NRC Centre for ice loads on offshore structures

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CHC CANADIAN HYDRAULICS CENTRE

NRC Centre for Ice Loads on Offshore Structures

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ABSTRACT

The National Research Council of Canada has acquired an extensive set of reports and information pertaining to the development of the Canadian Beaufort Sea. The information primarily focuses on the measured ice loads and the environmental conditions in the region. Contributions have been made by Gulf Canada Resources Ltd., Imperial Oil (Esso) and Amoco Canada / Canmar. The collection houses over 1800 reports, 300 films & videos, and includes most of the significant event data measured on the Gulf offshore structure "Molikpaq" and Canmar SSDC. This report documents the current contents of the Centre and provides an overview of its activities.

RÉSUMÉ

Le Conseil National de Recherches a obtenu une grande série d'information concernant le développement de la mer de Beaufort dans l'océan arctique. Cette information concerne principalement les efforts dus à la glace et les conditions environnementales de la région. Des contributions à cet ensemble de données ont été fournies par "Gulf Resources Canada Ltd.", "Imperial Oil (ESSO)" et "CANMAR". Plus de 1800 rapports, 300 bandes vidéos et tous les événements mesurés sur l'ouvrage offshore de Gulf "Molikpaq" font partie de cette collection des données. Ce rapport décrit les contenus de ce centre des données et offre également un aperçu général de ses activités actuelles.

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1 INTRODUCTION

During the 1970s and 1980s, there was an enormous effort spent in exploration of hydrocarbons in the Beaufort Sea region of Canada. Several major Oil Companies including Gulf Canada Resources Ltd., Imperial Oil (Esso) and Dome Petroleum / Canmar were involved in this offshore exploration. Further, many government departments participated in these research activities. In the Beaufort region, the offshore structures were placed in waters that contained quite severe ice conditions. Thus, a considerable effort was spent in documenting the ice properties and characteristics, and measuring the ice loads on several different offshore structures. Further, several computer models were developed for predicting the ice loads on the structure. Several tens-of-millions of dollars were spent in this area.

The presence of floating ice provides a primary impediment to exploration for, and possible production of, hydrocarbons in the southern Beaufort Sea, as well as many other regions globally. The definition of forces which floating ice features may generate on offshore structures is one of the major uncertainties in the safe and efficient design of such structures.

At the present time, there is no activity taking place in the Canadian Beaufort Sea. It is clear, however, that it is in the national interest to maintain an expertise in this area. There is a critical need to maintain the ice information and full-scale data on ice loads on structures. This information and data are irreplaceable.

A "Centre of Ice/Structure Interaction" has been established at the Canadian Hydraulics Centre of the National Research Council of Canada in Ottawa. This Centre houses a large collection of the reports, films and data which have been collected over the years documenting the activities in the Beaufort Sea region of Canada. This Centre was established to maintain and actively use the information. The Centre has received financial support for several years from the Program on Energy Research and Development.

The objective of the Centre is to develop and maintain a centre of expertise in ice/structure interaction. The activities include:

- collecting, cataloguing and distributing reports related to ice/structure interaction;
- maintaining and developing computer programs of ice loads on structures;
- maintaining a data base on ice loads on structures; and

- acquiring and maintaining the full-scale data released by Industry on the loads on their offshore structures.

An efficient, orderly archival of the past research work that has been carried out in the frontier regions will greatly assist future work in this area. It should allow a smooth resumption in knowledge of ice loads and ice conditions in the offshore regions of Canada. Without it, there is a high potential that a significant amount of the current knowledge would have been lost.

This report describes an overview of the activities in the Canadian Beaufort Sea. It lists the information that is housed in the Centre. Here, valuable contributions have been made by Gulf Canada Resources Ltd., Imperial Oil (Esso) and Amoco Canada / Canmar. Brian Wright, Ken Croasdale and Kurt Kennedy, respectively have each prepared a short report that documents the approach used by each of these companies in the exploration of the Beaufort Sea. Their reports are reproduced in the Appendices of this report.

2 OVERVIEW OF PAST ACTIVITIES IN THE BEAUFORT SEA

There have been several approaches used to design platforms for oil exploration in the Arctic regions. In the Beaufort Sea off both Canada and Alaska, over 140 wells have been drilled. Innovative technology and good management have allowed development of this region. The development took place over a fairly short time span, but care was always taken to ensure safe and environmentally secure techniques were used. Almost all of the major oil companies were involved in the development. There was both competition and collaborative work to investigate the ice loads and types of structures that could be used.

The development of the Beaufort was initiated in the early 1970s in quite shallow water using artificial islands (see Figure 1). These islands were constructed by either dredging the local sea bottom and building-up an island, or by trucking gravel from the shore and dumping it to form an island. The latter approach was carried out during winter months across ice roads. These structures were placed in shallow water (up to 12 m). For most of these islands, the ice was landfast, with first-year ice having little movement during the winter months.

Figure 1 Photograph of the Esso dredged island at Issungnak.

Starting in the mid 1970's, floating drillships (see Figure 2) were employed during the summer months. Canmar deployed three drillships (Explorer, Explorer 2 and Explorer 3). These were moored on site during the summer (open water) months. With these ships and support icebreakers, Canmar has developed considerable expertise in offshore Arctic operations.

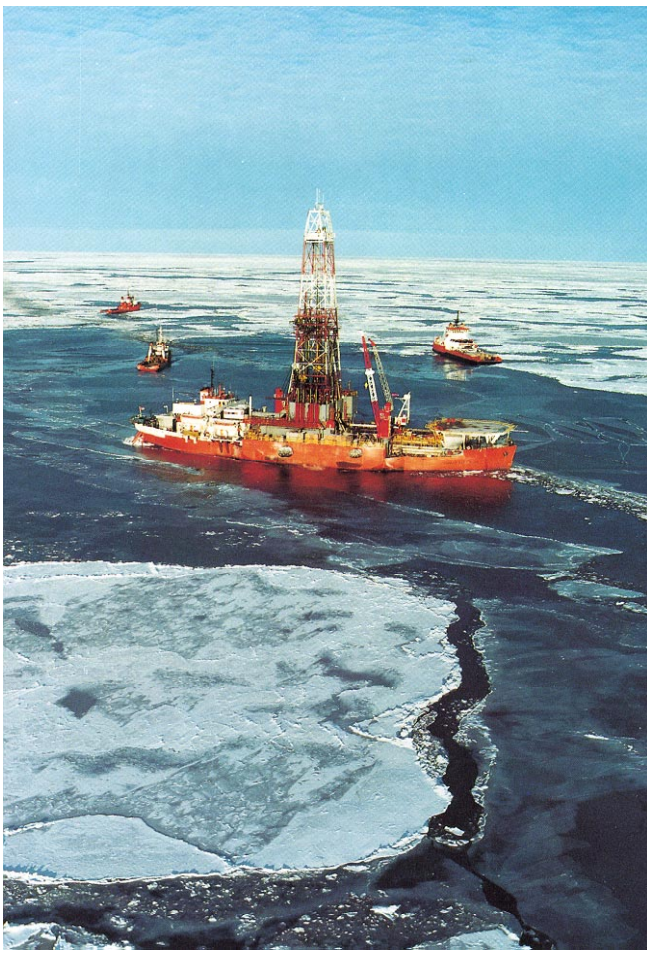

Figure 2 Canmar drillship in the Beaufort Sea.

Gulf Canada Resources Ltd. built an inverted-cone shaped floater, the Kulluk which could be used throughout the summer and early autumn months. The vessel was towed to the drill site (see Figure 3) and moored with a twelve-point anchor system that was capable of resisting ice forces from any direction. Usually ice management was necessary to break the ice locally in the region of the Kulluk (see Figure 4). This technique extended the drilling season.

Figure 3 Kulluk in 8/10's ice under tow to a drill site.

Figure 4 Ice management around the Kulluk in the Beaufort Sea.

In the early 1980's, special-built caisson structures were designed and built to allow year-round drilling, and development of regions further offshore in harsher ice conditions. There were five different caisson structures used in Arctic regions. A brief description of each follows (from Masterson et al. 1991):

Tarsiut Caissons - This structure was operated by Gulf Canada Resources Ltd. and was the first caisson-type structure used in the Arctic. It was first deployed at the Tarsiut site in 1981 (see Figure 5). The structure consists of four individual concrete caissons. These caissons are floated to the drilling site and ballasted down with sand to form a square. The inner core is filled with dredge material. This structure is not regarded as a "mobile" structure since the difficulty of resetting and connecting four caissons limits its mobility.

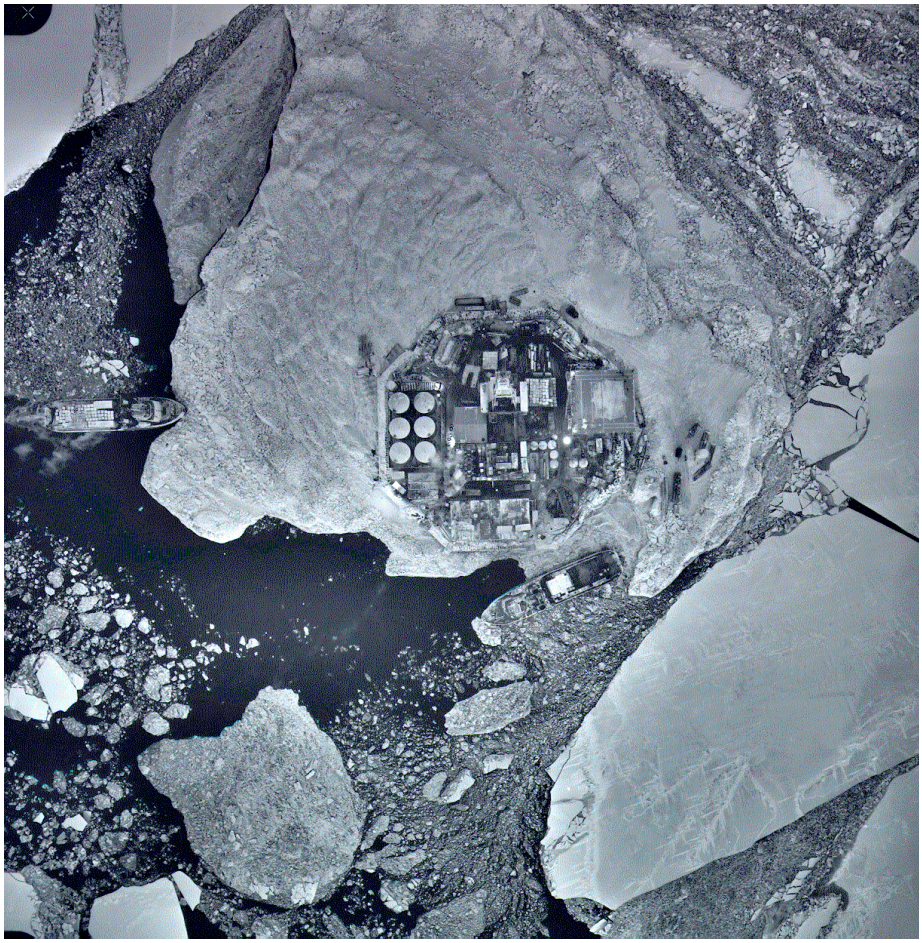

Figure 5 Overhead view of Tarsiut Island in the Beaufort Sea.

SSDC/MAT - The Single-Steel Drilling Caisson – SSDC- (see Figure 6) was operated by Canmar (Amoco Canada). It was constructed from a disused tanker and brought to the Beaufort Sea in 1982. In the winters of '82-83 and '83-84, it drilled at two different locations in approximately 30 m of water. In 1985, a new steel base, the MAT, was designed. This eliminated the restrictions imposed by the SSDC by the requirement for a sand berm. The MAT was constructed and mated to the SSDC in 1986. It is capable of operating year round in water depths of 7 to 24 m, and a wide variety of soil conditions.

Figure 6 SSDC in ice conditions.

Stressed CRC - This structure was originally built by Esso Resources Canada Ltd. but it is now owned by Arctic Transportation Ltd. It was developed in the 1976/77 period as a means of reducing dredge quantities, as compared to the more traditional sand island. It was built in 1982/83 and first deployed in the Canadian Beaufort Sea in the summer of 1983 (see Figure 7). The design has 8 individual caissons in a ring, stressed together with two rings of cable. The core is filled with sand to provide a surface for drilling operations.

Figure 7 Esso Caisson Retained Island (CRI) with a grounded rubble field.

Molikpaq - This structure was developed by Gulf Canada Resources Ltd. and operated by Beaudril, a subsidiary of Gulf. The Molikpaq is a Mobile Arctic Caisson (MAC) which was deployed in the Canadian Beaufort Sea in 1984 (see Figure 8). The Molikpaq was used for exploration drilling for 4 winter seasons in the Canadian Arctic. It consists of a continuous steel annulus on which sits on a self-contained deck structure. The core of the annulus is filled with sand, which provides over 80 percent of the horizontal resistance. The outer face of the Molikpaq is designed for extreme ice features. The structure can operate without a berm in water depths ranging from 9 to 21 m. In water depths over this, the structure is designed to sit on a submerged berm which can vary in depth, as required. Ballasting is entirely by water. To achieve the design resistance under dynamic load, densification of the hydraulically-placed core is required. At the present time, the Molikpaq has been purchased by Marathon Oil, and it is being modified for use in the Sakhalin region offshore Russia.

Glomar Beaufort Sea I (CIDS) - This structure is operated by Global Marine. It is made of a steel mud-base, concrete "brick" units through the ice zone and steel deck storage barges. The steel units are not exposed to severe ice loading. The brick units are honeycomb construction which provides an optimum strength to weight ratio. The forces imposed by the ice are distributed evenly throughout the structure. The "silos" within the honeycomb structure are used only for water ballast, as are the tanks in the base. Ballast and deballast is entirely by water. The deballasting and reflotation process can be completed in 3 days under normal conditions. This structure was used only in the American Beaufort Sea.

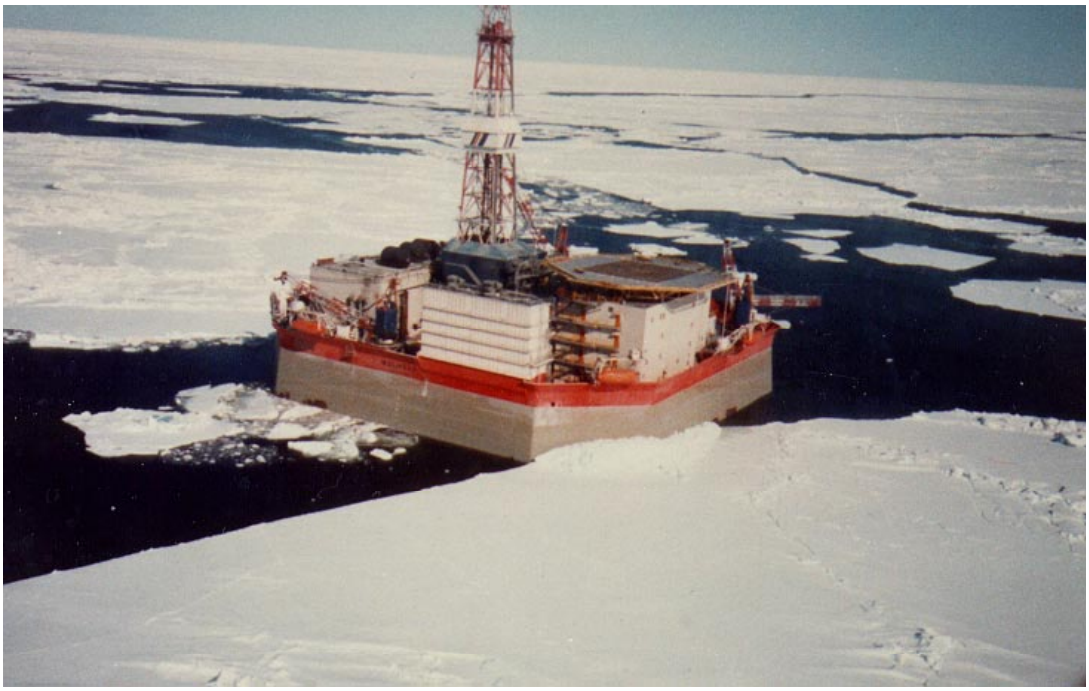

Figure 8 Molikpaq in broken ice conditions.

Most recently, in the late 1980's, spray ice islands (see Figure 9 and Figure 10 after Poplin 1990) were used for a few wells. These were deployed in landfast ice in both the Alaskan and Canadian Beaufort Sea. The cost of these spray islands was approximately one-half the cost of a gravel island.

During the development of this region, there was great effort placed in measuring the environmental conditions, types of ice features, ice strength, and ice loads on the structures. In Canada, the oil companies collaborated under the Arctic Petroleum Operators Association (APOA), and more recently, the Canadian Association of Petroleum Producers (CAPP). A large number of major field and laboratory projects were sponsored by the APOA. Most of these reports are now available for public review.

Some of the salient details of these structures are presented in Table 1. The information in these tables is based on the paper by Masterson et al. (1991)[1]. Important information on ice loads and failure behaviour of ice has been obtained from all of these structures. Based on this information, a "flow chart", shown in Figure 11, has been produced that shows the activity in the Canadian Beaufort Sea. Note the progression from seasonal artificial islands and drill ships to the more robust caisson-type structures.

[1] Reprinted in Appendix A of this report

Figure 9 Photograph showing an overview of the Nipterk spray island.

Figure 10 Photograph showing the Nipterk spray island from ice level.

Table 1 Details of Fixed Structures used in Arctic Drilling

	Tarsiut	SSDC	CRI	Molikpaq	CIDS
Drilling Days (per year)	365	365	365	365	365
Base Area (m^2) (including core)	7947	18590	10875	12383	8551
Oceanographic Limitations (wave height - m)	12	12.2	15	12.2	5.2
Limiting Level Ice Conditions (m)	5.6	10	3	10	2
Ice Concentrations	10/10s	10/10s	10/10s	10/10s	10/10s
Design Ice Load - Global (MN)	560	900	436	640	640
Design Local Ice Pressure (MPa)	4.1	8.3	2.8	3.0	6.2
Area for Local Pressure (m^2)	3.7	3.7	0.7	2.3	2.3
Wells Drilled	Tarsiut N-44 Tarsiut N-44A	Uviluk P-66 Kogyuk N-67 Phoenix #1 Aurora #1	Kadluk O-07 Amerk O-09 Kaubvik I-43	Tarsuit P-45 Amauligak I-65 Amauligak I-65A Amauligak I-65B Amauligak 2F-24 Amauligak 2F-24A Amauligak F-24 Amauligak 2F-24B Isserk I-15	Antares #1 Antares #2 Orion #1

Significant oil and gas discoveries were made in the Beaufort Sea (see Figure 12), including the Amauligak oil reservoir, but, to date, these reserves are insufficient to justify economic development. Current discovered reserves for this region are 12 TCF gas, and 1.6 billion Bbls of oil. During the drilling of the Amauligak well, 320,000 barrels of oil were shipped to Japan in the tanker "Gulf Beaufort", making it the first major shipment of crude oil from the Canadian Beaufort Sea.

Date	Island		Drill Ships		Tarsiut	SSDC	Kulluk	Caisson Retained Island	Molikpaq
1972	Roland Bay L-41								
1973	Immerk B-48	Adgo F-28							
1974	Pullen E-17 Unark L-24	Pelly B-35							
1975	Adgo P-25 Nerlerk B-44 Adgo C-15	Garry P-94 Ikattok J-17 Nerlerk F-40							
1976	Sarpik B-35 Kugmallit H-59	Unark L-24A Arnak L-30	Kopanoar D-14 Nektoralik K-59	Tingmiark K-91					
1977	Kannerk G-42 Isserk E-27		Ukalerk C-50 Kopanoar M-13	Nerlerk M-98					
1978	Garry G-07		Natserk E-56 Ukalerk 2C-50 Tarsuit A-25	Kaglulik M-64 Kaglulik A-75					
1979	Adgo J-27		Kenalooak J-94 Kopanoar L-44	Koakoak O-22 Kopanoar 2L-34					
1980	Issungnak 2O-61		Kilannik A-77 Kopanoar I-44 Kopanoar 2I-44						
1981	Alerk P-23		Issugnak L-86 Irkaluk B-35		Tarsuit N-44				
1982	Issugnak O-61 West Atkinson L-17	Itiyok I-27	Kiggavik A-43 Orviluk O-03	Aiverk I-45 Aiverk 2I-45	Tarsuit N-44	Uviluk P-66			
1983			Natiak O-44 Havik B-41	Siulik I-05 Arluk E-90		Kogyuk N-67	Pitsiulak A-05 Amauligak J-44	Kadluk O-07	
1984	Adgo H-29 Nipterk L-19						Nerlerk J-67 Akpak P-35	Amerk O-09	Tarsuit P-45
1985	Nipterk L-19A Adgo G-24	Minuk I-53 Ellice L-39	Adlartok P-09 Edlok K-56, N-56				Akpak 2P-35 Aagnerk E-56		Amauligak I-65
1986	Arnak K-06							Kaubvik I-43	Amauligak I-65A Amauligak I-65B
1987	Angasak L-03								Amauligak 2F-24
1988									Amauligak 2F-24A, 2F-24B Amauligak F-24, O-68
1989	Nipterk P-32		Kingark J-54						Isserk I-15

Notation
sacrificial beach island
sandbag retained island
hauled island
spray ice island

Figure 11 Overview of drilling activity in the Canadian Beaufort Sea

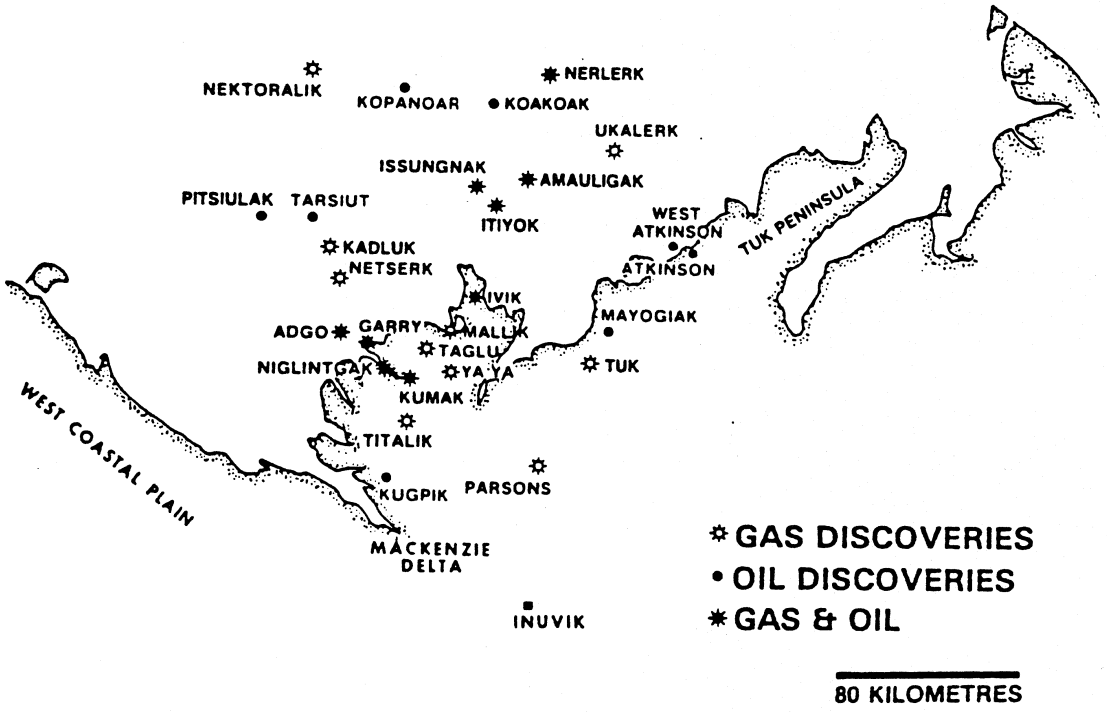

Figure 12 Map showing the gas and oil discoveries in the Canadian Beaufort Sea (after Jahns 1985).

This section provided a brief overview of the past activities in the Canadian Beaufort Sea. Further details can be found in the Appendices of this report as follows:

- **Appendix A** reproduces the 1991 paper by Masterson et al. which presents detailed information on the activity in this region;
- **Appendix B** presents a report prepared by Brian Wright describing the approach used by Gulf Canada in the development of the Beaufort Sea;
- **Appendix C** presents the report prepared by Ken Croasdale describing the approach used by Imperial Oil (Esso);
- **Appendix D** presents an overview of the activities of Amoco Canada / Canmar prepared by Kurt Kennedy.

3 ACTIVITIES OF THE CENTRE

There have been several activities associated with the Centre:

- A concentrated effort has been made to acquire, from the Oil Industry, reports and films related to ice loads on structures. Gulf Canada Resources Ltd., Imperial Oil (Esso) and Amoco Canada / Canmar have all made major contributions to the Centre. This information is being maintained in the form provided by the industry. In some cases, however, it has been further analysed and/or processed to make it more accessible to use with more current technology. For example, the 16 mm films donated by Esso of their past activities have been transferred to a video tape format.

- NRC acts as a repository of all reports related to the area of ice loads on structures. These reports are housed in a separate archival room at NRC in Ottawa. A number of these reports, which have not been previously available publicly, are also catalogued through the CISTI Library (Canada Institute for Scientific and Technical Information). This ensures that they are accessible through on-line retrieval systems.

- There have been a number of computer models developed for the prediction of ice loads on offshore structures. These models include both ice load models and probabilistic models. NRC has acquired the probabilistic and deterministic models developed by Gulf Canada. They are operational on the NRC computer system, and have been used to do systematic parametric sensitivity studies of the important parameters in ice loading events (Timco and Irani 1994; Watson and Timco 1995).

- There has been a concentrated effort to acquire and convert a large amount of the measured full-scale time-series data onto the NRC computer system. Much of the existing data was collected using computers which, by today's standards, represent obsolete technology. The conversion to more modern computer systems provides a better basis for storing this information. Further, it makes it more accessible to interested researchers. In this regard, a large number of the ice loading events on the Molikpaq have been transferred to the NRC computer system (Klohn-Crippen 1995: Singh and Timco 1995) where they have been further analysed (Wright and Timco 1994). The Molikpaq data has been developed into a software package (DynaMAC) that is distributed through the NRC Centre.

- The NRC has been managing the PERD Ice/structure Interaction program since the early part of 1997. Prior to that date, the National Energy Board of Canada managed the program. There is an Advisory Committee (ISIAC) that met at least twice a year to provide advice to PERD and the NRC on the research directions for ice/structure interaction. The Advisory Committee is comprised mostly of Industry members from several of the major oil companies, as well as Government members from Regulatory Departments. In addition, a number of other Government departments are represented

to ensure that there is synergy with other Canadian government–sponsored activities. G. Timco of the NRC/CHC is the Chairman of the Committee.

- The NRC is developing, as part of a Joint Industry Project, a Catalogue of Ice Load Events. The Catalogue will contain time-series records of a large number of ice load events on a number of different offshore structures.

4 ORGANIZATION OF REPORTS

The NRC Centre houses a large number of reports. These reports cover many topics and come from various sources. The initial organization of the reports was done based on the source of the report. More recently, however, the reports have been re-organized into Tables based on individual topics. Their listing has been set up in a database format using Access97™ as the platform. With this approach, reports relevant to any particular topic are easy to find, and using the database allows a quick check of cross-referenced reports.

The topic areas covered in the Centre are as follows:

ID	Topic
2	Ice Cover Characteristics
3	Ice Properties
4	Ice Strength
5	Ridges, Rubbles and EIF
7	Ice Force Theory
8	Laboratory & Model Studies - General
9	Computer Models
10	Field Measurements - General
11	Offshore Operations
12	Tarsiut Caisson
13	Molikpaq at Tarsiut P-45
14	Molikpaq at Amauligak I-65
15	Molikpaq at Amauligak F-24
16	Molikpaq at Isserk I-15
17	SSDC Deployment
18	Esso CRI and Islands
19	Hans Island
20	East Coast Canada & Icebergs
21	Confederation Bridge
22	Bridge Piers & Light Piers
23	Ice Platforms & Spray Ice
24	Pack Ice Stress
25	Kulluk
26	Ships in Ice - Field & Model Tests
30	Environmental Impact Statement (EIS)
31	Scour & Pipelines
32	INSROP Reports
33	CRREL Reports
35	General
60	Conferences

The contents of these tables provide a summary of the information available in the Centre. It should be noted that not all of the reports that are in the Centre are publicly available. Some have confidentiality restrictions.

A listing of all of the current holdings is given in Appendix E.

5 ORGANIZATION OF FILMS, VIDEOS

There are several hundred films and video tapes that have been donated to the Centre. The films (mostly 16mm obtained form Esso) have all been converted to a video format for easier display. The videos are organized based on the Source of the video, and a listing of each video tape is included in the database. They are categorized according to the source as follows:

ID	Topic
70	Gulf Videos
71	Esso Videos
72	Amoco Videos
73	Canadian Videos
74	International Videos

A listing of all of the current holdings is given in Appendix E.

6 ORGANIZATION OF THE FULL-SCALE DATA

At the present time, there is an ongoing effort to obtain and transfer full-scale data into digital format, as part of the JIP Ice Load Catalogue. To date, there has been data transferred from several offshore structures including the Molikpaq, SSDC, and the Esso Caisson-Retained Island. The most extensive data conversion was done for the Molikpaq, since it was very well instrumented, and it was subjected to a wide range of ice conditions. There have been a number of Molikpaq events that have been transferred to the NRC VAX computer system (Klohn-Crippen 1995; Singh and Timco 1995). A number of the ice load events have been put onto a CD ROM by Klohn-Crippen, under contract from the Canadian Government (Klohn-Crippen 1998). This CD-ROM, titled DynaMAC, is distributed through the NRC Centre. Work is continuing to develop a comprehensive database related to full-scale ice loads.

Several large boxes of computer disks and tapes are stored at the Centre, from both the Molikpaq and SSDC structures. These are the original data tapes that were stored on a HP format, which was used during the mid 1980s when the data was collected. This format is not readily readable with today's modern computers. The data is stored, as is, in the Centre. Additional resources would have to be obtained to do further data conversion to a more standard data format.

7 LISTING OF COMPUTER PROGRAMS

There are a number of computer programs available in the Centre. These include:

ICESTRIKE - A database that lists a large number of ice loading events on various offshore structures (see Metge et al. 1989). This database was developed through PERD funding.

Gulf Canada Deterministic Ice Load Model - A program developed through Gulf Canada to determine the loads on an offshore structure due to the interaction with a large ice floe. The program has considerable flexibility for incorporating ridges, pack ice stresses, etc.

Gulf Canada Probabilistic Ice Load Model - A probabilistic model developed through Gulf Canada. It is a sophisticated model that incorporates considerable environmental information obtained by Gulf during their frontier exploration in the Beaufort.

Nevel's Cone Program - A program developed by Dr. Don Nevel of Conoco Inc. It calculates the ice loads on a conical-shaped structure (see Nevel 1992).

Sodhi's Ice Crushing Model - A program developed by Dr. Dev Sodhi of USA CRREL. It calculates the ice load during intermittent and continuous crushing of ice against vertical-sided structures (see Sodhi 1994).

Thermal Ice Loads - A number of the current theories for predicting thermally-induced ice loads have been programmed by NRC. The theories include the work by Fransson, Rose, Drouin and Michel, Bergdal, Cox, Xu Bomeng and the Russian SN 76-66 code.

Ice Loads on Conical Structures - A number of the common theories for predicting ice loads on sloping structures have been programmed by NRC. The theories include those of Ralston, Edwards and Croasdale, Croasdale 2D and 3D, Kato and Hirayama.

Ridge Loads - Analytical Models related to the forces developed by first-year ridges, especially the forces due to the keel portion of the ridge.

Numerical Models - A number of sophisticated discrete element models, lattice models and most recently, smooth particle dynamics have been developed by Dr. M. Sayed of the CHC/NRC:
IceSim is a family of 2D and 3D discrete element (molecular dynamics) solvers, which consists of an efficient framework capable of handling tens of thousands of elements. **IceSim** models have been applied to a wide variety of floating ice problems including mesoscale ice forecasting, prediction of ice jams on rivers and ice/structure interaction (see Figure 13). Environmental forces such as spatially and temporally varying water currents and winds drive the system of rough inelastic disks or spheres. The disks and spheres can be joined to create arbitrarily shaped structures.

Lattice models of solids fracture: New models are based on discretizing solid bodies into nodes that are linked by breakable elements. Properties of those elements can be chosen to simulate complex rheologies. Fracture is introduced according to macro failure criteria (e.g. tensile strength). The simulations can predict the initiation and propagation of crack networks (see Figure 14).

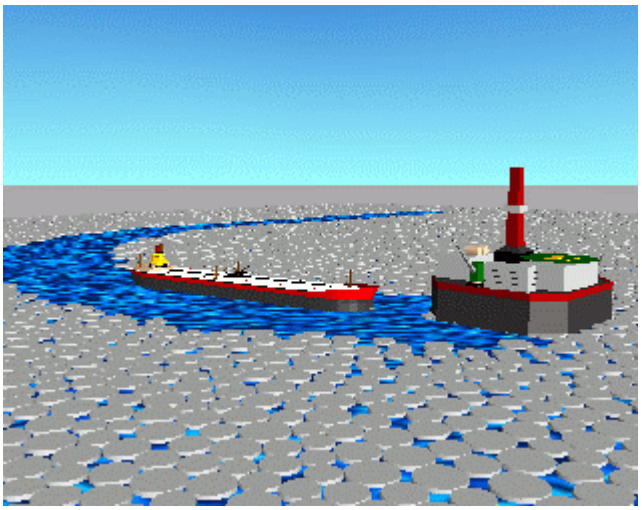

Figure 13 IceSim used to investigate the changes in wake geometry behind an offshore structure in ice-covered waters with changes in environmental driving forces.

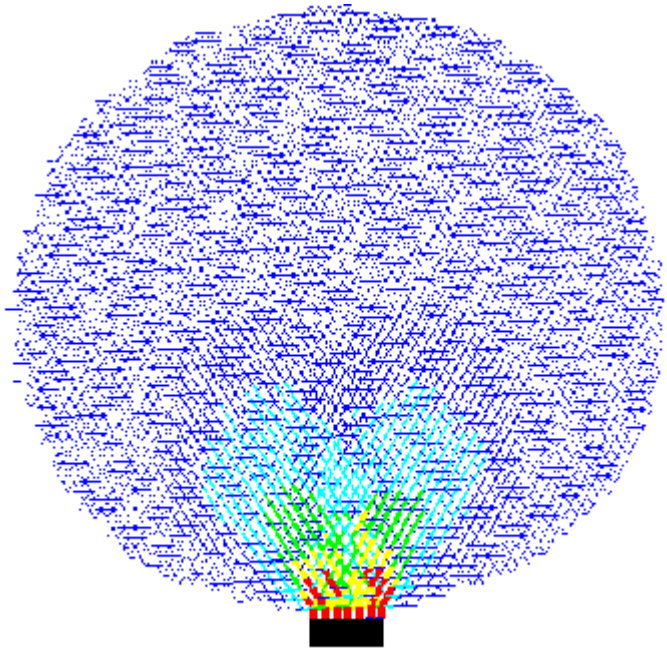

Figure 14 Lattice model used to investigate stresses in ice and the ice failure process during indentation with a rigid indentor.

8 SUMMARY

The Canadian Hydraulics Centre of the National Research Council of Canada has acquired an extensive set of information pertaining to the development of the Canadian Beaufort Sea. Contributions have been made by Gulf Canada Resources Ltd., Imperial Oil (Esso) and Amoco Canada / Canmar. With financial support from the Program on Energy Research and Development, a Centre of Ice/Structure Interaction has been established at NRC in Ottawa. The information in the Centre primarily focuses on the measured ice loads and the environmental conditions in the Beaufort Sea region. The Centre houses over 1800 reports, 300 films & videos, and includes most event data measured on the Gulf offshore structure "Molikpaq". The information contained in the Centre is used as a basis for in-house NRC research, and in supporting Canadian industry and government departments in matters related to ice forces on structures. Anyone interested in accessing the information in the Centre should contact the author (garry.timco@nrc.ca) at the Canadian Hydraulics Centre in Ottawa, Canada.

9 ACKNOWLEDGEMENTS

The author would like to thank several agencies and participants who made possible the Centre. Valuable funding was obtained from the Program on Energy Research and Development. The donation of material from Gulf Canada Resources Ltd., Imperial Oil (Esso) and Amoco Canada / Canmar is gratefully acknowledged. Several individuals were instrumental in the development of the Centre including B. Wright, K. Croasdale, R. Frederking, K. Kennedy, K. Sato, T. Baker, S. Lord and I. Konuk, and their participation is gratefully acknowledged.

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Abstract
The National Research Council of Canada has acquired an extensive set of reports and information pertaining to the development of the Canadian Beaufort Sea. The information primarily focuses on the measured ice loads and the environmental conditions in the region. Contributions have been made by Gulf Canada Resources Ltd., Imperial Oil (Esso) and Amoco Canada / Canmar. The collection houses over 1800 reports, 300 films & videos, and includes most of the significant event data measured on the Gulf offshore structure "Molikpaq" and Canmar SSDC. This report documents the current contents of the Centre and provides an overview of its activities.

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