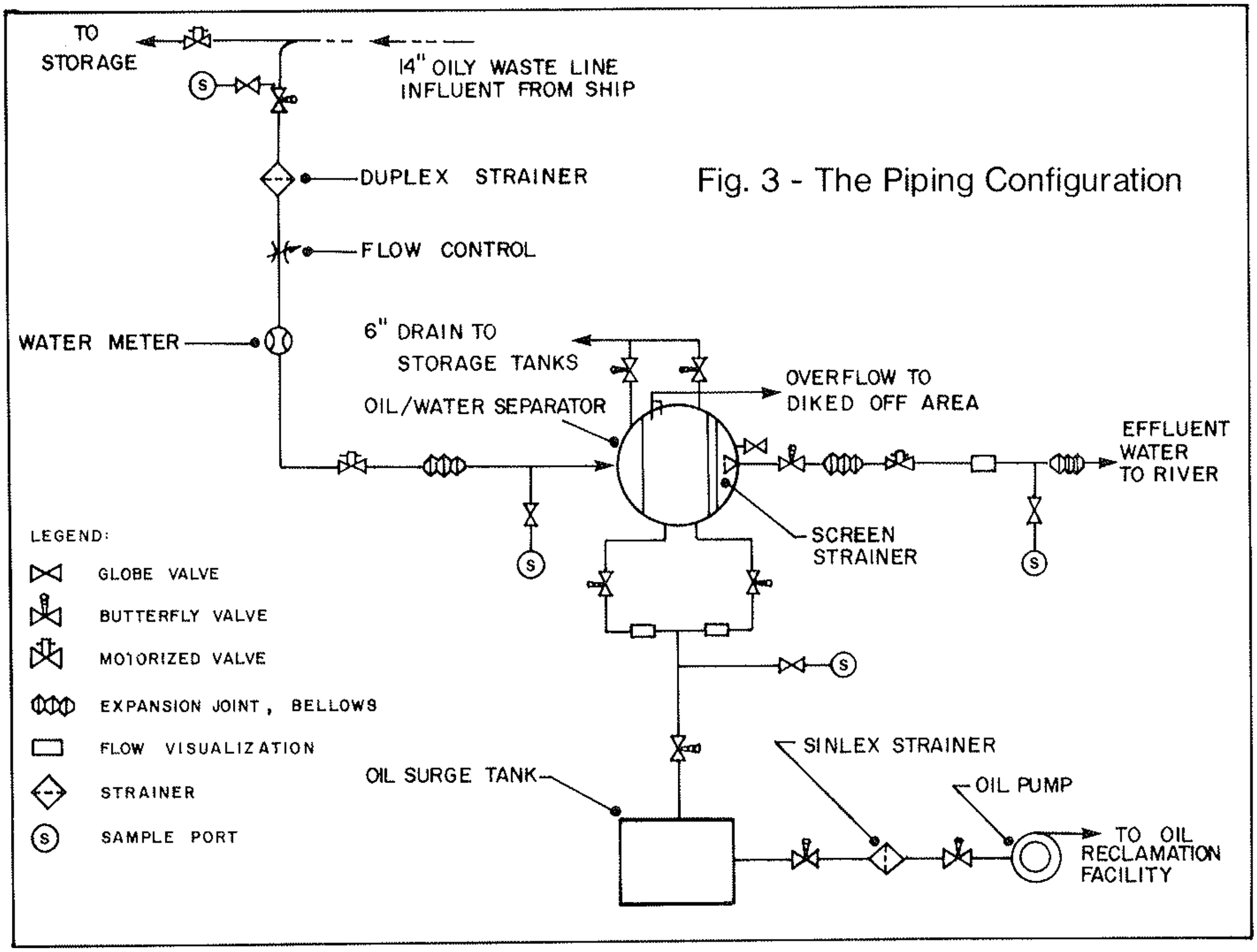

Fig. 3 - The Piping Configuration

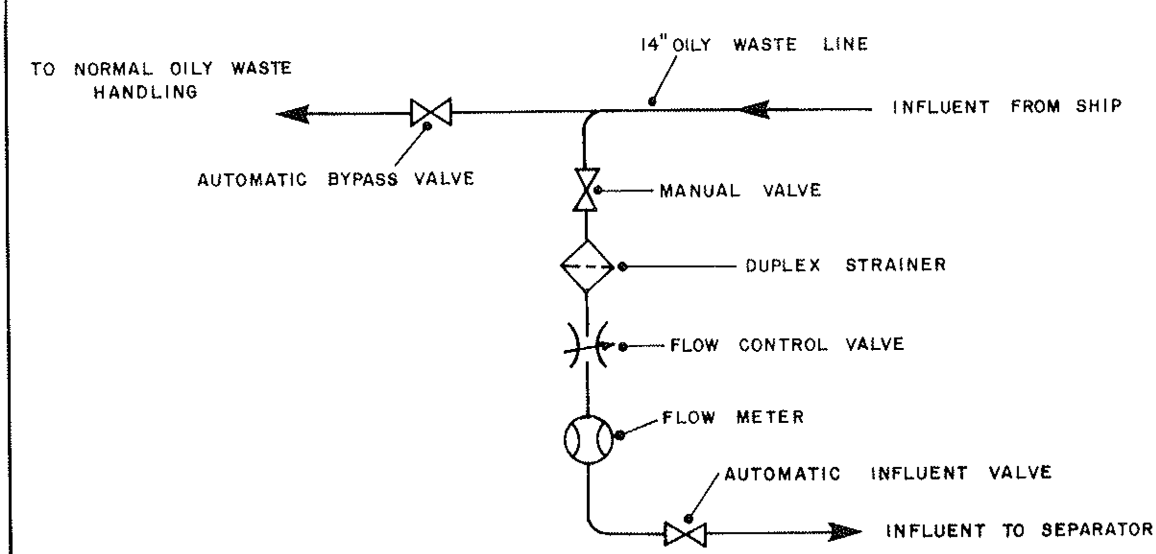

Fig. 4-The Influent System

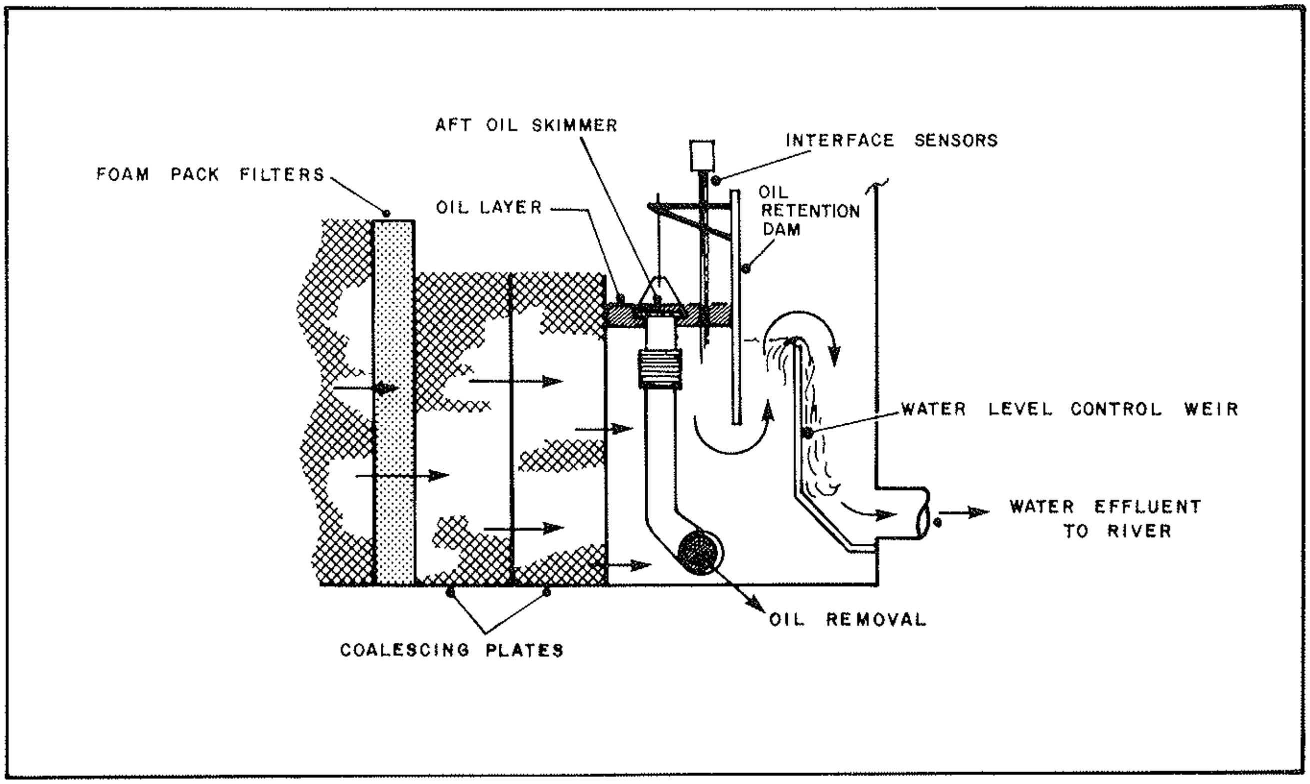

Fig. 5 - The OPC-3000 Influent Section

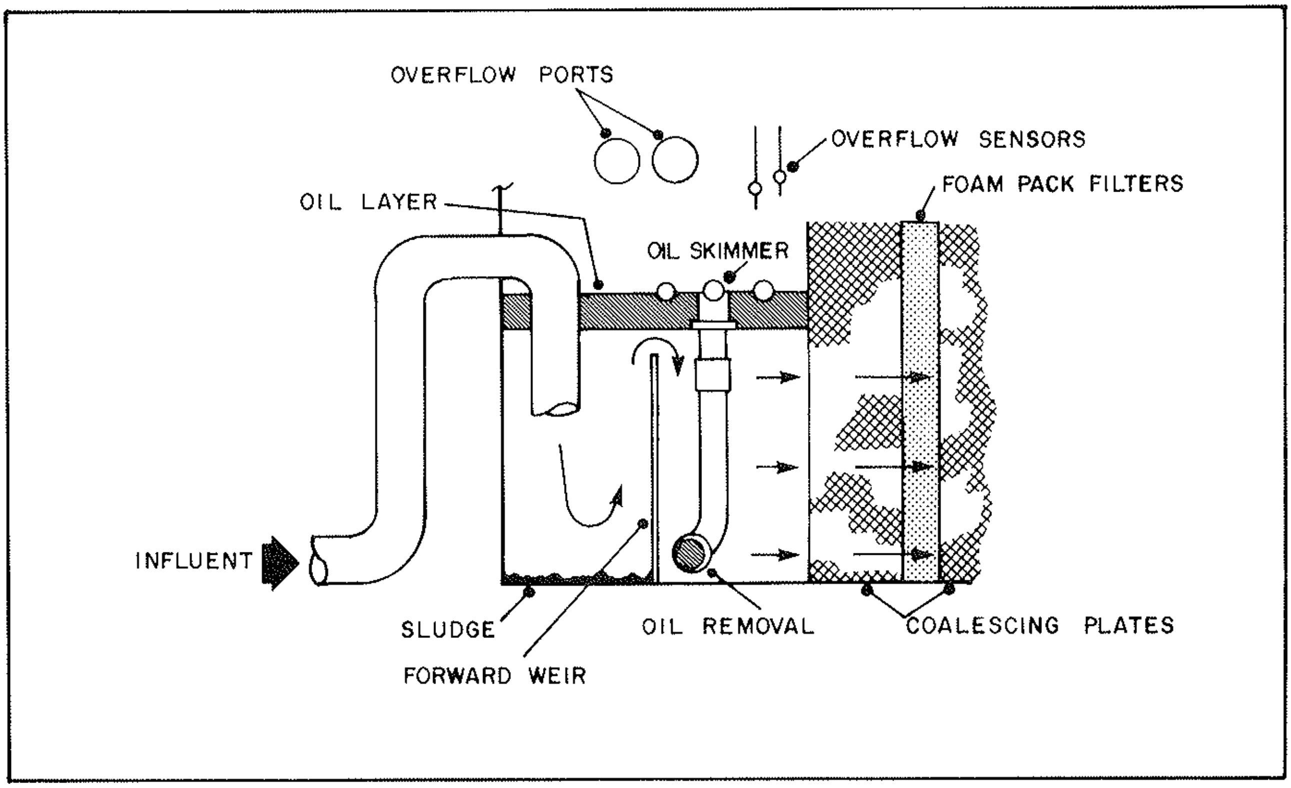

Fig. 6 - The OPC-3000 Effluent Secton

- The OIL HOLDING TANK - 13 feet long, 8 feet in diameter. This 5,000-gallon tank provides a reservoir for oil reclaimed from the oily wastes. Periodically, a pump evacuates a portion of the oil and directs it to the Craney Island oil reclamation tanks.

- The OIL MONITOR SHACK - A Horiba OCMA-32 Continuous Oil Content Monitor is housed in this shack adjacent to the water effluent pipe. Water which meets established effluent criteria is discharged into the Elizabeth River.

- The CONTROL PANEL - The center of operator activity, with valve controls and status displays.

OPERATIONAL DESCRIPTION

The OPC-3000 Oil-Water Separator has been installed on a branch of Craney Island's standard oily waste handling pipeline so that oily waste may either be treated by the separator or bypassed to existing storage tanks. The fluid schematic shown in Figure 3 illustrates the piping of the separator system. With this piping configuration the Separator may draw its influent directly from the pier where ships connect into the oily waste line, or from storage tanks where oily wastes previously have been collected. The Separator is brought on line by closing the automatic bypass valve and opening the automatic effluent valve shown in Figure 4. Other components of the influent piping system include a duplex strainer which removes large particles commonly found in sludge barge oily waste; a flow control valve which limits the maximum flow arriving at the separator to 3,000 gallons per minute; a flow meter; and a manual valve which isolates the influent pipe section for periodic maintenance. The two automatic valves respond in all emergency situations by shutting off influent to the Separator and bypassing the flow to existing storage tanks.

Once through the influent piping, the oily wastes enter the 23-foot diameter Separator Tank, the first half of which consists of the influent section shown in Figure 5. If the oily waste contains large percentages of oil, much of this oil will separate by gravity in the influent section and be removed by a skimmer which floats approximately three inches below the free surface in the Separator Tank. Sand, pipe scale, and other similar heavy solid particles also settle out of the flow in the influent section. Oily waste water, now free of bulk oil, enters the first bank of coalescing plates. The small oil particles passing between the closely-spaced polypropylene plates are removed from the flow when they strike and adhere to the coalescing plates. Oil detained in this manner gradually forms a film on the plates. Periodically large drops of oil are shed from the oil film on the plates and rise through holes in the stack plates. Further coalescence of small oil droplets occurs as the oily water flows through the coalescing foam packs. Additionally, these foam packs serve as a loose filter to remove some of the finely divided solid particles which may be coated with extremely small oil droplets. The flow now passes through a second set of coalescing plates which further favors the formation of large oil droplets from the extremely small oil droplets remaining. When the flow leaves this second set of coalescing plates, it passes through a short open section in which the large oil droplets shedding off the coalescing plates are allowed to rise to the liquid surface. This bulk oil is skimmed off to the 5,000-gallon storage tank while the water passes under an oil retention dam and into the final effluent section of the Separator. Flow in the second half of the

Separator occurs as is shown in Figure 6. As the effluent water leaves the separator it is automatically sampled and tested for purity by the Oil Content Monitor. Under normal conditions, purity standards - defined as 15 ppm of oil or less - are met, and the effluent water is returned to the Elizabeth River. If the effluent does not meet this criteria, the Separator siphon is shut down, and the influent is rerouted to a large capacity Oil Holding Tank. Subsequent to shut down, efforts are made to determine the cause of system malfunction.

The Electrical Control Panel, located on the concrete pad adjacent to the Separator Tank, serves as a focal point for operating the Separator. From this panel, which is shown in Figure 7, the operator can control all motor driven valves. Lights on the panel not only indicate the position of these valves, but also cue the operator as to what, if any, actions he should take. Inside the Electrical Control Panel is the logic circuitry which coordinates valve motions, responds to emergency conditions, and controls the oil removal pump. Enough flexibility has been allowed in the logic circuitry to permit the eventual incorporation of inputs from the Oil Content Monitor.

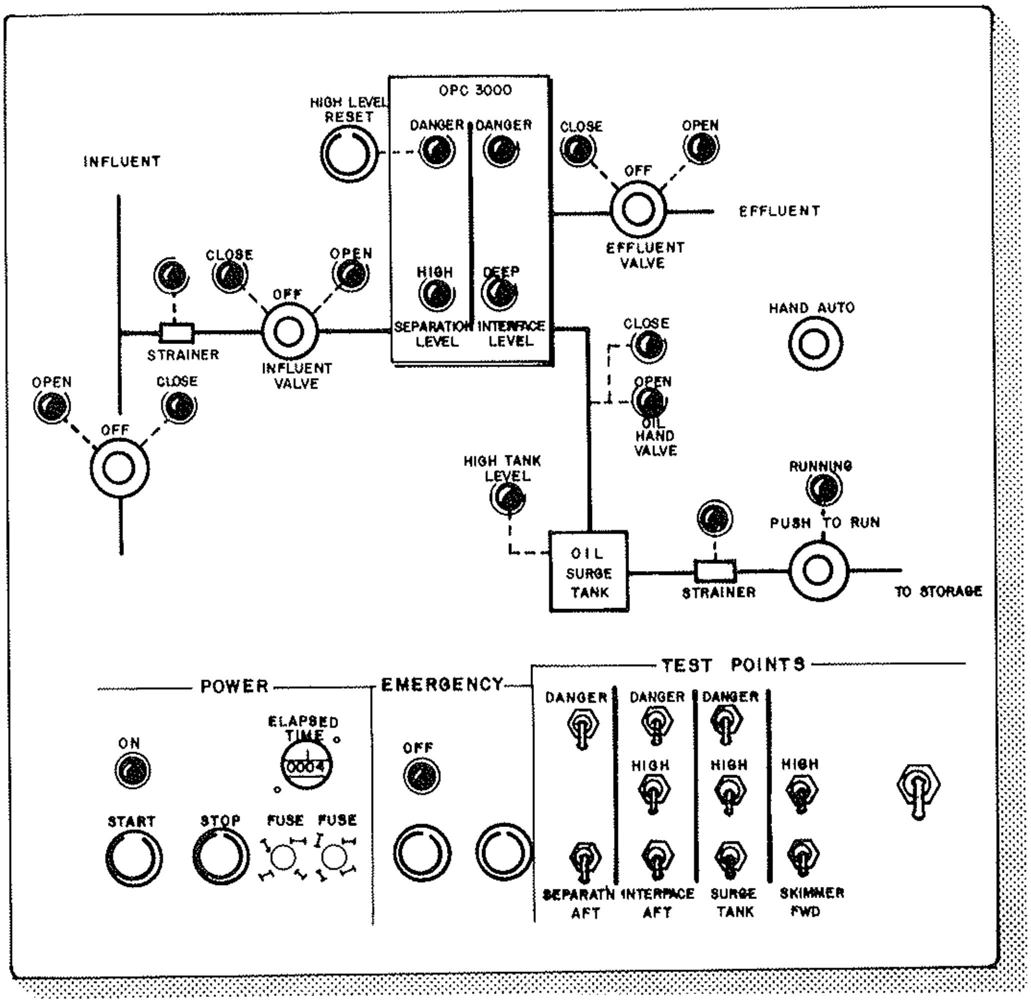

Fig. 7 - The OPC-3000 Control Panel

ACCEPTANCE TESTS AND PRELIMINARY EXPERIENCES

During the autumn of 1976, the OPC-3000 was erected at the Craney Island Fuel Depot and acceptance tests were begun. It should be noted that the scope of these tests was limited to mechanical and electrical performance since the Separator's performance, in terms of effluent purity under the wide range of influents available at Craney Island, was then being evaluated by an NCSL Test Program which was scheduled for completion in October 1977. In November 1976 a 10-inch salvage pump was connected to the oily waste handling line and preliminary tests were performed at 2,200 gallons per minute through the Separator. Although no major problems were detected, several small leaks were noted an repaired in December. While waiting for parts and correcting small construction anomalies during December, the Separator processed a variety of oily wastes including wastes including wastes from the Settler Tanks, "Cooker" Tanks, and sludge barges at Craney Island. Results in terms of separation performance looked promising, but no serious attempt was made to document purity levels. Nonetheless, casual observations led without question to the conclusion that the OPC-3000 greatly outperformed existing installed API Separators in terms of water effluent purity and in manpower requirements. Craney island personnel began to look on this new construction as an asset rather than a scientific novelty.

In early January 1977 the unusually severe winter weather finally took its toll on the Separator. Ice formations in the separator tank crushed the flexible hoses which connect the oil removal skimmers to their respective effluent flanges, and ice in the influent pipe section burst a welded section of the Flow Meter. The Flow Meter was repaired promptly, but a design modification was considered appropriate for the oil removal subsystem.

In early February 1977, in spite of the damaged oil skimmers, final acceptance tests were begun. Two 10-inch salvage pumps were brought on line to move slightly more than 3,000 gallons per minute through the Separator. Under normal operating conditions, all controls operated well, and the hydrodynamic parameters used to size the system correlated closely with design predictions. The Separator responded as expected to intentionally induced emergency conditions, and no further malfunctions were experienced.

The performance of the OPC-3000 was so impressive that final acceptance of the system was made by the NAVY prior to the arrival of spare parts and the repair of the oil removal subsystem.

PERFORMANCE EVALUATIONS

Performance evaluations were begun prior to repair of the oil removal subsystem and immediately following the final acceptance tests. The first deballasting evaluation, however, produced unusual results both in the influent and effluent samples. During the Separator design phase, historical records of deballasting had been analyzed and the design influent parameters had been set to a profile showing high initial and final oil concentrations with a main cycle influent concentration of 50 parts per million. However, actual influent samples taken during the main cycle of the first deballasting revealed concentrations whose average was approximately 20,000 parts per million. The effluent, which was supposed to be less than 10 parts per million, actually ranged between 50 and 135 parts per million. The post-Operational Analysis of this deballasting operation showed that the abnormally high influent concentrations were attributable to diesel oil stored in a section of oily waste handling line which was neither flushed nor isolated from the OPC-3000 Separator prior to commencing the test. It was also found that the abnormally high effluent concentrations were attributable to damage of the oil removal system within the Separator Tank. The aforementioned collapsed flexible hoses, which had not been repaired yet, allowed the thickness of oil collected in the Separator Tank to grow excessively. As separated oil accumulated, the oil/water interface in the vicinity of the oil retention dam dropped to within about four inches of the lower edge of the dam. Hydrodynamic forces at the interface then stripped small droplets of oil from the oil layer and carried them into the effluent water.

Repairs to the oil removal subsystem were made in April 1977. Since that time, tests have included the processing of two tankloads of "butterworthings" (tank cleanings similar to ballast water) and approximately one million gallons of oily waste from tanks and barges at Craney Island. The data collected from performance tests has been separated into two categories: 1) high flow rate deballastings or tank cleanings, and 2) lower flow rate influents from tanks and barges.

The two offloadings of tank cleanings performed in April and June 1977 produced far more realistic results than the earlier deballasting. Although influent concentrations during the main pumping cycle were higher than the design level of 50 parts per million, the effluent purities still fell within acceptable limits of 15 ppm or less. TABLE 2 provides specific information about these operations.

TABLE 2 OPC-300 PERFORMANCE: TANK CLEANING

Ship	Date	Flow Rate (GPM)	Influent Concentration(1) Average	High	Low	Effluent Concentration(2) Average	High	Low
AO-98 (Caloosahatchee)	6 Apr. 1977	1,500-2,000	3.7%	70%	2.5%	4.3	15.1	3.8
AO-99 (Canisteo)	9-10 June 1977	2,000-2,500	0.085%	100%	0.070%	9.2	13.3	8.9

NOTES: (1) 1% = 10,000 mg per liter (2) mg per liter

An important observation made during the unusual deballasting operation in February was that the operator had no control over the influent oil concentration. He did, however, have control over the routing of the influent (through the Separator or to Storage Tanks) and always had the option of reducing the flow rate by partially closing the manual influent valve. To date, the flow rate has only been reduced when the influent oil content has been above about 20 percent at the end of the off-loading cycle.

On one occasion the Separator was exposed to a chemically stabilized emulsion in which a significant amount of oil was contained in droplets less than five microns in diameter. Processing this oily waste at approximately 750 gallons per minute, the Separator reduced the influent concentration of approximately two percent oil to approximately 160 miligrams per liter. Because the emulsion was so stable, it met the "no sheen" criteria, but the high oil concentration was detected by the Oil Content Monitor. The need for additional treatment or preventative measures against chemically stabilized emulsions are discussed in the conclusions.

The more routine oily wastes at Craney Island come from three generic sources:

1) Settler Tanks which hold approximately 2 million gallons of oily waste. Several of these large tanks at Craney Island have historically been used to receive bilge water and ballast as well as wastes delivered by barges. In the past their contents were slowly drained through API Separators between deballastings or tank cleanings. Oily waste in the settler tanks typically contained moderate amounts of finely divided solids with some having a pronounced sulphide odor. Waste from Settler Tanks may be gravity fed and processed by the OPC-3000 at rates up to about 800 gallons per minute.

2) "Cooker" Tanks used to heat reclaimed oil in order to reduce the water content of the oil. The water collected in the bottom of these tanks may be gravity fed and processed by the OPC-3000 at approximately 400 gallons per minute. The influent is usually about 120°F and may contain a small amount of solids.

3) Barges used to collect and transport oily waste from nearby Naval Activities to Craney Island for disposal. The older barges deliver an unpredictable mixture of oil, water, detergent, and solid debris at rates up to about 1,500 gallons per minute. The newer Ship Waste Offload Barges (SWOBs) deliver a somewhat cleaner product at less than 500 gallons per minute.

These wastes, because of their solids content and the presence of small amounts of detergent-like compounds, pose a more difficult problem than do the relatively clean ballast and tank washing products. Experience in handling these oily wastes since May 1977 (after the oil skimmer repairs) is presented in TABLES 3, 4 and 5. The data presented in these TABLES do not include the tank cleanings described in TABLE 2. The data are based on a total throughput of 1.2 million gallons. The chemically stabilized emulsion discussed previously is also excluded from the statistics because it presents a radically different problem requiring a separate solution.

TABLE 3 OILY WASTE SOURCES

Source	Percentage of Total Throughput	Approximate Influent Oil Content
Settler Tanks	76%	500 mg/l
"Cooker" Tanks	9%	500 mg/l
Barges (SWOB)	3%	200 mg/l
Sludge Barges	12%	1600 mg/l

TABLE 4 FLOW RATES

Flow Rate Range	Total Throughput
0-300 GPM	11%
300-600 GPM	27%

TABLE 5 EFFLUENT PURITY LEVELS - CUMULATIVE DISTRIBUTION

27% of the effluent gallons contained less than 5 mg/l.
76% of the effluent gallons contained less than 10 mg/l.
85% of the effluent gallons contained less than 15 mg/l.
99% of the effluent gallons contained less than 25 mg/l.
100% of the effluent gallons contained less than 30 mg/l.
600-900 GPM

CONCLUSIONS

The OPC-3000, now operational at Craney Island, uses technology that was not available at the time the NAVY first laid plans to comply with the FWPCA water quality standards. Its success in treating the vast majority of oily wastes at Craney Island should make the coalescing plate configuration an attractive alternative for shore reception facilities in the planning stage. While it is true that tertiary treatment or "on-line" chemical pre-treatment may be required for chemically stabilized emulsions, it is evident from the results of the OPC-3000 performance evaluations that most oily wastes can be treated in real time, producing a legally-dischargeable water effluent.

Tank cleanings, which would otherwise be stored at Craney Island, also have been treated by the OPC-3000. Their "on-line" real time processing has eliminated the need for both large volume storage tanks and the additional manpower that would be required for subsequent treatment through the API Separators at a greatly reduced flow rate. Similarly, sludge and SWOB deliveries have been treated without the need for intermediate storage.

Oily wastes currently contained in Settler Tanks and "Cooker" Tanks have also been processed by the OPC-3000. The evacuation of these tanks has led to the possibility of returning at least one 50,000 barrel tank from waste storage to oil storage service.

REFERENCES

1. Hura, M. and S. Finger, "U.S. Navy R&D Efforts in Support of Oil Pollution Abatement Strategies," Proceedings 1977 Oil Spill Conference, pp. 61-63.

2. Smooker, A.L., J.W. Warden and P.D. Conroy, "Navy Development of Suitable Shipboard Bilge Oil-Water Separator," Proceedings 1977 Oil Spill Conference, pp. 423-428.

SPILL TECHNOLOGY NEWSLETTER

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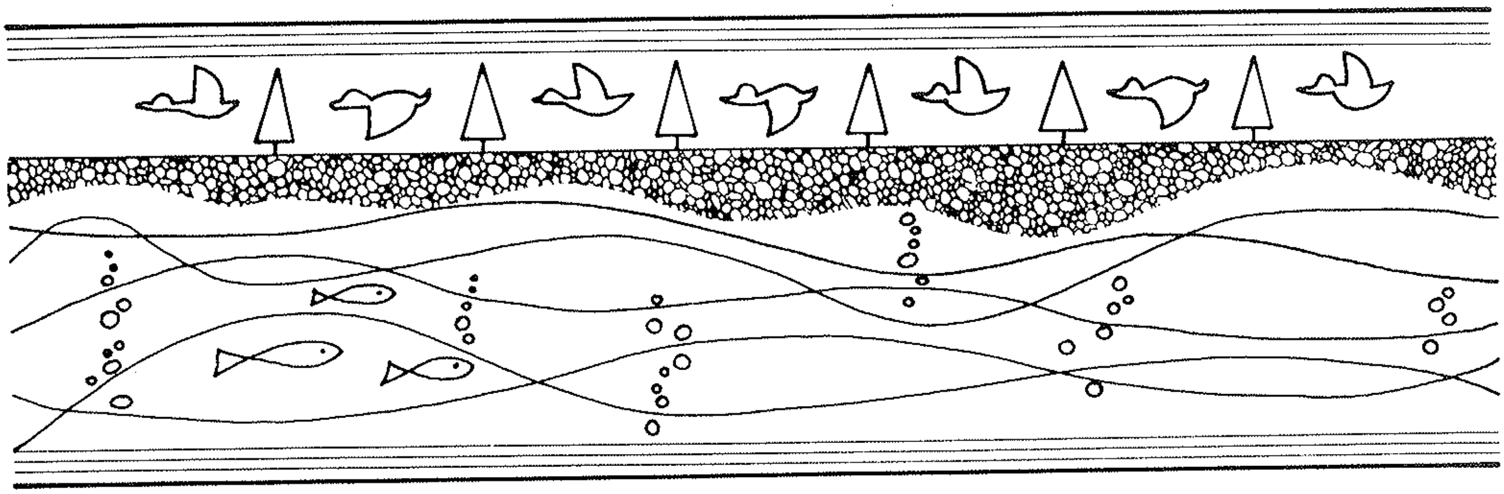

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Spill Technology Newsletter

EDITORS

Dr. S.L. Ross & Mr. M. Fingas

Research and Development Division
Environmental Emergency Branch
Environmental Impact Control Directorate
Environmental Protection Service
Department of Fisheries and The Environment
Ottawa, Ontario
K1A 1C8

Phone: (819) 997-3921

The Spill Technology Newsletter was started with modest intentions in 1976 to provide a forum in Canada for the exchange of information on oil spill countermeasures and other related matters. The interest in it was such that we now have almost 2,000 subscribers in Canada and around the world.

To broaden the scope of this newsletter, and to provide more information on industry and foreign activities in the field of oil spill control and prevention, readers are encouraged to submit articles on their work and views in this area.

INTRODUCTION

We have experienced lately a dearth of articles submitted to the Newsletter. It could well be that potential contributors are busily occupied preparing papers for the upcoming, all-important Los Angeles oil spill conference in March. Whatever the reasons, dear readers, we make the appeal:

PLEASE SEND US ARTICLES

Fortunately we were able, with some arm-twisting, to collect four articles for this issue that you will find interesting. Two submissions by Brian Mansfield of the Environmental Emergency Branch and Jim Hoffman of Emergency Planning Canada discuss the government's oil spill contingency plan for the southern Beaufort Sea, and two response exercises that took place in 1976 and 1977 to test and further refine that plan.

An article by Ken Meikle discusses the role of Air Cushioned Vehicles in oil spill cleanup operations.

And we have a short but stimulating article from Dr. Bob Skinner that continues the debate on the question: "Why Clean-Up Oil Spills".

For the next issue we hope to have a detailed review of all the technical projects being carried out by the Environmental Emergency Branch in this fiscal year (April 1978 -March 1979). It should be available in about one month's time.

P.S. PLEASE SEND US ARTICLES

REPORTS AND PUBLICATIONS

●The Environmental Emergency Branch has released two new publications: the titles and abstracts of which appear below. These publications may be obtained upon request from:

Publications Coordinator,
Environmental Impact Control Directorate,
Environmental Protection Service,
Ottawa, Ontario.
K1A 1C8

Arctic Oil Spill Countermeasures Logistics Study: Summary Report (EPS 3-EC-78-8)

The Summary Report is one of two major reports submitted as part of the Oil Spill Countermeasures Logistics Study of the Transportation Infrastructure. This is one of the projects commissioned by the Department of Fisheries and the Environment as part of the Arctic Marine Oilspill Program. The objective was to compile a consolidated reference describing the air and surface transportation systems currently serving Northern Canada. The reference will be used as a basis of oilspill countermeasures equipment design. A separate Analysis Report also forms part of this project.

The Summary Report provides tabulated listings of the various aspects of the transportation infrastructure for which information was collected. The study involved collection data for the air system, marine system, land system and communities in the north.

The air system information includes tabulations of the characteristics of the aircraft available for use in the north in terms of their classification as heavy, medium or light transports or helicopters. Of importance also is the summary of the companies presently operating in the north and their types of licence. The report includes a description of the air strips available for operations in the north and the contacts and sources from which the information was gathered. A section is included on special technology and future developments for the air system and the marine and land systems.

The summary of the marine system includes tabulations of the available vessels which have had experience in the north, the government agencies and companies operating in the north, and a more detailed description of the ports and anchorages which would be available for use in the event of an oil spill. This includes the description of the degree of shelter and anchorage. As before, there are descriptions of the sources and contacts and special technology in future developments in the marine system.

The summary of land systems includes a description of the rail access to the north, the road access to the north, the possibility of use of air cushion vehicles and, as before, sources and contacts and future developments. The summary of communities in the north describes the population, location and facilities available.

The information included in this report and the Analysis report has been summarized by region within the Arctic. Five separate regions have been considered:

Western Arctic
Eastern Arctic
High Arctic
Hudson Bay/Ungava/Foxe Basin
Labrador Coast

This has been undertaken to provide a convenient basis for comparison of the various systems within a given area.

Arctic Oil Spill Countermeasures Logistics Study: Analysis Report (EPS 3-EC-78-9)

This report is the second of two major reports submitted as part of the Oil Spill Countermeasures Logistics Study Transportation Infrastructure. This study was commissioned by the Department of Fisheries and the Environment as part of the Arctic Marine Oilspill Program. The objective was to compile a consolidated reference describing the air and surface transportation systems currently serving Northern Canada. This reference will be used as a basis for oilspill countermeasures equipment design.

The first report summarizes the information gathered. This one, the Analysis Report, provides an analysis of the air systems, marine systems, land systems and community facilities available in the north.

The analysis of the air systems includes a description of the aircraft in terms of the payload available, the maximum package size which the aircraft can take and the requirements for a full load landing and take-off under Canadian Transport Commission regulations.

Companies operating in the north are described in terms of the type of service offered by these companies as licenced by the Canadian Transport Commission. The airports are rated according to the availability of fuel, the length of runway and the instrumentation available to aid landing.

The analysis of the marine system includes a description of vessels in terms of their payload and a rating of the vessels for use in an oil spill program. The companies operating in the Arctic are also listed and the marine ports rated according to their viability for use in such a clean-up program. The navigation season and the maximum ice cover in late May and mid-September are described graphically.

The analysis of the land system includes a description of rail capacities and roadway capacities in terms of the boxcar and truck semi-trailer freight package size that can be accomodated. In general the land mode is not likely to be usable for access to the oil spill areas in the Arctic before 1979. The analysis of the communities in the north includes a comparison of the medical services available, the population and a ranking of the cummunities as support bases and operational bases.

The final chapter of this report includes description of the possible choice of mode for transport of men and material to the site of an oil spill and the rating of individual sites either for the purposes of operation centres or supply centre.

4

The following reports are available from the U.S. Department of Commerce, National Technical Information Service, Springfield, Virginia, 22161, telephone (703) 321-8543. Most reports are also available on Microfiche at $3.00 each (U.S.A. Price). Canadian buyers add $2.50 to each paper copy and $1.50 for each microfiche report.

"Response of a Salt Marsh to Oil Spill and Cleanup: Biotic and Erosional Effects in the Hackensack Meadowlands, New Jersey," P.C. Dibner, URS. Co., San Mateo, California. June, 1978. 62 p. PB-285 211/9SL $5.25

"Oil Spill in Bermuda: A Case-study of Effective Litigation." T.D. Sleeter and J.N. Butler, Harvard University, Cambridge, Massachusetts. 1978. 5 p. PB-285 365/3SL $4.00

"Oil Spills: The Policy of Prevention and the Strategy of Recovery." J.M. Conrad, Massachusetts University, Amherst. October, 1977. 97 p. PB-285 931/2SL $6.00

"Techniques For Mixing Dispersants with Spilled Oil." G.F. Smith, Mason and Hanger-Silas Mason Co. Inc., Leonardo, New Jersey. June, 1978. 50 p. PB-285 679/7SL $4.50

"Clean-up Efficiency and Biolgical Effects of a Fuel Oil Spill in Cold Weather: The 1977 Bouchard No. 65 Oil Spill in Buzzards Bay, Massachusetts." E. Schrier, URS Co., San Mateo, California. July, 1978 203 p/ PB-286 362/9SL $9.25

"Tank Barge Oil Pollution Study." A. Bender, G.G. Brown and J.M. Rosenbusch, Automation Industries, Inc. Silver Springs, Maryland. February, 1978. 69 p. AD-AO59 116/4SL $5.25

"Infaunal Benthos of Petroleum-Contaminated Sediments: Study of a Community at a Natural Oil Seep." R.B. Spies, P.H. Davis and D.H. Stuermer, California University, Livermore. May, 1978. 16 p. UCRL-8044 $4.00

"American-Soviet Symposium on the Biological Effects of Pollution on Marine Organisms (1st)." May, 1978. 176 p. PB-285 923/9SL $9.00

"Control of Volatile Organic Compound Leaks from Petroleum Refinery Equipment." K.C. Hustvedt, R.A. Quaney, and W.E. Kelly, Environmental Protection Agency, Research Triangle Park, North Carolina. June, 1978. 72 p. PB-286 158/1SL $5.25

"Evaluation of Hydrocarbon Emissions from Petroleum Liquid Storage." P.R. Peterson, P.S. Bakshi, A. Kokin, and L. Norton, Pacific Environmental Services, Inc., Santa Monica, California. March, 1978. 138 p. PB-286 190/4SL $7.25

UPCOMING CONFERENCES

- The Scottish Marine Biological Association is sponsoring a meeting on "The Marine Environment of Sullom Voe and Implications of Oil Developments". The meeting is being held to collate the results and observations from the various scientific studies carried out in Sullom Voe over the past few years. The meeting is divided into five sessions dealing with: the physical and chemical environment, the marine biology of Sullom Voe, studies on Shetland vertebrates, pollution and monitoring, and Sullom Voe and other oil terminals. The meeting will be held at the Dunstaffnage Marine Research Laboratory, Oban, Argyll, Scotland on 18 and 19 April, 1979. For further information contact:

  The Secretary, S.M.B.A. Meeting,
  Dunstaffnage Marine Research Laboratory
  P.O. Box 3
  Oban, Argyll
  PA34 4AD

- The Society of Petroleum Industry Biologists has issued a call for papers for the second annual meeting on the topic of ecological damage assessment. The conference will be held 12-14 November, 1979 and the deadline for abstract submission is March 1, 1979. Authors are asked to submit 3 copies of a three-page-maximum abstract which should include a summary of the purpose of the study, a synopsis of methods used and a summary of significant findings. These abstracts are to be submitted to:

  Dr. Geraldine Cox
  American Petroleum Institute
  2101 L Street, North West
  Washington, D.C. 20037
  Telephone: (202) 457-6368

- The Vancouver Island Section and the Analytical Chemistry Divison of CIC, in cooperation with the Institute of Ocean Sciences, Sidney, British Columbia, the University of Victoria, the Province of British Columbia, are sponsoring a two day symposium devoted to discussion of the directions for "Marine Chemistry" in the coming decade. The symposium will be held on May 31 and June 1, 1979 at the University of Victoria. The program includes four plenary speakers and 12 guest speakers. Contributions for poster sessions will also be solicited. Those wishing further information and registration forms are asked to contact:

  Dr. J.A.J. Thompson
  Institute of Ocean Sciences
  P.O. Box 6000
  Sidney, British Columbia, V8L 4B2
  Telephone: (604) 656-8408

- The "1979 Conference on Control of Hazardous and Toxic Materials in the Environment" will be held March 22-23, 1979 at Miami Beach, Florida. For further information contact:

Hazardous Materials Control Research Institute
4843 Broad Brook Drive
Washington, D.C. 20014

- The "1979 Offshore Technology Conference" will be held April 30-May 3, 1979 in Houston, Texas. For further information contact:

Offshore Technology Conference
6200 North Central Expressway
Dallas, Texas 75206

- The "1979 Southwestern Conference on Control of Spills of Oil and Hazardous Materials" will be held May 3-4, 1978 in Corpus Christi, Texas. For further information contact:

George Oberholtzer
National Spill Control School
Corpus Christi State University
6300 Ocean Drive
Corpus Christi, Texas 78412

- The "1979 Northeastern Conference and Exhibition on Control of Chemical and Oil Spills" will be held in May, 1979 in Providence, Rhode Island. For further information contact:

Hazardous Materials Control Research Institute
4843 Broad Brook Drive
Washington, D.C. 20014

- The "1979 Oil Spill Conference" will be held 20-22 March, 1979 at the Hotel Bonaventure, Los Angeles, California. Further information on this conference can be obtained by contacting:

Mrs. Pat Shenkle or Dr. C. Bates, Program Chairman
Suite 700, 1629 K Street, North West
Washington, D.C. 20006
Telephone: (202) 296-7262

The conference will be composed of 4 sessions being held simultaneously. The following is a preliminary schedule on events:

Tuesday, 20 March, 1979

<u>Room 1</u>

<u>MORNING</u> - <u>TRAINING & PREVENTION</u>

205 (Spill Prev. & Cont. Trng., Oberholtzer, Oil Spill Cont. School, TX) 15 min.
012 (Texas A&M's OSC Course, Payne, Texas A&M) 15 min.
024 (Firemen Trng., Canadian, Duerden, Dept. of Fisheries & Envt.) 15 min.
115 (SPCC Practices at Small Facs., McCracken, Sciences Appl. Inc.)
099 (OS Prev. & Cont. at Naval Shoreline Acts., Hansen, SCS, Wash.)

AFTERNOON - CONTINGENCY PLANNING

044 (CP for Offshore Ops., Poley, Shell, Den Haag)
184 (OS Countermeasures, Fraser, Shell, TX)
021 (Computer Searching for CU Equip., Imbrie, USCG)
087 Comparative Risk Assessment for Tanker Spills, Murphy, Envt. Res. & Tech)

OIL SPILL COOPERATIVES

039 (Clean Caribbean Coop, Alberts, Texaco)
101 (Clean Atlantic Assoc., Hubbard, Clean Atlantic Assoc)
153 (Clean Gulf Assoc, Shipmen, Clean Gulf)
197 (Mobilization of Open Water Poll. Response Equip., Ross, USCG) PUBLISH ONLY

Room 2

MORNING

Tanker Panel - Speakers Arranged By:
API, CG, EPA 15 min. each
TANKER POLLUTION CONTROL - ISSUES AND PROGRESS

279 (VLCC Lightering Operations in Southern CA, Wolfson, USCG) PUBLISH ONLY
280 (West Coast Oil Spills: Fact & Fiction, Bright, Port of Long Beach) PUBLISH ONLY

AFTERNOON - SENSING & MONITORING

005 &
253 (Remote Sensing Sys. & AIREYE, White & Plage, USCG)
171 (Airborne OS Surveillance Sys., Backlund, Swedish Space Corp)
185 (Use of Space Tech. in Monitoring OS, Croswell, NASA Langley)
122 &
123 (Remote Sensing in Baffin Bay & Arctic Waters. Neville & Thomson. Canada)
166 (Safety, Analysis of Foreign Tanker Boarding Program, Ecker, USCG)
125 (Source Ident. & Quant., Gruenfeld, EPA)
060 (Chem. Assess. of Levels & Sources of Hydro. Poll. on Georges Bank, Boehm, Energy Resources Co.)

Room 3

MORNING - BIRDS & SCIENTIFIC RESPONSE TEAMS

265 (Effects on Marine Bird Pop., Perry, DOI)
002 (Tanker Traffic on Bird Ecosystems, British Columbia Coast, Vermeer, Canadian Wildlife Service)
227 (Eco. Impacts of OS Cu, Are They Significant, Siva, ARCO)
219 (Scientific Response to OS in Beaufort Sea, Wright, Fish. & Mar. Serv., Canada)

AFTERNOON - SPILL EFFECTS ON NEKTON & PLANKTON

168 (Ecosystem Analysis, Cowell, BP, UK)
029 (Pet. Hydro. as a Mutagen Source, Payne, Newfoundland Bio. Stat.)
259 ("White Eye Syndrome" in Shrimp Exposed to Crude Oil, Minchew, Miss. State)
066 (Sensitivity of Alaskan Marine Organisms to Oil, Rice, NOAA, Auke Bay)
078 (Pet. Hydro. in a Controlled Ecosystem, Gearing, URI)
117 (Relation of PHC Solubility to Toxicity in Algae, Hutchinson, U. Toronto)
251 (Ecological Effects of Oil-Dispersant Mixtures in Fresh Water, Scott, Canada Centre for Inland Waters)

Wednesday, March 21, 1979

Room 1

MORNING - LEGAL & FINANCIAL ASPECTS

079 (Legal Overview of CU Ops., Evans, Shell)
121 (Legal Aspects of Oil Fingerprinting, Bents, USCG)
187 (Intl. Liab. & Comp. Regimes, Carves, Exxon)
188 (Internationalisation of Superfund, Vorbach, USCG)
213 (Imp. of Proposed Superfund, Bridgman, USCG)
208 (Imp. of Federal Offshore OS Poll. Fund, Title III of OCS Land Act Amends. of 1978, Beck, USCG)

AFTERNOON - LEGAL-SOCIO-ECONOMIC ASPECTS

053 (Assessment Toward a Methodology, Fricke,East Carolina Univ.)
151 (Eval. of Effects, Juhass, OECD, France)
041 (Litigation, Plaintiff's View, Dubiel, State of California)
152 &
215 (Basis for Spill Penalties, Cahill, Standard Oil, & Brown, Pillsbury, Mason)
209 (Damage Assessment Rulemaking, Fidell, LeBoeuf, Lamb, Leiby & MacRae)
263 (Oil Spill Adjustment, DeNoville, Crawford & Co)
050 (Legal Controls to Prevent Pipeline Spills, Driscoll, DOT) PUBLISH ONLY
119 (Economic Damages from Oil Poll. A Review, Meade, NOAA)

Room 2

MORNING - COLD WEATHER TECHNIQUES

223 (Containment & Recovery Tech. for Cold Weather, Allen, Crowley)
063 &
064 (Cold Regions Spill Response Systems, Schultz & DeBord, ARCTEC)
192 (Valdes Superport Operation, Baylise, Alaska Dept. of Envtl. Conservation)
038 (Prudhoe Bay CP, Shafer, Sohio Pet. Co.)
090 (CU of Cold Weather Terrestrial Pipeline Spill, Buhite, Alyeska Pipeline Co.)
180 (IMPERIAL ST. CLAIR, Oil in Ice, Beckett, Canadian Coast Guard)

AFTERNOON - OIL SPILLS IN ICY RIVERS

004 (Lab. & Theo. Study of Oil Under River Ice, Tsang, Canada Ctr for Inland Water) 10 min.
017 (Novel Ice Oil Boom for Flowing Waters, Vanderkooy, Env. Canada)
196 (Unloading Heating Oil from Holed Barges in an Ice Gorge, Baily, USCG, Paducah) 10 min.
235 (Between a Dam & a Hard Spot -- The Story of Markland Locks in January, 1978, Morrison, USCG, Cincinnati) 10 min.

CLEAN-UP TECHNIQUES FOR RESTRICTED WATERS

035 (Deflectors for Deployment of Oil Booms, Greene, Imperial Oil, Canada)
113 (CU Efficiency of Buzzards Bay Oil Spill of January, 1977, Schrier, Woodward Clyde Con)
108 (OS Cleanup and Control After SS SANSINENA Explosion at Long Beach, CA, Wahbash, IT Corp.) 15 min.
194 (Utility of CU Practices Used in SS SANSINENA Spill, Kopeck, USCG) 15 min.

Room 3

MORNING - PET. IN BENTHIC ORGANISMS

061 (Hydro. in Benthic Fish off Californai, Rossi, Scripps)
032 (Napthalene Uptake by Benthic Amphipods, Anderson, Battelle NW)
037 (Interactive Effects of Phenathrene on Juvenile Mud Crabs, Loughlin, Naval Biosciences Lab)
095 (Effect of Tar on Intertidal Organisms of S. Calif., Straughan, USC)
124 (Exposure to Sublethal Levels of Hydro. off Norway, Bakke, Inst. Marine Res., Bergen)
252 (Biostimulation-Spill CU in Ground Water, Raymond, SUNTECH)
137 (Biodisposal Farming, Weldon, SUNTECH)
202 (Effects of #2 Fuel Oil on Feeding of Mud Snail, Hyland, EPA Narrangensett)

AFTERNOON - PET. IN BOTTOM SEDIMENTS

016 (Pet. in Bottom Sediments of Bermuda, Butler, Harvard)
018 (Assoc. of Hydro. & Suspended Sediments under Arctic Conditions, Shaw, U. Alaska)
052 (Hydro. in New York Bight Sediments, Thomas, Natl. Mar. Fish. Service)
266 (Dis. & Persistence of Oil in Sediments, Gundlach, USC)

AFTER BREAK - LEVELS OF PET. HYDRO. IN NORTH SEA

100 (Detection & Mapping of Spilled Oil, Johnson, NALCO)
229 &
230 (EKOFISK - Fisheries Invest. & Productivity & Chlorophyll A Patterns, Redmond & Hauser, NALCO)
228 (Impact on Biota, Carpenter, NALCO)
146 (Pet. Hydrocarbons, Grahl-Nielsen, Inst. of Marine Research, Norway)

Room 4

MORNING - OIL SPILL MODELING TECHNIQUES

189 (Oil Spill Forecasting--Where Is it Going!, Lissauer, USCG R & D Center)
250 (Motion of Oil on the Sea, Hess, NOAA Tech. Dev. Lab)
080 (Effect of Slicks on Waves, Liu. Flow Research Co.)
046 (Fate of Oil on Georges Bank, Cornillon, Univ. of Rhode Island)
077 (Fate of Oil on the Norwegian Shelf, Audunson, Continental Shelf Inst., Norway)
042 (Fate of Oil Spills in the Arctic Ocean, Venkatesh, Atmos. Envt. Service, Canada)
051 (Oil Spill-Fish Interaction Model, Reed, Univ. of Rhode Island)
013 (CP Riverspill, Tsahalis, Shell)

Thursday, 22 March, 1979

Room 1

MORNING - CONT. PLANNING IN VARIED GEOGRAPHIC REGIONS

081 (10-Yr. Overview-Combating OS on High Seas, Garnett, Intl. Tanker Owners, England)
236 (Balanced Oil Combating Force, Sweden, Engdahl, Swedish Coast Guard)
262 (OS Prev. in Australia, Manuell, ESSO) PUB ONLY
261 (Marine Poll. Cont. Sys. in Japan, Funatani, ESSO)
091 (Dispersant Use in Brazilian Marine Incident, Dewling, EPA)
020 (Oil Poll. Prev. in Soviet Union, McClelland, US TEAM REPORT, USCG)
268 (CNEXO Action Regarding Fight Against Marine Poll. by Hydro., Nounou, CNEXO, France)

AFTERNOON - MARINE DEVELOPMENTS

241 (Monitoring & Cont. in Mediterranean, Boxer, Rutgers Univ.)
254 &
258 (USA Natl. & Regional Response Teams, Clow & Kirkland, USCG)
015 (Major Spill Response Planning for Tanker Ops., Kazmierczak, Sun Co.)
207 (GLOBAL HOPE is Aground, Salem Sound, Mathews, USCG)
190 (Future of CG Poll. Response Prog., Valenti, USCG)
059 (Navy's Oil/Water Separator Prog., Sholander, Dahlgren)
077 (Large-Scale Ballast Waste Treatment, Lysyj, Rockwell Intl.)

Room 2

MORNING - DISPERSANTS

009 (Use of Chemical Disp., Canevari, Exxon)
027 (Behavior & Effectiveness of Disp. at Sea & At Shorelines, Mackay, Univ. of Toronto)
098 (Logistic Planning for Chemical Use, Lindbloom, Exxon)

112 (Manual for Use of Disp., Castle, Woodward Clyde)
177 &
178 (ACW-400 Assessment & Dev. Disp. Spraying Capability, Gill, Canadian Coast Guard)
186 (Use of Aircraft in OS Clearance, Cormack, Warren Spring Lab. Hertfordshire)
231 (SP-PCO Test Prog., David Smith, David Smith Assoc.)

AFTERNOON - NEW EQUIPMENT AND TECHNIQUES

068 (Air-Jet Oil Boom, Cohen, Hydronautics, Inc.)
070 &
073 (Skimming Barrier Perf. Eval. & Boom Configurations, Lichte & Schwartz, Mason Hangar, OHMSETT)
140 (Ozone UV Treatment, Schneider, Rockwell) PUBLISH ONLY
191 (CG ZRV Fast Current Oil Recovery Sys., Becker, USCG)
023 (OS Debris Disposal Hardware Sys. Hansen, SCS)
129 (Williamsport, PA OS Cleanup, Villaume, PA Power & Light Co.)
278 (Effects of Rep. Oil Recovery Vessels of Opp. on Surface Oil Fate & Behavior, Kraus, Univ. of CA) PUBLISH ONLY

Room 3

MORNING - FIELD OPERATIONS

030 (Effects of Seto Inland Sea Spill, Hiyama, Univ. of Tokyo)
036 (Hydro. Dist. at Tropical Oil Spill, Page, Bowdoin College)
127 (Chem. Invest. in Estuarine Ecosystems, Bieri, VIMS) 10 min.
169 (Eco. Monitoring in Port Valdez, Cowell, Soc. of Pet. Biologists, England)
221 (Wind Wave & Turbulence Observ., Shonting, Naval Underwater Systems Ctr.) 15 min.
243 (Sea State Limit of Oil Slicks, Raj, A.D. Little) 15 min.
174 (Val. of Microcosm Approach, Pilson, Univ. of R.I.) PUBLISH ONLY
260 (Tidal Simulation System, Johnson, Miss. St. Univ.) PUBLISH ONLY

AFTERNOON - CASE HISTORY: AMOCO CADIZ

198 (AMOCO CADIZ--CU Techniques, Massart, France)
114 (Cleaning Products Used in AMOCO CADIZ, Croquette, CNEXO) 15 min.
165 (Resource Requirements for AMOCO CADIZ, Hann, Texas A&M)
143 (Chem. Charact. of Samples, Overton, Univ. of New Orleans)
199 (Eco. Effects on Pelagic & Benthic Comm., Ecological Team, France)
AMOCO FILM - "The Spill 68 Days After"
200 (Pet. Poll. in Sediments, Marchand, France)
089 (AMOCO CADIZ, Coastal Processes, Hayes, Univ. of S.C.) 5 min.

BRIEF NOTES

- The State of Sao Paulo in Brazil has set up an organization known as the "Coastal Protection Committee (Codel)" under the authority of the Ministry of Works and Environment. The committee consists of representatives from 10 different departments and has the following functions; to propose studies with the purpose of improving the quality of the coast, to propose plans and standards for emergency action in cases of accidents involving polluting agents, to prepare guidelines for ongoing activities and to prepare internal regulations.

"WHY CLEAN UP OIL SPILLS?" - ANOTHER VIEWPOINT

Submitted by: R.G. Skinner
Departmental Environmental Coordinator
Energy, Mines and Resources Canada
Sir William Logan Building
580 Booth Street
Ottawa, Ontario
K1A 0E4

Editors' Note: This article is a comment on two articles which appeared in past issues of the Newsletter, one by D. Mackay in Vol 3, No. 4, the other by E. Levy in Vol 3, No. 5.

Levy's response to Mackay's article is fascinating because I think he is serious - it is as defensive as Mackay's was tongue-in-cheek (Churchill might have said 'offensive').

Mackay raises a valid question for which I think there is already implicitly an answer. Society cleans up oil spills, for the time being at least, because society believes it can afford to, or put another way; our pious perception of ourselves makes us think that we can not afford not to.

Having got that straight, I would like to know how a "massive clean-up problem (can be) avoided by having conducted (such) environmental studies" as the Beaufort Sea Program and EAMES. Most of the studies under these programs, especially the latter, related to the impact of a presumed blow-out, not prevention. If counting birds, measuring the hydrocarbon content of sea water and painting numbers on Polar Bears' bums constitutes oil spill prevention, then Boots and Coots and poor old Red would have been out of work a decade ago. These studies are perfectly valid things to do for a variety of reasons but prevention they are not. The only way they could prevent an oil blow-out is if they revealed a snail darter or such a concentration of threatened species that a no-drill decision is made ... but that's another story.

A popular report in the Beaufort Series was one on sub-sea permafrost. Ask Canmar whether any of their drilling problems were due to permafrost. Yet, the Beaufort Sea planners would not approve funding for the permafrost study - it was funded elsewhere. Thus, while I agree with Levy's view that the economic argument lies in prevention, most of these offshore environmental baseline studies do not nor did they pretend to constitute prevention.

What of the sea birds that get "soiled with an amount of oil which is hardly apparent on a casual inspection (but) which ... is sufficient to lead to the birds' slow and painful death ..." (my emphasis). How do all of Dick Brown's floating fledgling sea birds make it through the natural oil slicks off North Baffin?

I am afraid we clean up oil slicks because we are told we can not afford not to. There is a sufficiently vocal public constituency that demands it, which is in symbiosis with a sufficiently energetic bureaucracy and an imaginative academe which depend on its being kept a concern. This, Dr. Levy, is the ecosystem most affected by oil spills and if society answers Professor Mackay in the negative, the symbiont will be in serious trouble.

AIR CUSHION VEHICLES (ACV'S) AND OILSPILL CLEANUP OPERATIONS

Submitted by: K.M. Meikle, P. Eng.
Environmental Emergency Branch
Environmental Protection Service
Department of the Environment
Place Vincent Massey, Hull, Quebec K1A 1C8
Phone: (819) 997-1788

Canada has been actively investigating practical applications for air cushion vehicle technology for many years. Achievements include the evolution of ice-breaking capability, production of the Bell Voyageur, implementation of an air cushion ferry service, an operational CCG search and rescue unit, and commercial hovercraft transportation operations by Northern Transportation Co. Ltd. (NTCL) in the Mackenzie Delta/Beaufort Sea sector of the western Arctic.

It is only natural then that consideration should be given to the use of air cushion vehicles for cleanup operations in the event of a major oil spill, especially in the Canadian Arctic where communities are few and far between and access is extremely limited.

Accordingly, in the first year of the Arctic Marine Oilspill Program (AMOP), two separate contracts were let to develop design concepts for the use of ACV's as platforms for oilspill cleanup in ice-infested waters. The primary objective was to determine feasibility, capability and probable cost involved.

One of the contractors was German and Milne, Naval Architects, in consort with Bell Aerospace Division of Textron Canada Ltd. and Fenco Consultants Ltd., who proposed to develop a system based upon the Bell Voyageur and its demonstrated Arctic operating capability (references 1 and 2).

The second contractor was Hoverlift Systems Ltd. of Calgary who proposed to apply the experience gained in the development of a 120-tonne gross weight vehicle ferry for the Peace River crossing at La Crete, Alberta, and an icebreaking bow for a St. Lawrence Seaway Authority tug.

One objective of the studies was to make best use of the ACV's unique capabilities. To that end, both contractors were given the option of using the ACV simply as a platform to transport skimmers and other countermeasures equipment to and from the scene and serve as a "mothership" for operations, or to convert the ACV itself into an oil-skimming vehicle.

Regardless of the approach selected, the vehicle was to be able to survive at sea in moderate gale conditions (significant wave height 5.5 m) and be capable of effective oil recovery operations under the following conditions:

a) open water and 12 knot winds (significant wave height 0.7m);
b) open pack ice (up to 6/10 ice cover);
c) open leads and polynya;
d) frazil, brash, nilas and pancake grey ice up to 3m across and 15cm thick.

In addition, the vehicle was to operate efficiently at temperatures from -15°C to 10°C, its maximum draft was not exceed 2m, it was to be resistant to salt water corrosion, and all operating personnel on board were to be adequately protected from the elements.

The oil recovery system was to be optimized for unemulsified medium gravity crude oil that had weathered on the water at 0°C for 2 days, by which time it was to be assumed that the specific gravity of the oil would be 0.914 and its pour point would be 1°C. A corresponding minimum oil recovery rate of 275 litres (72.5 US gals) per minute was specified for the open water/12 knot wind condition at a sea temperature of 1°C, and the oil content of the recovered fluid was to be at least 75% by volume.

Both contractors concluded that an ACV oil recovery vehicle could be developed to satisfy the specified requirements.

The German and Milne et al concept mounted a specially designed 6.8m wide wire brush zero relative velocity belt recovery device over the bow of a Bell Voyageur. The ACV would operate on-cushion at a forward speed of about 0.8 km/hr (0.5 knot) and would be able to pass over broken ice without creating an accumulation of ice ahead of the vehicle or the recovery belt. At that speed the escaping air and other cushion effects were not expected to interfere with the recovery of oil. A self-contained processing system would be installed on the deck of the Voyageur to strip the oil from the belt and dispose of it by burning using a flare burner. The cost to design and install the system was estimated to be $1.1 million.

The hoverlift Systems Ltd. concept employed a large-payload air cushion transporter to carry skimmers, booms, pumps, temporary storage and incineration equipment sufficient to deal with a 2500 barrel per day oil blowout. Two alternatives were offered:

a) a special-purpose vehicle optimized for oil recovery operations with a payload of 90 tonnes, design calm water speed of 70 km/hr (38 knots), and able to perform alternative functions to the extent of its capability.

b) a vehicle optimized for commercial transport operations but adaptable for oil spill cleanup work as required; its payload would be 227 tonnes and its cruising speed over ice would be 32 km/hr (17 knots).

The purchase cost of the special purpose vehicle was estimated to be 6 to 8 million.

It was not the intent initially to proceed beyond the concept design and cost estimation stage, and there are no plans to do so now that the studies have been completed. However, to confirm the feasibility of recovering oil while operating an ACV "on cushion" at low speed, the Canadian Coast Guard Air Cushion Vehicle Evaluation and Development Unit at Montreal, Quebec was tasked to determine how close a Voyageur can approach an oil slick without disturbing the oil. Target-of-opportunity slicks were to be used and estimates rather than precise measurements were acceptable. The CCG's own Voyageur, which is fitted with a spray-suppression curtain, was to be used for the trials.

Only one suitable slick was encountered and it consisted of a middle-distillate oil. On the basis of the following observations, it was concluded that the action of the air cushion on the oil slick would not prevent recovery operations being conducted from the craft:

a) When the craft moved over the slick on full cushion at slow speed, some of the oil was blown aside to about two to three feet from the craft; the remainder of the oil in the path of the craft was partially emulsified with the water under the craft. A small amount of oil was detected in the air circulation at cab level (sketch A).

b) When the craft was in the boating mode or on reduced cushion (about 75% to 80% N2) and operating at speeds up to 5 knots, the skirt seal prevented air from escaping and the oil was pushed aside one to two feet leaving a clear track after the craft's passage (sketch B). The craft could also be used as a mobile boom and deflect oil when placed at an angle to the current.

The Canadian Coast Guard has also reported on some further trials to evaluate the capabilities of the hovercraft in the oil pollution countermeasures role. The operation included the loading and unloading of their Bell Voyageur craft with various combinations of available equipment, and conducting practical oilspill countermeasures exercises using the hovercraft as transport and a work platform for each load.

Four days were devoted to the trials and a separate exercise was conducted each day. The craft was evaluated as:

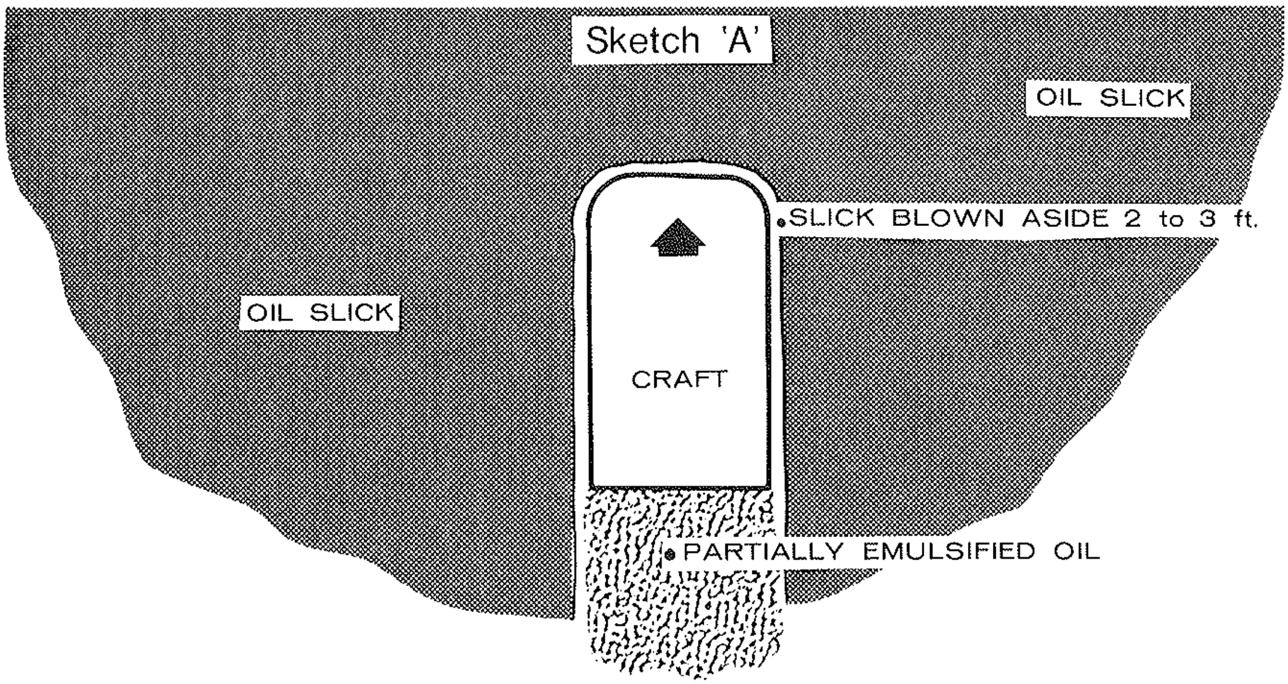
a) a carrier,
b) a work platform, and
c) as a self-sufficient resource craft to perform the following functions without the aid of small boats;
   - lay and anchor booms,
   - tow booms,
   - manoeuver over the top of booms,
   - come alongside another vessel to place transfer pumps,
   - recover booms and anchors,
   - act as an oil deflector, and
   - serve as a communications centre.

Total deck loads carried ranged from 15,700 lbs up to a high of 25,100 lbs. Highlights included:

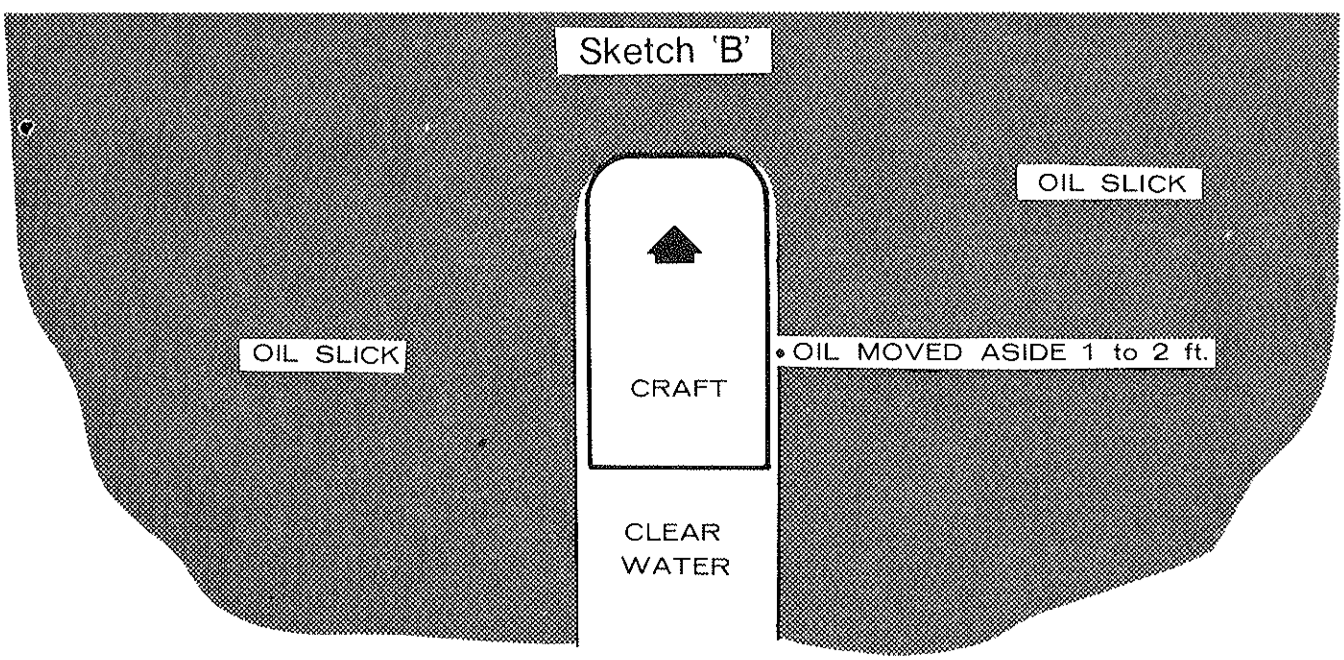
a) Towing 250 ft of 18" Flexy boom at a speed of approximately 20 knots; the boom towed well even during turns, never twisting or becoming entangled in the anti-spray skirt; manoeuvrability of the craft was not affected, even at reduced speed.

b) Dispersion of Oil Blotter sorbent by pouring it in front of an open puff port; the sorbent was blown up to 50 feet away by the escaping air; when dispersed on the surface, the sorbent could be re-directed using the propeller blast from the craft.

c) Recovery operations in water depths of 6 inches to 2 feet.



Craft on Full Cushion
(Slow Speed)



Craft in Boating Mode or at Reduced Cushion
(Slow Speed)

d) Re-enactment of an actual cleanup operation involving the deployment of equipment from Sorel to Trois-Rivières, a distance of about 31.5 nautical miles; it took the hovercraft just 3 hours to bring men and equipment to bear on the simulated incident, whereas it had taken 9 hours to do so for the actual spill.

It was concluded that:

a) The Voyageur and her crew were able to perform all assigned tasks.

b) The craft has many advantages over conventional vessels, primarily those of speed, amphibious nature, low freeboard, freight capacity and stability.

c) A considerable saving in both time and money can be realized by using the Voyageur hovercraft as an oil pollution resource craft.

REFERENCES

1) Transport Canada, "Bell Voyageur 002 ACV Cold Weather Evaluation" August 1974.

2) Transport Canada, "Bell Voyageur 002 ACV Engineering and Commercial Evaluation" -June 1975.

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GOVERNMENT CONTINGENCY PLANS FOR THE BEAUFORT SEA

Submitted by: Mr. Brian Mansfield
Chief, Contingency Planning Division
Environmental Emergency Branch
Environment Canada

Mr. Jim Hoffman
Regional Director
(Alberta/Y.T./N.W.T.)
Emergency Planning Canada

INTRODUCTION

Canada, in common with many other countries, uses more oil than it produces domestically. This petroleum shortfall and its costly answer in imported oil, has resulted in approvals by the Canadian Government for exploratory drilling in remote frontier areas such as the Arctic, to seek energy self-sufficiency for Canada. Exploratory drilling in the shallow offshore waters of the Beaufort Sea was permitted from drillships, starting in 1976 after several previous years of drilling from artificial islands closer to shore. In recognition of the formidable problems to be faced due to the harsh environment, remote location and new technology required, final approval was granted only after intensive study of environmental baseline data, operational risks and potential environmental impacts was made. The most serious potential impact from offshore exploratory drilling in the Beaufort Sea was concluded to be the risk of an oilwell blowout. The concern for such an event arising was considered by Cabinet and resulted in a series of technical and environmental operating conditions being attached to the Drilling Authorities which are the site-specific final approvals to drill a well. This concern also led to two other interrelated initiatives on the part of the Government: (1) to begin an intensive research and development program of new and improved Arctic oilspill countermeasures techniques and equipment; and (2) to develop a "back-up" Government Contingency Plan for major oil spills in the Beaufort Sea. This latter project is the main subject of this paper, although it must be recognized that the ultimate success of the Government contingency plan will depend not only upon its own strengths, but also upon the results of research and development such as the program mentioned above.

PLAN DEVELOPMENT

Government response to spills from ships in Canadian waters is the assigned responsibility of the Canadian Coast Guard. The plan discussed here is intended to cover major non-ship spills, including potential blowouts from drilling operations involving drill ships, but still involves the Coast Guard as a major resource agency.

Although the probability of a major oil spill or blowout occurring is considered low, the potential magnitude and difficulty of the problems involved in logistics, spill response, countermeasures and cleanup in the Beaufort Sea are enormous. The prospective size and complexity of these problems dictated that the government agencies which would inevitably become involved or affected by such a spill should have ready a coordinated plan of response before open-water drilling began in 1976 in the Beaufort Sea beyond the winter zone of land-fast ice. Therefore, beginning at the start of 1976, an inter-agency Task Force, under the Chairmanship of Environment Canada, set out to develop such a plan for the area. The Task Force in the following months worked at producing a workable contingency plan which would:

(a) clearly define various government agency roles and responsibilities;

(b) ensure integration and support of other related plans and committees;

(c) provide guidance on suitable conditions or requirements of the operators contingency plans; and

(d) ensure proper training and evaluation exercises for personnel and plans of both the government and the various operators potentially involved.

This work progressed on paper to a point where, in August, 1976, a gathering of most potential participants was held to meet face-to-face, discuss the draft plan and suggest plan improvements and modifications brought to light through a series of scenario problem sessions and probing written questions on the subjects of communication, logistics and support, field operations and coordination of operations. This meeting was termed the Beaufort Response Exercise No. I or "BREX I". Later exercises (especially BREX III) have been focused toward evaluation of the capacity of the organization to direct and coordinate operations. More details are given on the BREX III exercise in an accompanying article.

PLAN CONTENT

The "umbrella" plan combines the expertise and resources of the Operator, available spill cooperatives, contractors, and a number of governments, their departments and agencies under the overall operational leadership of the Government of Canada. The plan incorporates action plans of the individual agencies or teams which are assigned specific spill responsibilities in the plan. It is also compatible with other Regional Contingency plans and with the Joint Canada-U.S. Marine Pollution Contingency Plan (Annex IV) for the boundary waters area of the Beaufort Sea between Alaska and the Yukon Territory.

Government participation in the plan comes partly from agencies and departments of the N.W.T. and Yukon Territorial Governments. Also included are the federal departments of Indian and Northern Affairs, Transport (Canadian Coast Guard), Fisheries and the Environment, National Defence, Communications, agencies of Energy, Mines and Resources, the Canadian Employment and Immigration Commission, as well as from Labour Canada, Emergency Planning Canada and the RCMP. (Representatives of most of these agencies participated in the inter-governmental, inter-departmental Task Force formed to develop the plan.) The concept of Government involvement and resource commitment is based upon legislative provisions for cost recovery from the operator's posted bonds and liability insurance coverage.

It should be noted at this point that there is a unique feature to this contingency plan. The plan provides for a response organization to deal with a peacetime emergency, in which the resources of the private sector, three civilian governments and the military operate under a single command structure through a Headquarters which integrates all of the agencies participating. This is a unique structure for peacetime emergencies in Canada, and is one which creates a unified task force, with an organization to ensure the efficient direction of all elements. Considerable time and effort have been devoted to the establishment of proper procedures, and to HQ and field responsibilities and staffing.

The government plan could be activated if the spill were judged by a joint government-industry observation team to be beyond the capability of the operator and supporting industry to handle, or if the degree of environmental protection being provided by a non-governmental response was considered inadequate. It is visualized that activation of the Government plan would normally only follow a sequence of:

(a) countermeasure and cleanup operations solely by the operator;

(b) operations with support from other companies and spill cooperatives; and

(c) operations involving some government resources and equipment in support of industry.

Of course, the timeframe for escalation of the situation through these various phases could vary widely, from as much as several weeks to as little as one or two days.

The Government plan initially relies upon two supporting action plans after a spill or blowout has occurred. The first is an initial alerting plan which serves to pass the available spill information from the company personnel through the regional office of the Department of Indian and Northern Affairs to the pre-designated on-scene commander, who can start the alert procedure within the Government plan and then await the reports resulting from the Spill Observation Team, which acts under the second supporting action plan. The Spill Observation Team is comprised of personnel from key government agencies plus the operating company. Based upon this Team's report and recommendations to the Deputy Commissioner of the N.W.T. Government, the government plan could be activated by Order-in-Council through the Minister of Indian and Northern Affairs. The Deputy Commissioner of the N.W.T. Government has been appointed by the Minister as On-Scene-Commander of the joint government action group.

The balance of the Government plan consists of an organization for coordinated operations and problem-solving, with each individual group or team having the responsibility for developing its sub-organization and for preparing and maintaining a supporting procedure or plan for its own area of assigned activities. Among the separate group functions identified for the overall response functions identified for the overall response organization are the following groups identified in the field headquarters at Inuvik:

(a) An on-scene commander (O.S.C.);
(b) a deputy on-scene commander (D.O.S.C.);
(c) an executive assistant to the O.S.C. to handle administrative details;
(d) a legal advisor to the O.S.C.;
(e) three advisory functions dealing with:

i) environmental affairs and scientific advice;
ii) public and community affairs;
iii) rig surveillance;

(f) an operations staff including:

i) a director of operations;
ii) functions for long-range planning, communications, spill surveillance, intergovernmental affairs and liaison with Ottawa;
iii) an operations coordination group, looking after communications facilities, air tasking and operations information;

(g) an administrative support group responsible for administration, finance, personnel and safety;
(h) a logistics support group responsible for resupply of food, fuel and water, for accommodation and food services, repair and maintenance services, and crew/operations transportation.

At the field operations office location, the following groups would be based, if possible, together with the original company operations centre, to supervise the field operations:

(a) a rig operations team under the direction of industry;

(b) a water and ice cleanup operations team, with the combined resources of the Coast Guard, industry, the military and other government agencies;

(c) shore protection and cleanup operations team(s), with combined resources of the governments of the Yukon and Northwest Territories, the Departments of National Defence, Indian and Northern Affairs and other federal agencies.

The above organization is guided in general by certain sections of the overall plan dealing with broad job descriptions, agency taskings, descriptions of major communications systems, procedures for reports and requests, action lists for coordination of activities in the various operating phases, and an operational information system which shows who, where and why information may be provided and requested. An identification of sources of major resource inventories is also given, in summary form, with individuals tasked to assemble and maintain up-to-date information details on these resources.

PLAN EXERCISE BREX III

The third "Beaufort Response Exercise" was the 1978 exercise which went beyond the problem discussion and plan development stage. This exercise was the first true evaluation of the organization and procedures established in the plan. BREX III was more complex than previous exercises in that it required the combined application of organizational, managerial and operational procedures in a simulated setting of field and HQ operations, separated by communications links. Futher details of BREX III are given in an accompanying article.

SUMMARY

A plan has been developed for joint Government-Industry response to a major oil spill. It is the hope of all concerned that the "Government Contingency Plan for Oil Spills in the Beaufort Sea" will never be needed. If it is activated, however, the plan provides the basis for a coordinated response which can be made, involving all available government resources together with those of the private sector, to deal with a very difficult situation.

THE TEST

BEAUFORT RESPONSE EXERCISE - BREX III

Submitted by: Mr. J.M. Hoffman
Regional Director
(Alberta/YT/NWT)
Emergency Planning Canada

Mr. B. Mansfield
Chief, Contingency Plans Division
Environmental Emergency Branch
Environment Canada

EXERCISE BACKGROUND

In the 1970's the Canadian Government decided to issue drilling permits for oil and gas exploration in certain areas of the Beaufort Sea. In recognition of the remoteness of the areas and the potential for damage in the Beaufort ecosystem, the Canadian Government sponsored the development of a plan to deal with a major spill incident or oil well blowout.

This plan, entitled the "Government Contingency Plan for Major Oil Spills in the Beaufort Sea" is directed at combining the resources of the operator, industry and, the federal and territorial governments to deal with a spill which has gone beyond the capacity of the operator or industry. The plan identifies special organizations and procedures in conducting a coordinated operation. It is activated by Order-in-Council. The plan was prepared by a Task Force of six departments chaired by Fisheries and Environment Canada (Environmental Emergencies Branch). Further details on development of the plan are given in an accompanying article.

As part of the development process for the plan, two exercises BREX I, and II (Beaufort Response Exercise) were held in 1976 and 1977. These exercises made use of scenarios and problem-solving workshops to assist in production of the plan.

BREX III was the 1978 exercise designed for the purpose of evaluating the organization and procedures established in the plan. It was more complex than BREX I or II in that it required the application of organizational, managerial, communications and operational procedures in a simulated setting.

The exercise objectives included: evaluation of the capacity of the organization to plan, direct and control response to a major oil spill in the Beaufort Sea; identification of organizational and procedural gaps in the plan and supporting documents; and familiarization of participants with the working relationships in this special organization.

BREX III was held from 31 May to 2 June 1978 in the Yukon Territory Government offices, Whitehorse. Participants were organised into eight operations centres simulating deployment in Inuvik and Tuktoyaktuk, N.W.T. The operations centres were connected by a special telephone system to simulate planned radio and land line telecommunications.

Emergency Planning Canada was assigned the coordinating role for the exercise. In addition, they assisted in the development of a national operational information system to support the Beaufort plan and of principles which could apply to all peacetime emergencies involving more than one federal department.

Approximately 80 representatives of government and industry participated in the exercise. Agencies represented included the governments of the Yukon and Northwest Territories, and Federal Departments and agencies such as Environment Canada, Department of Fisheries and Oceans, National Defence, Transport Canada (Canadian Coast Guard), Canada Employment and Immigration Commission, Indian and Northern Affairs, Energy, Mines and Resources (Polar Continental Shelf Project and Geological Survey of Canada), Communications Canada, Labour Canada and Emergency Planning Canada. Industry was represented by Canadian Marine Drilling and the Arctic Petroleum Operators Association.

The exercise was directed by Mr. J. Parker, Deputy Commissioner, NWT. His position is designated as the government on-scene commander in the event that the plan is brought into force.

The exercise was prepared by Emergency Planning Canada with the assistance of representatives of Environment Canada, Yukon Territories and Northwest Territories Government.

SCENARIO

The scenario for the exercise was based on a July '78 blowout at a drill site, approximately 90 km north of Tuktoyaktuk. The incident was assumed to be clearly beyond the combined capacity of the operator and supporting companies in the oil industry to handle. At the point where the government plan was activated, 42,900 bbl of oil had been released, 40 km of environmentally sensitive shoreline had been oiled and an additional 160 km of shoreline containing a number of wildlife and fish habitats were threatened.

At the opening stage of the exercise, it was assumed that the government headquarters and logistical support organizations had been deployed at Inuvik and that shore and water cleanup groups had established an operating centre at Tuktoyaktuk in conjunction with industry.

METHOD

The exercise group consisted of a 'Players' group and a 'Control' group. The Players were staffed and organized in accordance with the plan to represent: The On-Scene Commander; a headquarters with advisory, operational and logistics staff; and Directors of line functions with their headquarters for water and ice cleanup, shore cleanup and protection, industry operations and logistical support. The Control staff was organized to represent advisory staff and external scientific resource organizations, field elements of water/shore/industry operations, surveillance systems, materiel and personnel resources, communications facilities and other government committees and industry agencies outside of the operational area.

The Players were 'given' those resources identified in the government plan, supporting documents and studies, with which to respond to the scenario. The Controllers responded to the orders given by the Players within the limit of the environmental, materiel, personnel and time factors available to them. The Controllers also had available, exercise data with which they could respond to requests for additional resources.

The Players were required to do their assessment, define priorities and tasks, allocate resources, issue movement and support orders, and request data in response to the scenario. As the Control staff responded to their directions and requests, incidents were also injected depicting changes and external influences of the concerned communities, general public, government and the environment.

The problems became progressively more difficult requiring greater operational coordination, logistic support and resources as the exercise developed. Where operational directives or assigned resources appeared inadequate, the Control staff built in problems to bring potential difficulties to the attention of the Players. In all cases the objective of the response or input by the Control staff was directed at evaluation of the arrangements as they existed in the plan or sub-plan. The scenario and the problems were not defined to test equipment, field operating techniques, or personal performance.

LESSONS AND OBSERVATIONS

The exercise resulted in many observations and lessons which required modifications to the plan. In general, the overall tasking and organization as set out in the plan were not changed. However, greater detail was required in operations coordination and logistic support arrangements. The observations and lessons fall into three main categories:

(a) Reinforcement of the principles and process for developing emergency plans.

(b) Gaps in existing arrangements for coordination of operations.

(c) Lessons in preparation and conduct of an exercise of this type.

Most observations on the gaps in the plan are specific and therefore not of general value to the readers. However, there are a number of observations which are valid to development of emergency plans by governments and industry.

Development of an emergency plan follows several distinct stages. In the first stage, a risk analysis is required which will determine the parameters of a potential problem. This is followed by a process to inform, and discuss with, those who may be affected or required to respond to the problem. This educational and consultative process should result in a consensus that special arrangements are necessary. The concept for the response arrangements should also be emerging from this process. At this point the plan begins to take shape and extensive consultation and effort goes into its initial development. Once a consensus is reached on the contents of the plan, and it is published, the participating agencies must fully appreciate their responsibilities to the plan and set into place their own arrangements to meet the plan's requirements. Concurrent with establishing these arrangements at all the appropriate levels, individuals involved in the plan must be informed of their duties and responsibilities. It is not uncommon for people to believe that they have a "plan" once they have reached this point. However, the "plan" does not exist until the arrangements have been validated by a test. This test can be a game or exercise involving complete implementation of the plan, or simply validation of those arrangements required to activate the response. In the first case, although the objective is desirable, it is seldom practical until the plan has been tested on a smaller scale and participants become knowledgeable of their own duties. The lessons learned in the validation must be adopted and provision made to update and maintain the plan. By this point, the plan may be imperfect, but it at least goes a long way to significantly improving the coordinated response to the emergency situation. Incidentally, Mr. Mike Garnett's article in the Sept.-October, 1978 issue of STN, supports the importance of the structural process in developing a good contingency plan.

There are also a number of well established principles which apply to development of a contingency plan for response to emergencies. Normally, breach of a principle will result in a penalty somewhere in response to an emergency. Therefore, the planner must be conscious of the penalties which he is accepting or avoiding. These principles are stated briefly for the benefit of those readers new to emergency preparedness:

(a) The arrangements should be based on an identified level of response. If necessary, an estimate should be made to identify the capacity or level of initial commitment which will be provided for. This is particularly essential in remote areas and when dealing with multiple agencies. In absence of this stated operational criteria, the action plan must provide for identification of the requirement particularly in resources and logistic support. In this latter case there is a danger of suddenly identifying a requirement for which extensive lead time is necessary.

(b) The resources of the response organization should be fully integrated under a single authority. Agencies detach their resources for employment by that authority. The further from the scene the authority is vested, the greater the coordination problems at the scene. In rapidly developing situations requiring immediate response, therefore, authority must be delegated to the lowest practical level. Application of this principle requires extensive cooperation in developing and executing the plan.

(c) Specialist advice should be coordinated at the highest level but provided at the operations level. The specialists' value is in their technical knowledge and objective advice. This essential advice may be prejudiced by placing the specialist in a controlling position. They will no longer be specialists, but rather operators.

(d) A system for timely, accurate and continuous exchange of information, direction and requests must exist in the plan.

(e) Specific actions required of participating agencies by phases or probable events should be contained in the plan providing as much advanced coordination as possible.

(f) The organization should, where required by protracted operations, be capable of forecasting long term operational and support requirements as well as controlling the immediate situation.

(g) Organizational arrangements and relationships for control, coordination, advice and logistic support must be clearly and simply stated.

(h) Legal and public affairs are a factor at all levels. Senior personnel must have direct access to public affairs and legal advisors and vice versa.

(i) Tasks should be identified where possible with existing sources of expertise and service. For example, the direction of drilling operations is best left as an industry function. Similarly, organizations exist in territorial and provincial governments which provide the expertise and resources for shore cleanup and logistic support. Those organizations and their existing procedures should be integrated into the response system. Simply put, do not re-invent the wheel.

(j) It is a common pitfall to under-estimate the resource requirement of an emergency situation when it is discussed in a non-operational setting.

(k) The plan must permit the local authority sufficient flexibility to respond to the situation. This will require simple lines of authority and communication together with clear operational tasking.

(l) The normal vertical integration of agencies in routine situations requires that special efforts, and the resulting costs, be accepted as a requirement to educate personnel in the horizontal coordination required by an emergency.

(m) Governments and industry are becoming more and more complex. It is becoming increasingly evident that designated individuals or special appointments are required to ensure the existence of knowledge and arrangements for integrated emergency response.

(n) Senior emergency headquarters should provide liaison officers to a special subordinate headquarters or emergency centre, to permit the exchange of information with minimum disruption of the operational activities at the subordinate headquarters. Similarly, operational organizations should provide for liaison with other operations teams in their geographical area of interest.

(o) The plan or its supporting procedures must provide for a 'battle procedure' whereby there is an ongoing and concurrent process in place to gather data, control costs, evaluate the situation and operating alternatives, issue orders, and deploy and support resources to meet the assigned aim.

The above-mentioned points are not all inclusive. They may be related to operational principles of flexibility, cooperation, unity of command, provision of operational information, selection and maintenance of the aim, concentration of force, simplicity, foresight and administration. These principles apply to both the plan, arrangements to place the task force into position to undertake coordinated operations, and the actual conduct of operations.

PREPARATION AND CONDUCT OF EXERCISES

As with a good plan, proper exercises have very precise patterns and stages of development. These stages, normally well known and practiced by the military and emergency services agencies, include:

(a) Definition of the aim, scope, duration, participation, location, type of exercise, and administrative arrangements.

(b) Preparation and early distribution of a general instruction and opening scenario for the participants.

(c) Organization of the evaluation/control group.

(d) Preparation of special instructions and scenarios for the controlling staff.

(e) Arrangement of exercise facilities and special requirements, eg. communications.

(f) Briefing of exercise participants, including a clear explanation and understanding of the "rules of the game".

(g) Briefing of the control staff.

(h) A test of the exercise play procedures.

(j) Execution of the exercise.

(k) Debriefing of the participants and preparation of an exercise report.

In BREX III commitment of the participants to the exercise was solicited from the Deputy Commissioner, Deputy Minister and corporate Vice President level. Approximately sixty days were available from the date of tentative approval of the exercise until it was conducted. Considering the diverse geography, functions and interests which were to be involved in the exercise, commitment at a senior level was essential. As a general principle, an undertaking of this magnitude must initially be fully supported by senior officials, if not Ministers and top-level management, to ensure cooperation and participation.

The second major principle that was reinforced during the exercise was that the objectives of the exercise must be limited to those aspects which can readily be tested. There are examples of major exercises, routinely conducted, which incorporate objectives which conflict with the overall aim. For example, a technical test of airborne surveillance systems would not have been complimentary to the evaluation of the main plan, which provides for a response organization. This would be, however, a desirable separate exercise with its own specific objectives of evaluating the surveillance system.

The third principle relates to the system of testing a plan. Exercises may be 'controlled' or 'uncontrolled'. In an uncontrolled exercise, incidents are injected and responses are given at an uncontrolled pace. This type of exercise presumes significant knowledge of the plan and the existence of well established procedures. The result is a test of participants. A controlled exercise is designed to teach and evaluate by designing events to identify organizational capacity and to teach the management function in an extreme situation. Events are injected at a rate equal to or just ahead of the capacity of players to absorb or handle material. A controlled exercise is obviously the system required for evaluation of a plan during its development. The disadvantage of the controlled exercise is that a great deal of effort is required to prepare the input data, design the response criteria and create the control staff organization.

The fourth exercise principle is identical to one of the criteria for development of an operational plan, that of informing the participants. Both the players and the controllers must be informed of the exercise system and arrangements. Publication and distribution of the exercise papers is only part of the informing process. A brief pre-exercise training session must also occur for the players and controllers in order that they can adapt to the exercise system, exercise expedients and the player and control organization. In BREX III, time precluded this introductory period. A predictable result occurred during the initial period of play. Our first session of the exercise play was directed at adjusting to the exercise rather than achieving the exercise objectives.

SUMMARY

To many readers, experienced in the conduct of exercises or development of emergency plans, the stated lessons and principles may appear self-evident. However, in an emergency, a majority of the participants are not those who deal with emergency arrangements as a daily routine. A common result of almost every test of plans or arrangements for emergencies is that the lessons and observations on the need for extraordinary arrangements for command, control, response and support are repeated. Therefore, some of these self-evident principles must be restated. As government becomes more complex, with greater vertical integration, there is a greater need for organizations to test their capacity to respond to the unique situation. This is a development process which includes an evaluation exercise.

BREX III provided an excellent exposure of the participants to the plan, together with an evaluation of strengths as well as the weaknesses. It also brought to light the need to restate, on occasion, the principles and process which should be applied in developing and testing a plan.

BREX III also re-emphasized an overriding factor in all plans and arrangements. A positive attitude by participants and contributors to plans and exercises is critical to success. BREX III was a success primarily because the eighty participants at Whitehorse and their parent agencies responded in a positive and responsible manner to the evident need for an integrated response system to deal with a major spill in the Beaufort Sea.