SURVEILLANCE OF YEAR-ROUND SHIPPING ROUTES IN THE CANADIAN ARCTIC: A CHALLENGE TO THE REMOTE SENSING COMMUNITY.

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ABSTRACT

The study reported here reviews the discoveries of hydrocarbons in the Canadian Arctic and discusses the mode of year-round transportation for carrying gas and oil through the Canadian Northwest Passage to the southern markets. Year-round navigation through M'Clure Straight and Viscount Melville Sound, portions of the Northwest Passage, requires ice-breaking tankers of Class VII and beyond. Surveillance of sea ice in front of ice-breaking tankers' routes in the Canadian Arctic is a challenge to the remote sensing community. This study suggest that, in addition to existing satellite TIR sensors, the remote sensing community need high resolution microwave (SAR) sensors because of its all weather capability. Moreover, vigorour R and D is needed to develope high speed digital processing of SAR and TIR data on sea ice for real-time transmission to ship's masters. Finally, the study suggests a surveillance operational plan in which a Central Operating Center (COC) will receive a real-time satellite data on sea ice and weather from the ground receiving station and then the COC will analyze the data with high speed computer processing and advise the ship's master via a communation satellite on the possible safe tanker routes.

1. Introduction

During the last three or four decades a great deal of attention has been focussed on the Canadian Arctic. Interest in northern mineral resources has increased greatly and will continue to do so, mainly because of relatively high prices of fossil fuels. Offshore and onshore areas in the Canadian Arctic contains geological structures with significant potential for gas and oil. Results of drilling in the Canadian Arctic indicate significant discoveries of natural gas and oil. This article reviews the discoveries of natural gas and oil and also other non-renewable resources such as lead, zinc and iron ore in the Canadian Arctic, discusses the mode of year-round transportation and suggests a means of surveillance for guiding ice-breaking tankers through the Northwest Passage of the Canadian Arctic.

2. Resources in the Canadian Arctic

The Canadian north is rich in non-renewable resources particularly in fossil fuel. It is estimated that the Canadian Arctic has more than half of Canada's petroleum reserve (APOA, 1981a; IAND, 1980). In addition to natural gas and oil, discoveries of other non-renewable resources such as lead, zinc, and iron ore have been made. Canada is regarded as a leader in the exploration of non-renewable resources in the arctic region.

In the Beaufort Sea, oil and gas have been discovered at offshore wells at Nektoralok, Adgo, Ukalerk, Issungnak and Itiyok by ESSO; at Koponar and other wells by Dome Petroleum; and at Tarsuit and other wells by Gulf Oil. Dome, Esso and Gulf Oil regard the Beaufort Sea as potentially one of the world's major petroleum producing area with estimated reserve of 1.5 trillion m^3 of gas (APOA, 1981b) and 30 to 40 billion barrels of oil (Meisler, 1979; Business Week, 1983). Besides Beaufort Sea, the seismic studies in the Lancaster Sound and Baffin Bay continue to indicate favourable geologic structure for gas and oil.

In the Canadian Arctic islands, a total of eleven gas fields have been discovered by 1981. The most significant discovery, gas amounting to 0.48 - 0.50 trillion m^3 was made by Panarctic Oil Limited in the Canadian High Arctic, in particular, the Drake Point Field on Melville Island and the surrounding region (Star Phoenix, 1980). Panarctic has made other gas and oil discoveries in the surrounding region. Gas has also been discovered in Ellef Ringnes Island, King Christian Island and the surrounding region by Trans Canada Pipeline Project with Dome Petroleum Limited.

In addition to natural gas and oil, discoveries of lead, zinc and iron ore have been made. A lead-zinc operation located at Strathcona Sound on Baffin Island began production in October 1976. A large deposit of lead and zinc, estimated at 23 m tons has been located on the southern point of Little Cornwallis Island (Arvik Mine). Moreover, a high grade iron ore deposit, estimated at 130m tons, has been discovered in 1962 on Baffin Island, south of Milne Inlet (Mary River iron ore deposit).

3. Year-round Transportation

The development of non-renewable resources in the Canadian Arctic will depend on safe and reliable transportation. Today, shipping occurs only during the summer season for resupply operations, ore shipments, marine survey, and ice breaker support operations. Shipping is limited to the short open-water season, which normally extends from mid-July to mid-October. At this time, some ice cover breaks and melts, permitting ships to penetrate arctic waters to meet their committments. Such seasonal shipping employs a variety of vessels including ice-breakers, ice strengthened ships, tugs and burges. However, most of these ships can not operate throught the year because of severe ice conditions in the arctic channels during the winter months (Fig.1). The author of this paper had previously examined the ice conditions in the Canadian Arctic channels and had delineated year-round shipping routes (Fig. 2) from southern Beaufort Sea to Davis Strait through Perry Channel to Baffin Bay, with an alternative route via Parry Channel, Prince Regent Inlet, Gulf of Boothia, Foxe Basin and Hudson Strait (Dey, 1981).

The ecomomics of gas and oil production and transportation requires continuous delivery. Year-round shipping will require large ships whose chief features are large size, strength and power. Ice-breaking tankers are now considered the most likely means for transporting hydrocarbons from the Canadian Arctic. Year-round navigation through M'Clure Strait and Viscount Melville Sound, portions of Northwest Passage, requires ice-breaking tankers of Class VII, which can move through ice up to three meters thick. But a large ice-breaking tanker of Arctic Class VII and beyond is required by CASPPR (Canadian Governments' Arctic Shipping Pollution Prevention Regulation) for year-round operation in the Canadian Arctic as a whole. At present, the ice-breaker technology of Canada, the United States and Scandinavia has not advanced beyond Class II-IV (McKenzie and Johansson, 1979). The Canmer Kigoriak, acquired by Dome Petroleum is a Arctic Class IV type ice-breaker (Fig. 3). Canmer Kigoriak has performed with considerable success operating in the Canadian Arctic waters throughout the year (Brewer, 1982).

The Arctic Pilot Project, a consortium of Petro Canada, Dome, Melville Shipping Limited and Trans Canada Pipeline is planning to place orders for two ice-breaking tankers of CASPPR Class VII which would be used to transport liquefied natural gas from the Melville Island terminal to a gasification plant in eastern Canada. Moreover, the Dome Petroleum plans to acquire, in the very near future, Arctic Class X (Fig. 4) ice-breaking tankers capable of year-round operation through the Northwest Passage.

4. Surveillance of Year-round Shipping Routes in the Canadian Arctic

The operational success of ice-breaking tankers depends on reliable ice and weather information in the Canadian Arctic in general, and the Northwest Passage in particular. Heavy consolidated multi-year ice prevails year-round in the M'Clure Strait and Viscount Melville Sound (Dey, 1981). Multi-year ice floes and ice bergs pose serious hazards to shipping in the Parry Channel.

The successful operation of ice-breaking tankers will depend on the surveillance of ice and weather condition in the shipping routes of the Canadian Arctic. The early proposal of this author (Dey, 1981) has been elaborated in this paper in the following four steps: a survey of existing satellites; the need for satellites with TIR and microwave sensors; the development of high speed real-time digital image processing; and the use of an arctic communication satellite.

The present environmental and resource satellites that carry visible, thermal infrared (TIR) and microwave sensors are, to a minor extent, useful for surveillance of ice and weather conditions in the shipping routes of the Canadian Arctic during the summer season. Most of the present operational satellites such as NOAA/TIROS and Landsat have visible and TIR sensors that can be used for environmental monitoring (Dey and Richards, 1981). However, the surveillance of Northwest Passage with visible and TIR senors is not always feasible because of heavy cloud cover during the summer season and also occasional cloud cover in the winter season. The SMMR microwave sensor of Nimbus satellite has all weather capabilities, but because of its poor ground resolution (30 - 50 km), it can not be used for surveillance of sea ice in the Northwest Passage.

For surveillance of sea ice in the Northwest Passage of the Canadian Arctic, the remote sensing community need high resolution TIR and microwave sensors. The TIR sensors of the present NOAA/TIROS and Landsat satellites can be very useful for surveillance of sea ice if a supporting satellite with a high resolution microwave sensor (SAR) can be operated. Canada is planning to have a radar satellite (RADARSAT) by the end of 1980's. The satellite will have a Synthetic Aparture Radar (SAR) as the primary sensor to provide information on arctic sea ice.

Real-time or near real-time digital processing of satellite data on sea ice and computer processing of weather and other data are necessary for successful surveillance work. At present, the processing of Landsat - TM data and Nimbus-SMMR data is very time consuming and expensive. The remote sensing community needs more R and D to develop high speed state-of-the-art components for real-time image processing of TIR and SAR data on sea ice.

Finally, the remote sensing community needs a reliable arctic communation system that would involve providing satellite derived information on sea ice and weather data from a COC (Central Operating Center) to a ship's master via a communication satellite.

5. Conclusions

Results of drilling in the Canadian Arctic continue to support the prediction of considerable hydrocarbon deposits in the area. The development of hydrocarbon and other nonrenewable resources in the Canadian Arctic requires environmentally safe and reliable transporation. Ice-breaking tankers of Class VII and beyond are now considered the most likely means of transporting Canadian Arctic hydrocarbons to southern markets. However, year-round shipping through the Canadian Northwest Passage need surveillance of sea ice and weather conditions in the ice-breaking tanker routes.

Surveillance of sea ice in the shipping routes of the Canadian Arctic and passing the information in real-time to ship's masters pose a challenge to the remote sensing community. This is a challange because, at present, we do not have a satellite with high resolution microwave (SAR) sensor that would provide detail sea ice information required for navigating ice-breaking tankers through the Northwest Passage. In additon, very time consuming satellite data (microwave/TIR) processing do not permit real-time transmission of sea ice information to a ship's master.

The remote sensing community can meet the challenge with multi-disciplinary research by (i) developing a high resolution microwave sensor (SAR) suitable for providing detail navigable sea ice information from space; (ii) developing high speed digital processing of SAR and TIR data on sea ice for real-time transmission; and (iii) providing sea ice and weather information in real-time or near real-time to ship's masters through a communication satellite.

This study suggests a surveillance operational plan in which satellite data will be received by ground receiving station in Prince Albert. The satellite data on sea ice and weather will be transmitted in real-time to a Central Operating Center (COC) to be located in Ottawa or St. John's. At COC, the satellite and air borne data on sea ice, weather charts and other data ahead of operating ice-breaking tankers will be compiled and analyzed with the help of high speed computers. Then the COC will advise in real-time or near real-time to ship's masters via a communication satellite on possible environmentally safe ice-breaking tankers routes.

6. References

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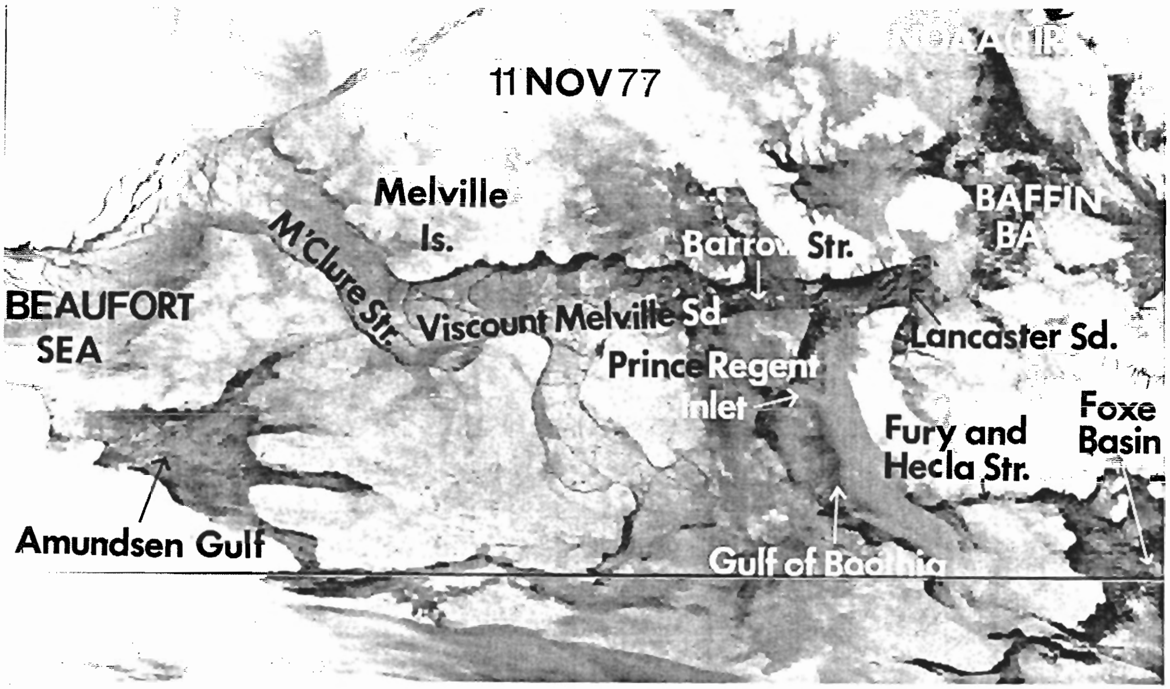

Figure 1: NOAA-TIR image of 11 November 1977. Imagery shows severe ice conditions in the channels of the Canadian Arctic.

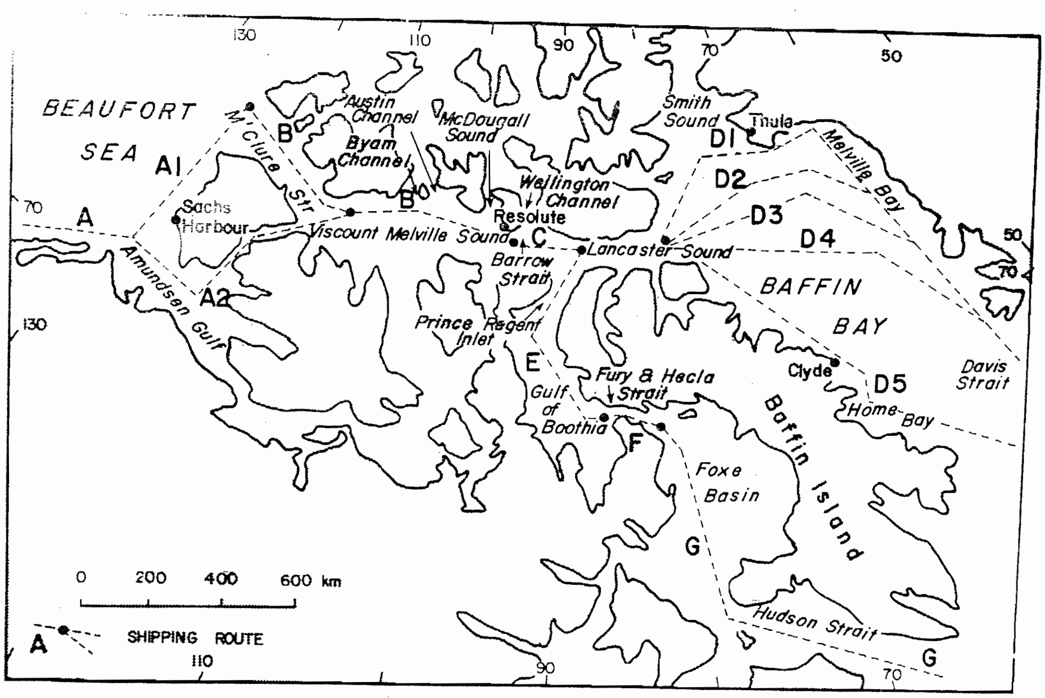

Figure 2: Year-round shipping routes in the Canadian Arctic (after Dey,1981)

Figure 3: Arctic Class IV type ice-breaker - Canmer Kigoriak (Courtesy: Dome Petroleum)

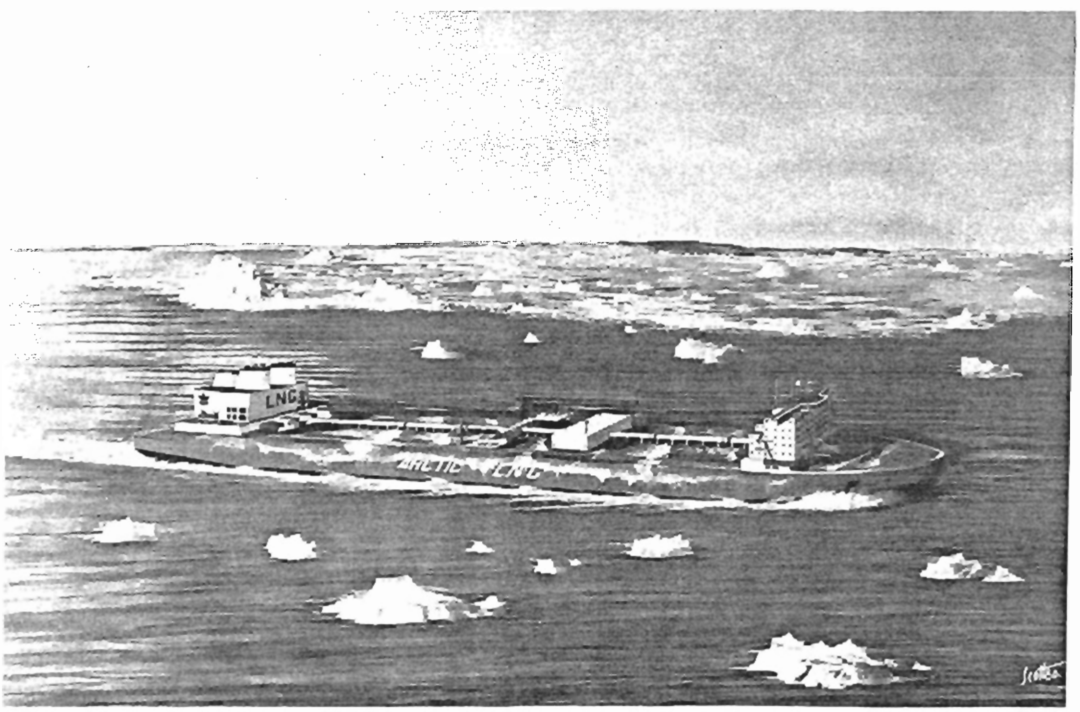

Figure 4: Arctic Class X ice-breaking tanker (sketch)