ARCTIC
VOL. 40, SUPP. 1 (1987) P. 34-41

Ice Conditions at Cape Hatt, Baffin Island

DAVID F. DICKINS[1]

(Received 12 June 1986; accepted in revised form 24 February 1987)

ABSTRACT. The ice environment at Cape Hatt was studied to determine annual variations in ice break-up and freeze-up, which could affect the design, execution and results of the Baffin Island Oil Spill Project. Data from lapse camera stations, field observations and historical charts were used to compare the Cape Hatt ice regime with other arctic sites and to assess the potential for ice interaction with oiled intertidal sediments.

The Cape Hatt area experiences 63 days of open water in an average year and generally has a similar ice cycle to other inlets in the eastern Arctic. Ice deterioration begins in June, and the area is normally clear of ice by late July. Freeze-up begins in late September, and complete ice cover is established within a month of first ice formation. Given the 30% shorter open water period at Cape Hatt compared with more southerly arctic locations, the long-term oil weathering rates derived from the BIOS Project can be considered conservative when applied to areas such as the Beaufort Sea. The summer of 1981 was characterized by an unusually long open water season, and ice did not hinder field operations associated with the experimental oil releases. The variability in open water seasons during subsequent summers will be an important factor in determining the long-term fate of oil stranded in Bay 11. The interaction of ice with the nearshore seabed was observed to play a major role in mixing and redistributing the upper layer of beach material ranging from fine silt to boulders.

Key words: Cape Hatt, ice break-up, ice freeze-up, time lapse, Baffin Island

RÉSUMÉ. L'environnement glaciaire du cap Hatt a été étudié afin de déterminer les variations annuelles dans la débâcle et la prise des glaces, qui pourraient affecter la conception, le déroulement et les résultats du projet de déversement de pétrole à l'île Baffin. Les données obtenues à partir de stations de photographies prises à intervalles, d'observations sur le terrain et de cartes historiques, ont été utilisées pour comparer le régime des glaces du cap Hatt avec celui d'autres sites arctiques, et pour évaluer le potentiel d'interaction entre la glace et les sédiments couverts de pétrole sur la laisse.

Le cap Hatt voit en moyenne 63 jours d'eau libre par an, et a en général un cycle glaciaire semblable à celui des autres anses de l'est de l'Arctique. La détérioration de la glace commence en juin et la région est normalement libre de glaces vers la fin juillet. La prise des glaces commence à la fin septembre, et la glace recouvre complètement la région dans le mois qui suit la formation de la première glace. Etant donné que la période d'eau libre est 30% plus courte au cap Hatt que dans des zones arctiques situées plus au sud, on peut considérer que les taux de dégradation à long terme du pétrole, obtenus à partir du projet BIOS sont sous-estimés quand on les applique à des régions comme la mer de Beaufort. L'été de 1981 s'est caractérisé par une longueur inhabituelle de la saison d'eau libre, et la glace n'a pas gêné les opérations sur le terrain reliées aux déversements expérimentaux de pétrole. La variabilité des saisons d'eau libre pendant les étés suivants sera un facteur important qui influencera le comportement à long terme du pétrole échoué dans la baie 11. On a observé que l'interaction entre la glace et le fond de la mer près de la côte jouait un rôle primordial dans le mélange et la redistribution de la couche supérieure des matériaux de la plage allant du limon aux gros galets.

Mots clés: cap Hatt, débâcle, prise des glaces, photographies prises à intervalles, île Baffin

Traduit pour le journal par Nésida Loyer.

INTRODUCTION AND OBJECTIVES

This paper is one of a set published in *Arctic*, Supplement 1 (1987), which together report the results of the Baffin Island Oil Spill (BIOS) Project. A major objective of the project was to examine and compare the fate and effects of oil treated with dispersant and untreated oil released into a representative nearshore arctic environment. A description of the general project design and a discussion of findings are given in Sergy and Blackall (1987). The purpose of this paper is to describe the methodology and results of a limited field survey of the nearshore ice environment at Cape Hatt (Dickins, 1981; Dickins and Browne, 1981).

The ice environment was considered as a potential hindrance to the BIOS Project planning, execution and interpretation. First, ice was anticipated to be the dominant environmental factor controlling logistics and scheduling of the experiment. Information was required to predict the probable open water window available to the project at the early planning stages. Second, the presence of ice effectively controls the timing and duration of exposure of an oiled intertidal zone to natural weathering processes in the Arctic. Third, ice was considered a potential mechanism for transport and redeposition of oiled sediments within the intertidal zone following the oil releases.

The BIOS Project ice monitoring programs had the primary objective of providing a qualitative description of the local ice environment within Ragged Channel and the three experimental Bays 9, 10 and 11 (see location map in Sergy and Blackall, 1987). Ice information collected during the summers of 1980 and 1981 was used in several different ways. Field observations in 1980 were combined with an analysis of historical break-up patterns in the Cape Hatt region to develop a prediction of ice clearing dates in Ragged Channel for 1981. Observations of break-up and freeze-up at Cape Hatt were also compared with historical records of nearby arctic sites to estimate annual variations in the number of days of open water. Observations of break-up and freeze-up processes within Ragged Channel and the test bays were used to assess the potential importance of sediment transport through ice motion along shore. Qualitative indications of ice movement patterns from 1980 observations were also used to guide the selection of test bays to minimize any potential for cross-contamination through ice motion (Dickins *et al.*, 1987).

[1]DF Dickins Associates Ltd., 3732 West Broadway, Vancouver, British Columbia, Canada V6R 2C1

MATERIALS AND METHODS

Ice monitoring was carried out by means of remote camera and direct field observations from 22 July to 6 October 1980 and from 1 June to 20 September 1981. Nine time-lapse camera systems were assembled in 1980 specifically for the BIOS Project. These systems used standard Sankyo EM60XL 8-mm movie cameras coupled to custom-fabricated electronic timers set for 4, 8 and 16 min intervals. These timers enabled the cameras to operate for periods of 10, 20 and 40 days respectively between film changes. The cameras employed automatic aperture control and a wide-angle to zoom lens providing up to a 40° field of view. Each camera was equipped with a battery-driven clock visible in the picture frame. Up to three 6-volt alkaline batteries were interconnected to enable unattended operation for up to five weeks, depending on temperature. Protection from the elements was provided by several layers of white plastic bags to minimize daytime heating of the camera body and associated condensation problems as the sun angle decreased later in the day. No external heat source was used. The cameras were mounted on standard photographic tripods heavily ballasted with rocks to provide secure support in strong winds. Figure 1 shows a typical camera installation with the clock extended 70 cm ahead of the lens focal point.

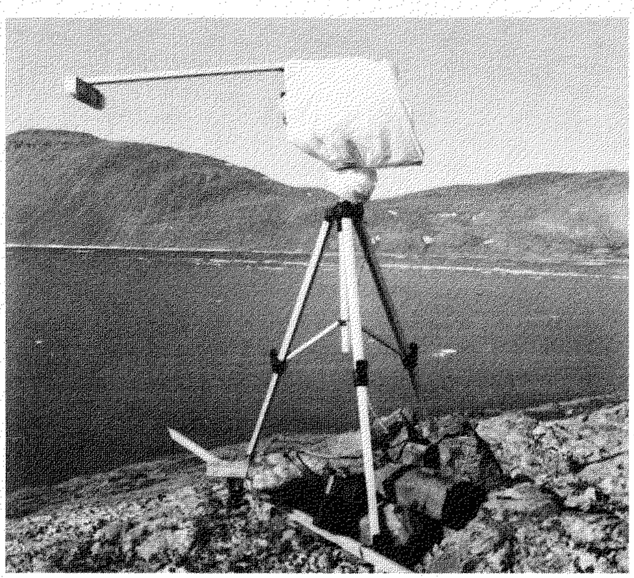

FIG. 1. View showing a typical time-lapse camera installation.

Up to nine time-lapse cameras were deployed at strategic locations around Cape Hatt to provide regional and site-specific coverage in 1980 and 1981. During the two summers, a total of 750 camera days of good quality time-lapse footage was obtained. The overall percentage recovery of usable data was approximately 85%, in spite of interruptions caused by lens fogging and chewing of battery cables by foxes.

Field observations involved a systematic daily review of ice conditions within the test bays and still photographs to compare with the time-lapse records. In 1980, regular helicopter reconnaissance was used to chart the progression of ice break-up and freeze-up around Cape Hatt.

Field observations and photographs were combined with historical ice charts and Pond Inlet ice thickness records to compare Cape Hatt conditions between the years 1980 and 1983 with historical normals dating back to 1964. Predictions of ice break-up at Cape Hatt in 1981 were made on the basis of winter ice thickness, snowfall and temperature trends recorded at Pond Inlet. Allowances were made for regional differences in break-up patterns observed in historical records.

RESULTS AND DISCUSSION

General Description of the Cape Hatt Ice Environment

Cape Hatt is surrounded every winter by the stable, smooth landfast ice of Eclipse Sound. Maximum, mean and minimum measured June ice thickness values at Pond Inlet, the nearest recording site, are 196 cm, 157 cm and 112 cm respectively (Allen, 1977). First melting of the ice cover in Eclipse Sound occurs in June at points of freshwater inflow. The eastern entrance to Pond Inlet clears first, and open water spreads west to include Eclipse Sound by late July. At the same time, the ice edge in Navy Board Inlet retreats southward. At final break-up, remaining ice usually drifts south into the western extremities of Eclipse Sound. New ice begins forming in Eclipse Sound in late September, but a month or more may pass before the young ice is stable enough to resist break-up by strong winds.

Table 1 compares dates of complete ice clearing and first new ice formation for a number of arctic sites, including Cape Hatt. This comparison indicates that although generally representative of other locations in the Baffin region, the Cape Hatt site normally experiences several weeks less of open water than the southern Beaufort Sea. The implications of this shortened summer season are that results from the BIOS Project in terms of shoreline oil weathering and natural oil removal through wave action can be considered conservative when applied to more southerly arctic locations.

TABLE 1. Ice break-up and freeze-up dates and open water duration for selected Canadian arctic locations

Location	Break-up	Freeze-up	Open water
Beaufort Sea			
Tuktoyaktuk	27 June	2 October	98 days
Sachs Harbour	12 July	1 October	81
Baffin Region			
Resolute Bay	7 August	22 September	46
Arctic Bay	31 July	7 October	68
Clyde	2 August	19 October	78
Cape Dyer	9 August	29 October	81
Frobisher Bay	17 August	22 October	66
Cape Hatt	1 August	3 October	63

Sources: for Beaufort Sea and Baffin Region, Allen, 1977; for Cape Hatt, A.E.S. Ice Charts, 1964-83.

Annual Variability in Break-up and Freeze-up Dates

The two years of direct ice observations associated with the BIOS Project were compared with historical records of ice break-up and freeze-up maintained by the Atmospheric Environment Service. Table 2 shows the historical variation in summer open water at Cape Hatt derived from Canadian government ice charts. Table 3 compares the historical normals

TABLE 2. Historical variation in summer open water duration at Cape Hatt derived from Canadian government ice charts

Year	Days open water	Open water period
1964	56	30 July-23 September
1965	56	30 July-23 September
1966	77	30 July-14 October
1967	45	10 August-23 September
1968	68	3 August- 9 October
1969	52	3 August-23 September
1970	77	23 July- 7 October
1971	77	23 July- 7 October
1972	35*	20 August-23 September
1973	91	23 July-21 October
1974	64	13 August-15 October
1975	64	23 July-23 September
1976	46	1 September- 5 October
1977	70	3 August-11 October
1978	49	1 August-18 September
1979	63	7 August- 8 October
1980	57	5 August-30 September
1981	84	28 July-19 October
	Mean 63	

*This is in doubt.

TABLE 3. Summary of Cape Hatt summer ice seasons, 1980-83

	1980	1981	1982	1983	Mean, 1964-83
Area clear of ice	2 Aug.	28 Jul.	27 Jul.	31 Jul.	1 Aug.
Days open water	59	84	62	62	63
First new ice along shore	30 Sept.	20 Oct.	28 Sept.	2 Oct.	3 Oct.

FIG. 2. Aerial photograph showing an example of early break-up around Cape Hatt, 25 July 1958. Photograph provided by National Air Photo Library, Ottawa.

with dates of first ice concentration less than 2/10 (aerial coverage) and dates of first new ice formation during the summers preceding, during and following the oil releases. Except for occasional intrusions of older rotting floes from Eclipse Sound, the time span between these two dates represents the approximate period that oil present in the intertidal zone would have been exposed to wave action during those years for which records are available. Table 3 shows that the test bays were exposed to open water for a normal length of time during the summer preceding and during the two summers following the oil releases (compared with the 20-year historical mean). During the 1981 summer, when oil was released, an early break-up and record late freeze-up resulted in an open water period at Cape Hatt three weeks longer than average. That the ice conditions experienced during the summer of 1981 were not unique is evidenced by Figure 2, showing an aerial photograph of Ragged Channel clear of ice on 25 July 1958.

Regional Patterns of Ice Clearing and Freeze-up, 1980 and 1981

In 1981, initial fracturing of the ice cover in Pond Inlet and Eclipse Sound was observed in a Landsat image obtained on 13 July. At that time, open water areas were found predominantly along the west shoreline of Navy Board Inlet. By 21 July 1981, open water extended as far south as Eclipse Sound, and Ragged Channel was in an advanced stage of break-up. The previous year saw Ragged Channel still completely ice-covered on 22 July (Fig. 3). Break-up in 1980 proceeded rapidly thereafter, as prevailing northerly winds broke up the rotting ice and drove loose floes to the south of Bay 9 (Fig. 4). In 1981, Ragged Channel was clear of ice by 28 July, approximately one week ahead of 1980. Figures 5 and 6 show contrasting views of the Bay 9 beach from similar camera angles on 27 July 1980 and 29 July 1981 respectively. A time history of ice clearing within Ragged Channel is provided by Figures 7, 8 and 9, showing ice maps derived from helicopter reconnaissance between 22 July and 1 August 1980. The response of ice within the channel to the changing wind directions is evident from the wind direction arrows drawn on each map.

The Cape Hatt area remained clear of ice in 1981 until 20 October, a record late freeze-up for the area. Even at this late date, open water was still present in the east end of Eclipse Sound. Figures 10 and 11 show the progression of new ice development within Ragged Channel in 1980, from the first coating of new ice within the intertidal zone on 30 September to grey ice extending halfway across Ragged Channel on 5 October.

Ice/Sediment Interaction

Observations at Cape Hatt demonstrated that during break-up drifting ice floes can transport nearshore sediments. Sea ice transfer of bottom material begins as the bottom-fast ice melts and floats free of the seabed in July. During the winter this ice is frozen to the bottom sediments out to about the 3 m isobath (depth below mean sea level). During ice break-up this material can be transported as the floe drifts and eventually deposited when the floe finally melts completely. There is limited opportunity for ice to drift out of Ragged Channel, so much of the sediment load incorporated in the nearshore bottomfast ice is likely to be deposited within the southern half of the channel,

FIG. 3. Ragged Channel completely covered by a rotting ice cover, 23 July 1980.

FIG. 4. Ragged Channel half clear of ice on 25 July 1980.

FIG. 5. View of ice along the Bay 9 shore, 27 July 1980.

where the rotting floes are often concentrated by prevailing northerly winds (Meeres, 1987). In 1980, a limited volume of bottom material was observed being deposited in the intertidal zone by floes that melted after becoming stranded on the beach (Figs. 12-14). Grounded ice tended to be concentrated on beaches having a northerly exposure, in response to the most prevalent wind direction.

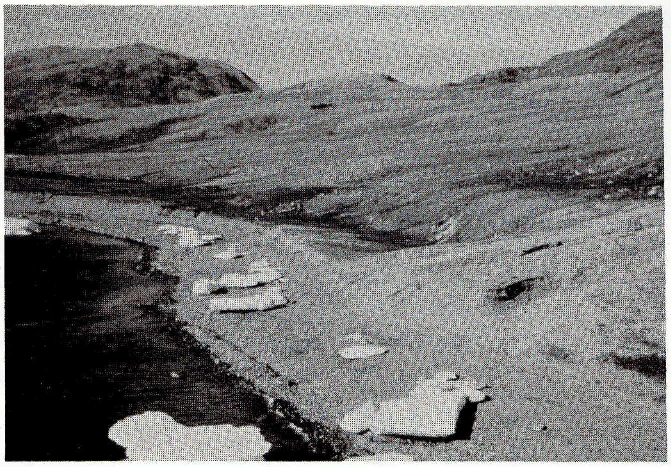

FIG. 6. View of ice along the Bay 9 shore, 29 July 1981.

The potential exists for ice to transport oiled sediments from one shore location to another. Ice motion was studied in a qualitative manner from time-lapse photography to estimate which test bays had the most potential for receiving floes from adjacent areas. Nearshore ice motion did not necessarily correspond to ice drift in the centre of Ragged Channel. Floes would often remain static for several hours within 30 m of shore, in apparent contradiction to the offshore ice movements. These observations agree with the descriptions of tidally controlled gyres within the test bays in Ragged Channel (Buckley *et al.*, 1987). In general, ice floes were observed to follow a clockwise motion in Bay 9 and a counterclockwise motion in Bays 10 and 11. Complete circulation of floes was least evident in Bay 11. In order of decreasing potential for receiving oiled sediments through ice drift from an adjacent oiled beach, the bays in Ragged Channel were subjectively rated in 1980 as numbers 9, 10 and 11.

CONCLUSIONS

The Cape Hatt area normally experiences less than nine weeks in the year when ice is not in direct contact with the shoreline. The interaction of this ice with the bottom sediments plays a major role in mixing and redistributing the upper layer of beach material ranging in coarseness from silt to boulders. During break-up in late July, rotting sediment-laden floes can move beach material along the shore. In Ragged Channel, the prevailing northerly winds act to keep the northern half of the channel clear while concentrating rotting floe ice to the south in the vicinity of Bay 9. Any beach with a northerly exposure in the Cape Hatt area will act as a natural catch basin for loose floes throughout the summer.

In a normal or worse than average year, ice would have acted as a severe constraint on the scheduling and execution of the BIOS Project. Fortunately, the summer of 1981 was characterized by an unusually long open water season and ice was not a major factor during oil releases. However, the variability in the open water season during subsequent years will be an important factor in determining the long-term fate of oil stranded in Bay 11.

Cape Hatt normally experiences three weeks less open water than more southerly arctic areas such as the Beaufort Sea. Three weeks represents an overall decrease in average open water duration of 30%, a significant reduction in the long-term

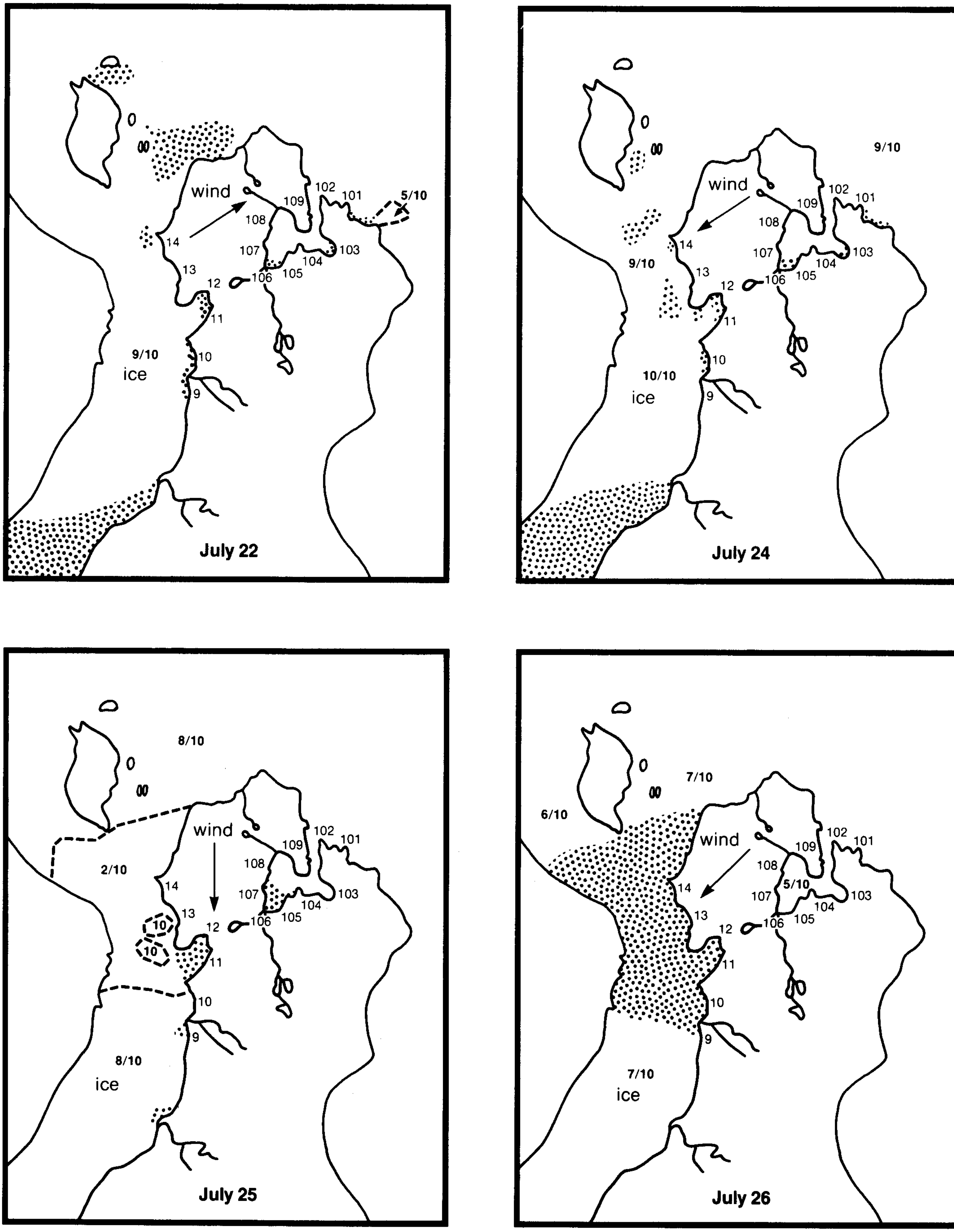

FIG. 7. Ice break-up in Ragged Channel, 22-26 July 1980.

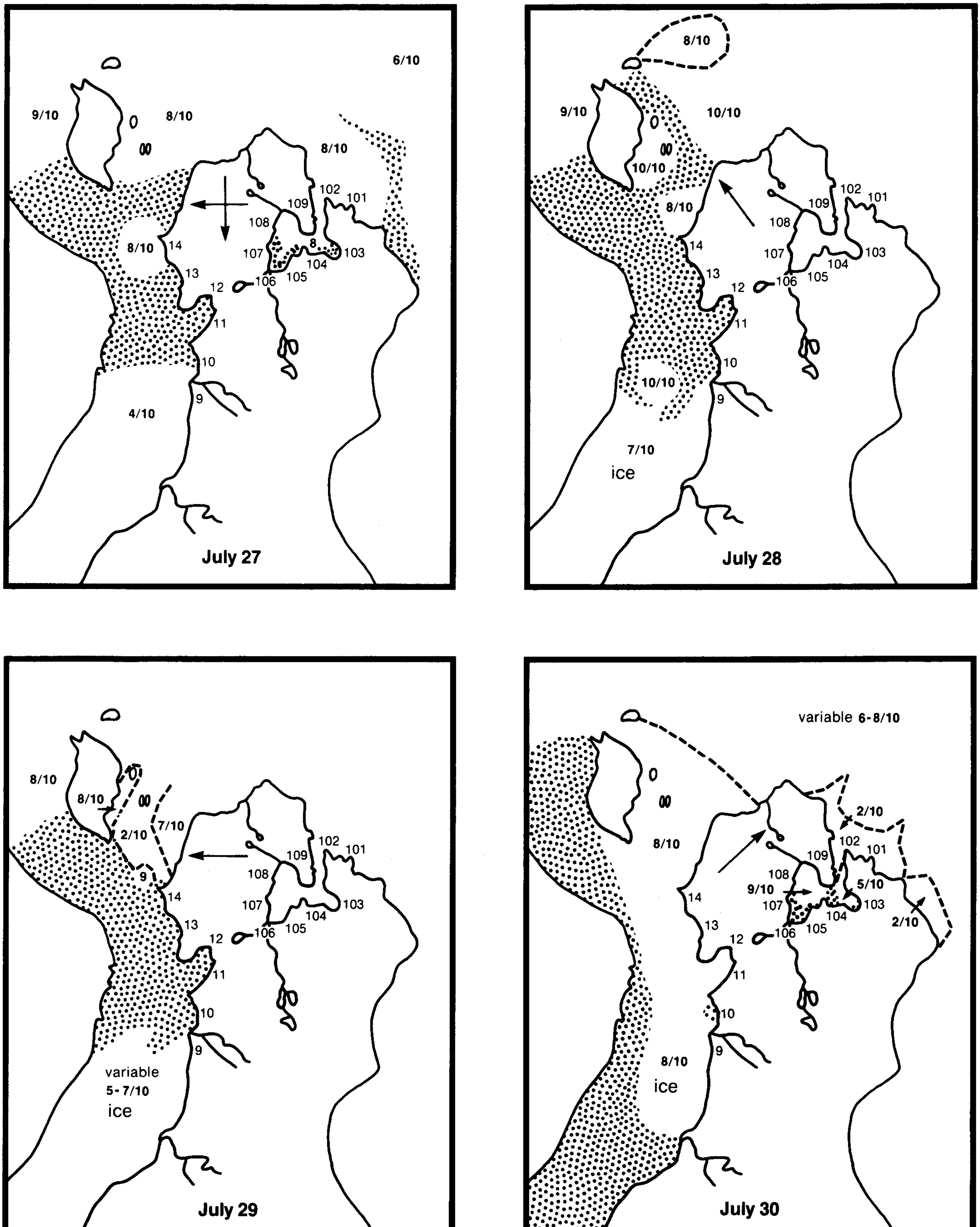

FIG. 8. Ice break-up in Ragged Channel, 27-30 July 1980.

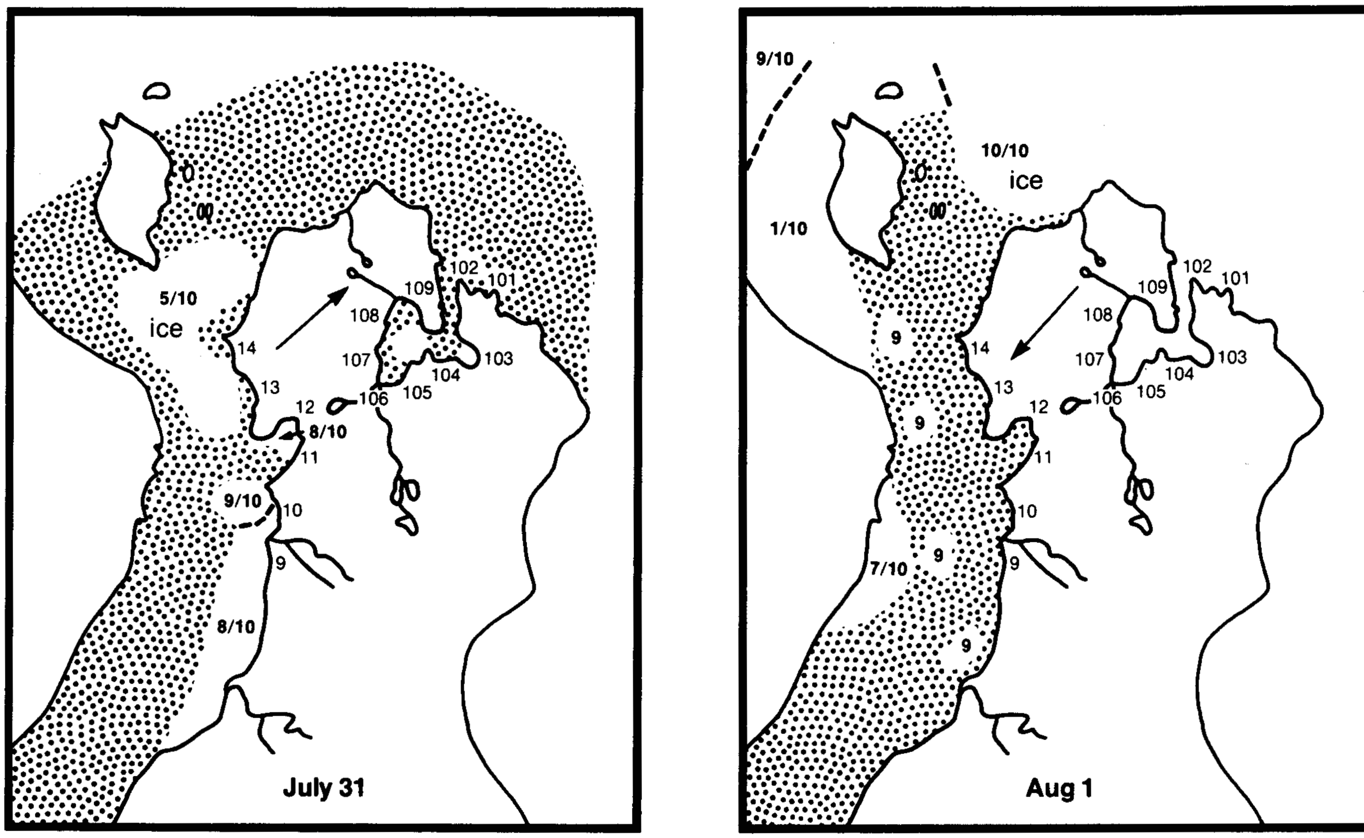

FIG. 9. Ice break-up in Ragged Channel, 31 July-1 August 1980.

FIG. 10. New ice coating the intertidal zone of Bay 9, 30 September 1980.

FIG. 11. New ice growing out into Ragged Channel from Bays 10 and 11, 5 October 1980.

exposure of oil to wave action. The implications of a shortened summer season are that the long-term results from the BIOS Project in terms of rates of shoreline oil weathering and natural removal through wave or tidal action can be considered conservative when applied to more southerly arctic locations.

Time-lapse cameras proved to be a reliable and economical method of obtaining long-term remote records of ice/shoreline interaction processes. With suitable heated enclosures, the same system could be deployed later in the season to effectively document nearshore ice movements in October and November along more exposed arctic shorelines than those represented by the Cape Hatt area.

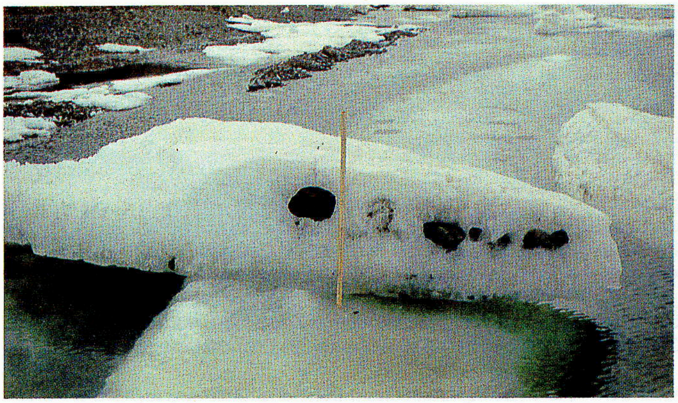

FIG. 12. Coarse sediment incorporated within a stranded floe in Bay 9, 25 July 1980.

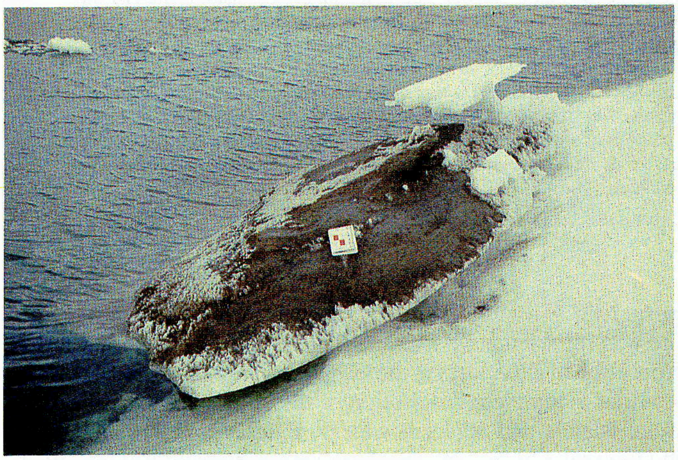

FIG. 13. Sediment-laden ice floe overturned in Bay 10.

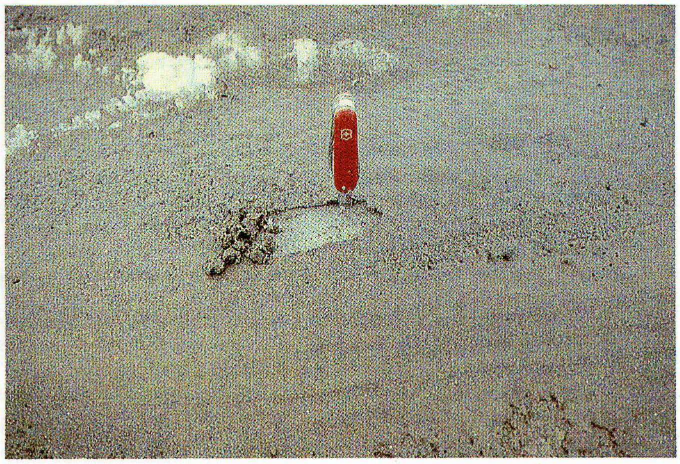

FIG. 14. Close-up view of sediment coating the floe shown in Figure 13.

ACKNOWLEDGEMENTS

The author wishes to acknowledge the contributions of Robin Brown, of Arctic Laboratories Ltd., who maintained the camera systems and carried out many of the field observations in 1980, Blair Humphrey for his field assistance in 1981, BIOS Project staff (Richard Clark, Paul Idlout) for their cooperation in checking and maintaining cameras while contractors were absent, and Peter Blackall for deploying the camera stations early in the season in 1981.

Funding for the ice monitoring programs at Cape Hatt was provided through the BIOS Project administered by the Department of the Environment.

REFERENCES

ALLEN, W.T. 1977. Freeze-up, Break-up and Ice Thickness in Canada. Ottawa: Atmospheric Environment Service. 185 p.

ATMOSPHERIC ENVIRONMENT SERVICE. 1964-83. Eastern Arctic Ice Charts. Available on order from A.E.S., Ottawa.

BUCKLEY, J.R., DE LANGE BOOM, B.R., and REIMER, E.M. 1987. The physical oceanography of the Cape Hatt region, Eclipse Sound, N.W.T. Arctic 40 (Supp. 1):20-33.

DICKINS, D.F. 1981. Ice conditions — 1981 study results. (BIOS) Baffin Island Oil Spill Project Working Report 81-8. Ottawa: Environmental Protection Service, Environment Canada. 41 p.

——— and BROWNE, R. 1981. Ice conditions — 1980 study results. (BIOS) Baffin Island Oil Spill Project Working Report 80-8. Ottawa: Environmental Protection Service, Environment Canada. 86 p.

DICKINS, D.F., THORNTON, D.E., and CRETNEY, W.J. 1987. Design and operation of oil discharge systems and characteristics of oil used in the Baffin Island Oil Spill Project. Arctic 40 (Supp. 1):100-108.

MEERES, L.S. 1987. Meteorological operations at Cape Hatt in support of the Baffin Island Oil Spill Project. Arctic 40 (Supp. 1):42-50.

SERGY, G.A., and BLACKALL, P.J. 1987. Design and conclusions of the Baffin Island Oil Spill Project. Arctic 40 (Supp. 1):1-9.