ROV and Submersible Video Interpretation of Iceberg Scour Features and Glory Holes on the Northeastern Grand Banks off Newfoundland.

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Abstract

Three ice scour features (Texaco Scour and Pit 89-01, Bowers Pit and Husky Scour 89-01) and two glory holes (Terra Nova and B-08), on the northeast Grand Banks off Newfoundland were investigated in 1990, using the Department of Fisheries and Oceans (DFO) Hysub 5000 ROV, sidescan sonar and acoustic profiling techniques. Observations from ROV video data suggest that Texaco Scour and Pit 89-01 changed little (other than some winnowing of fines) over a one year period. In Bowers Pit, exposed pre-consolidated fine grained sediment blocks have been eroded and biological colonization has increased since the original observations were made in 1986; observations from 1984-1985 video data, collected by the Cormorant SDL-1 submersible, also support these findings. Biological data suggest that Bowers Pit may be younger than previously thought. Other than some sediment winnowing, the Husky Scour has changed little since the initial survey in 1988. The Terra Nova Glory Hole has slight sediment infill with little or no sign of erosion; semi-consolidated sediment outcroppings and blocks within the hole appear fresh and angular. Observations from 1984-1985 and 1990 video data, show that a great deal of erosion and infilling has taken place in the B-08 Glory Hole between 1985 and 1990. Sediment slumping and transport has infilled the B-08 Glory Hole by as much as 13 m (much of which occured immediately after excavation); semi-consolidated sediment outcroppings and blocks, found within the glory hole, are heavily eroded.

Acknowledgements

This work was funded by the Panel for Energy, Research and Development (PERD) Offshore Geotechnics (East Coast) program. We would like to acknowledge Dave Frobel for providing the video equipment and his expertise during this study. We would also like to thank Kevin Robertson and Steve Solomon for their time, expertise and the use of video frame recorders. Finally, thanks to Russ Parrott and D.L Forbes for proofing this document.

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Introduction

In 1990 the Atlantic Geoscience Centre (AGC), as part of an Environmental Studies Revolving Fund (ESRF) seabed repetitive mapping project, initiated a cruise (**C.S.S. Dawson,** 90-021) to look for changes and/or additions to a network of iceberg scour features, and to resurvey selected scours and pits for degradation, infill and biological colonization; several industry glory holes were also investigated. Klein 50 kHz, Ferranti-ORE 100 kHz, dual frequency 100 and 500 kHz Klein sidescan, Huntec DTS subbottom profiler, and airgun single-channel seismic reflection data were collected. In addition, the Hysub 5000 ROV, equipped with SIT and colour video, Mesotech sector scanning sonar and still camera, was deployed to investigate specific seabed targets. Using these data a series of case histories of recent man-made and ice/seabed impact features have been assembled from hydrocarbon discovery areas on the northeastern Grand Banks off Newfoundland (Fig 1 and 2). These case histories have provided information on the processes of seabed disturbance and degradation of iceberg scours and pits.

This study reports on five targets surveyed during cruise 90-021, utilizing available seabed and ROV data to describe the dimensions, morphology, amount of infill and erosion, soil condition and surrounding seabed character for each dive site. Findings from these five sites were compared, where possible, with previous work in order to document changes over time. The five targets investigated include three ice scour features, Husky Scour 89-01, Texaco Scour 89-01, and Bowers Pit, and two "glory holes", Terra Nova O-9 and B-08, excavated by Mobil Oil Canada and Petro-Canada as test holes for burial of wellheads (Fig 2). Much of the new information about these targets came from eight ROV video tapes (numbered 1-8), collected in 1990. These tapes can be viewed by contacting the Atlantic Geoscience Centre Curation Section in Dartmouth, Nova Scotia.

Video cassette tapes of observations from the Canadian Navy Cormorant SDL-1 submersible collected on the Grand Banks in 1984 and 1985 provide high quality seabed information for Bowers Pit and the B-08 Glory Hole, and allow for direct comparison with the 1990 video data. Of the 5 video tapes, 3 are from 1984 and 2 are from 1985. The 1984 video data were collected on October 3rd (dive 3), 7th (dive 5) and 9th (dive 6), at Bowers Pit. The 1985 video data were collected on August 25th (dive 5), at Bowers Pit and on August 27th (dive 6), at the B-08 Glory Hole. These tapes can also be viewed at the Atlantic Geoscience Centre.

Photographs used in this report were either digitally or photgraphically captured from the video records and are generally less clear than the ROV video images. The geographic positions of these photographs had to be inferred since the ORE TRACKPOINT 2 positioning system, used to navigated the ROV, was not functioning properly. The ROV and bottom photo locations were determined from assumed locations and compass bearings which were related back to side scan images.

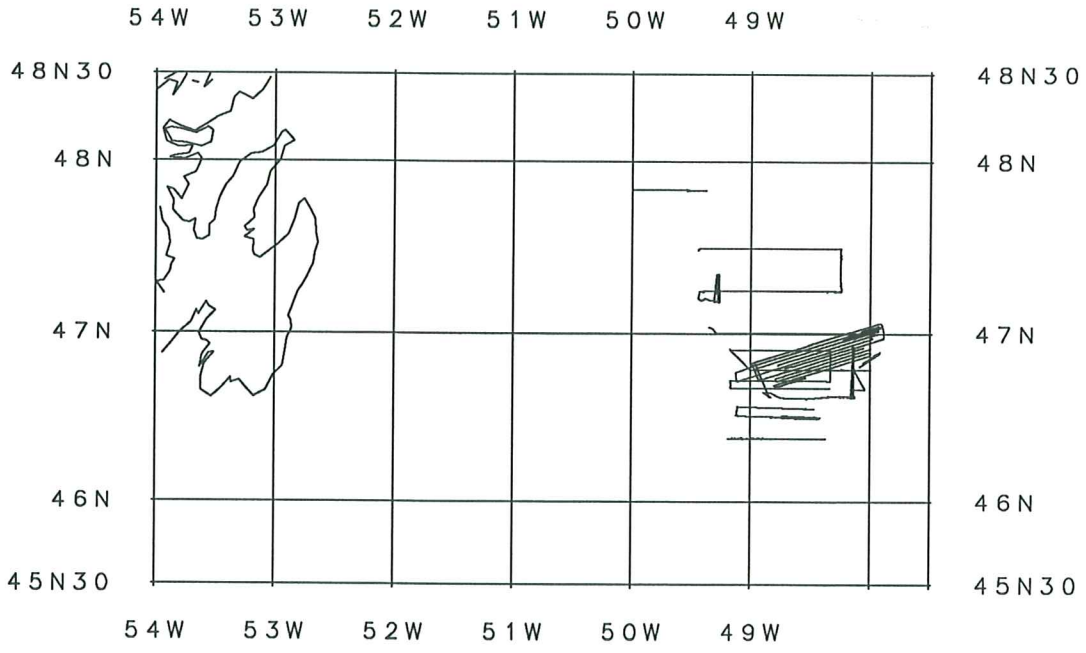


Fig 1 Regional map showing Dawson 90-021 survey lines.

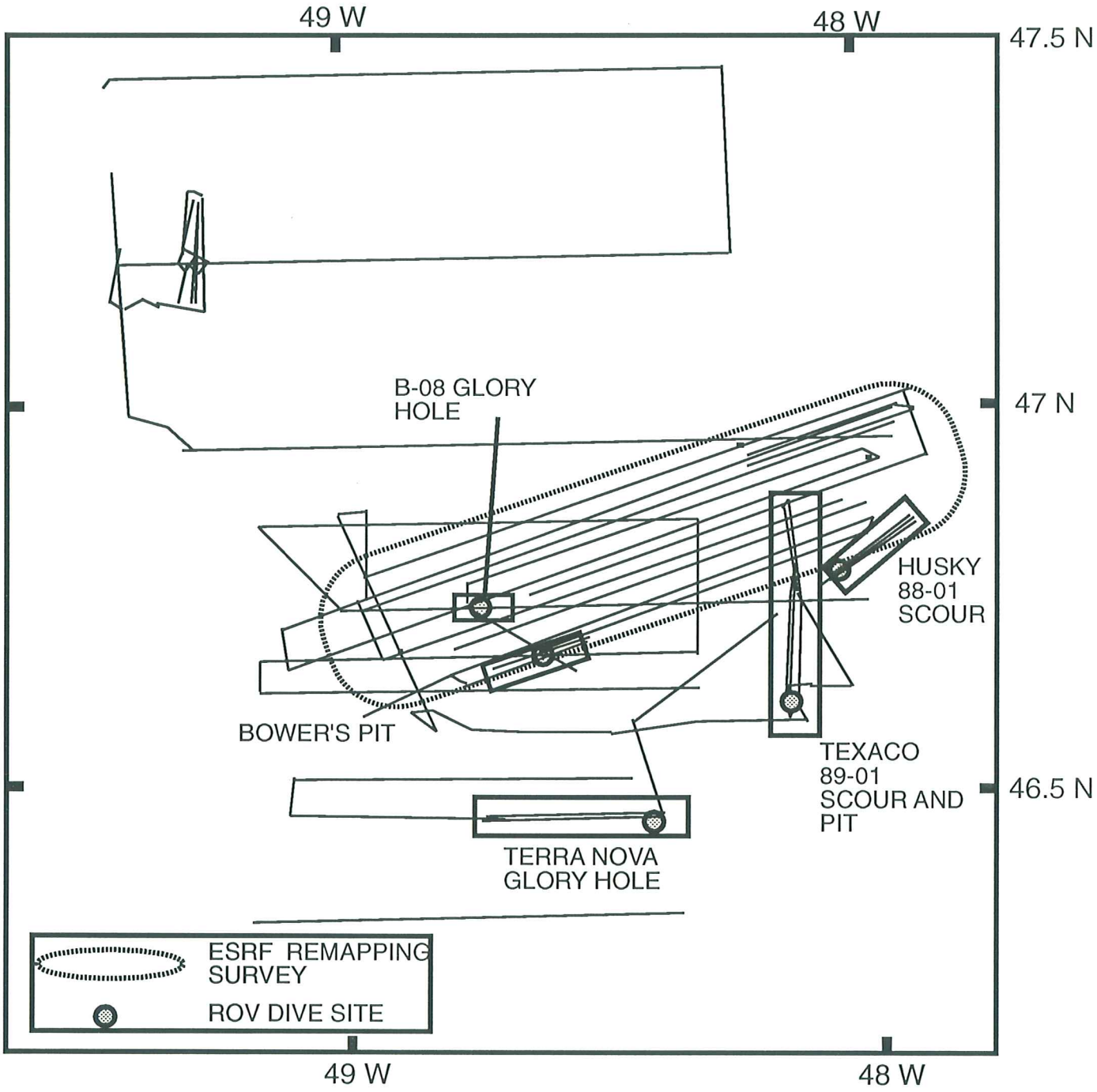


Fig 2 Study area, showing Dawson
of seabed features investig

Texaco Scour and Pit 89-01

On March 10, 1989 a large iceberg (1.3 million tonnes) grounded in 110 m of water near the Texaco Springdale M-29 well site on the Grand Banks of Newfoundland (Fig 2), and remained grounded for 45 days, drifting free on April 24, 1989. In May 1989, the Atlantic Geoscience Centre surveyed part of the iceberg grounding area, to study the nature of the seabed disruption. This iceberg grounding scoured the seafloor and produced a large pit, and provided a unique opportunity to study a well documented iceberg grounding. The findings from this study were published by Parrott et al. (1990).

Observations of the Texaco scour and pit were made using data collected in 1990 on cruise 90-021. Comparisons are made between these observations and those of previous work, in order to document change over time.

The iceberg scour has been interpreted from sidescan sonograms to be less than 1 m deep with a maximum width of approx. 80 m and a length in excess of 14 km. The scour terminates in a large pit having a maximum width of approx. 90 m and a depth of 5 m below the seafloor, with a berm rising 1-3 m above the seabed (Fig 3). From ROV observations, the top of the berm is generally rounded with hummocky relief in places. The top of the berm and exterior slope is often stony and well colonized by benthic biota (Fig 3A, 3C). The interior berm slope is composed mostly of unconsolidated sand (Fig 3E) and drops moderately steeply into the pit. Gravel patches are present in these areas. Parrott et al. (1990) described a complex structure of internal ridges within the pit, from 1989 sidescan sonar records. These ridges are still evident on more recent 1990 sidescan and sector scanning sonar data (Fig 3B). Video data show that the pit interior has hummocky relief in areas (Fig 3D, 3F) and that this relief is part of an internal ridge complex, with a few dropstones and boulders present. A steel tow cable, observed on the pit floor, (Fig 3F) was determined to be the cable used during an unsuccessful attempt to tow the grounded iceberg.

The seabed sediments surrounding the pit consist of occasional patches of gravel lag within a silty sandy seabed. Ice rafted dropstones and boulders are also found within the survey area. The most diverse biological life occurs in areas of the seafloor with gravel lag. Biota in these areas consist of hermit crabs, snails, sand dollars, starfish, basketstars, sponges, and many other encrusting forms. Sandy areas are dominated by brittlestars, sand dollars, and sea urchins. Pocklington (1990) suggests that some of the first biota into a newly disturbed area (scoured) will be the most mobile forms. ROV observations show that little change has occurred within the pit, between the initial survey (1989) and the 1990 survey. Some winnowing of fines may have occurred along with minimal sediment infill. Biological colonization may have increased.

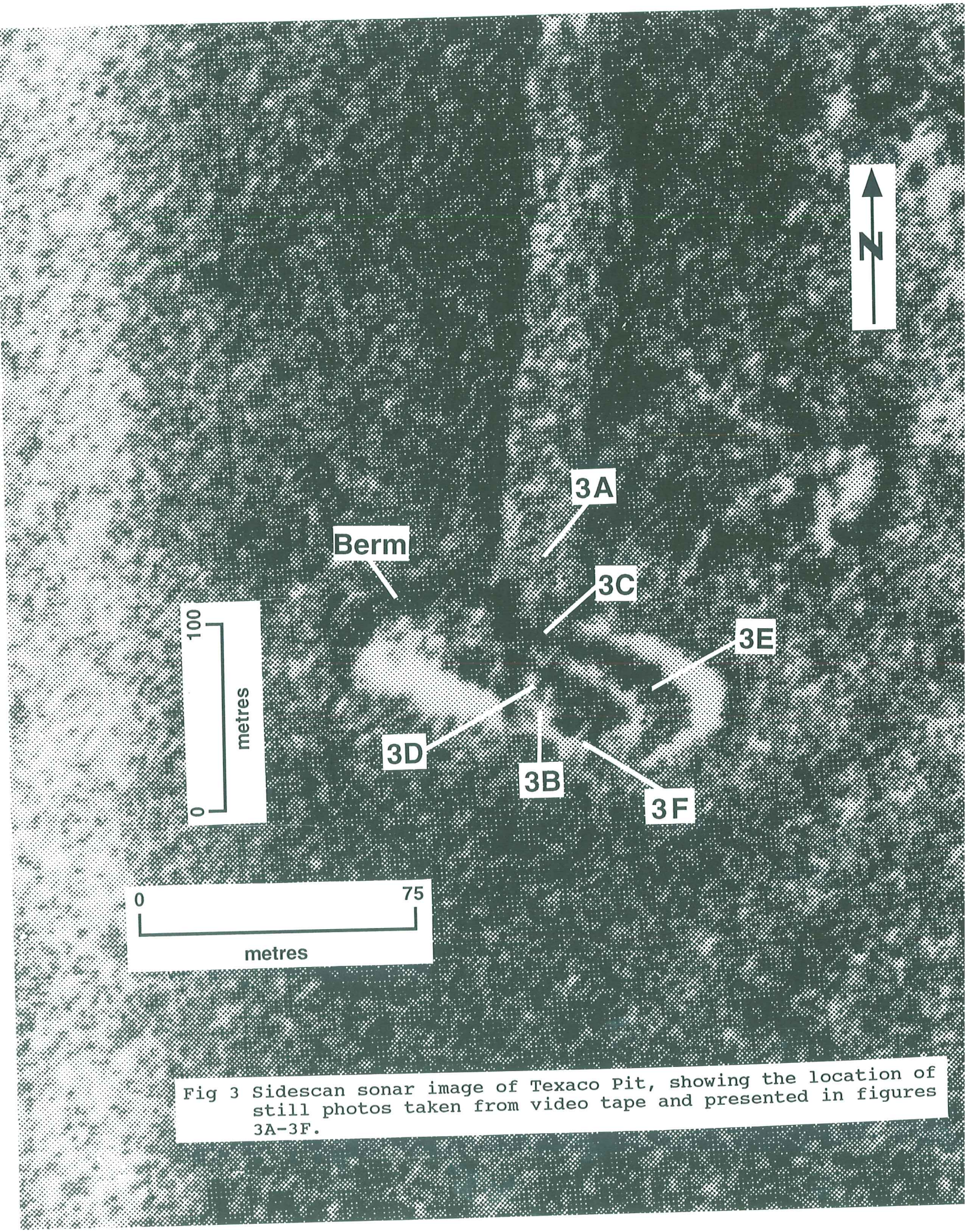


Fig 3 Sidescan sonar image of Texaco Pit, showing the location of still photos taken from video tape and presented in figures 3A-3F.

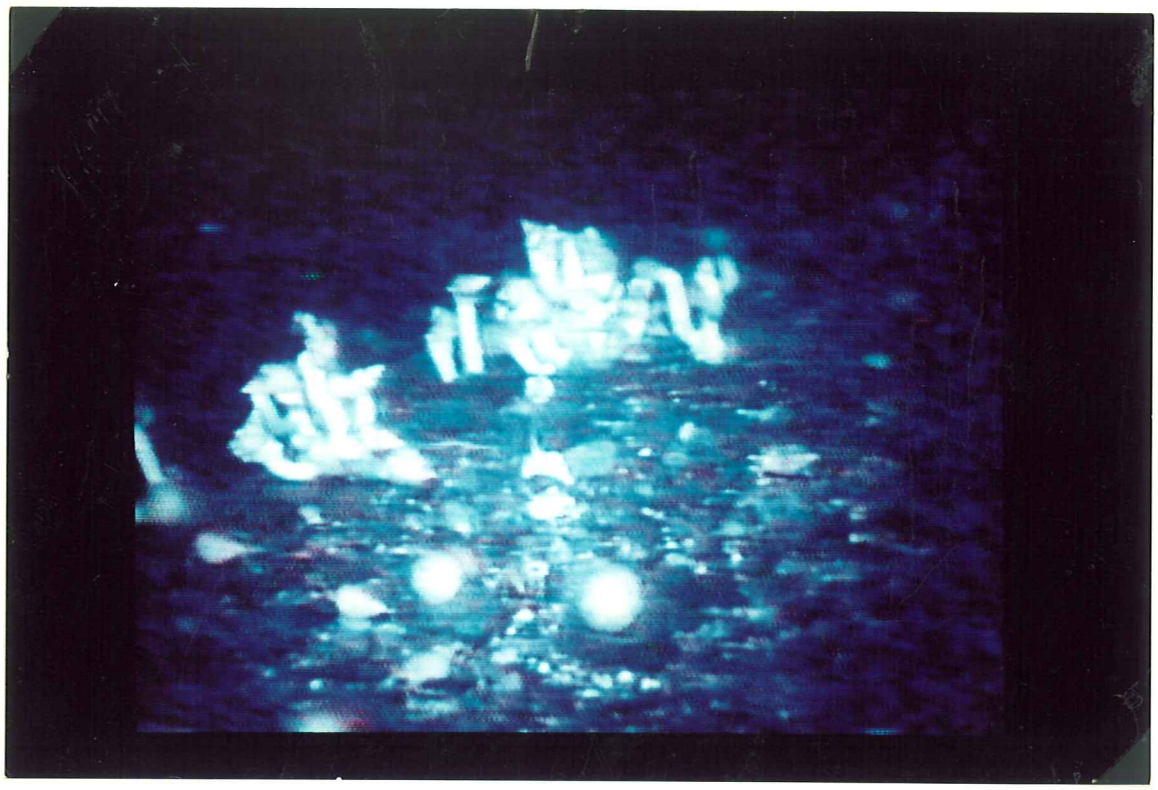


Fig 3A Berm top with a thick population of benthic organisms.

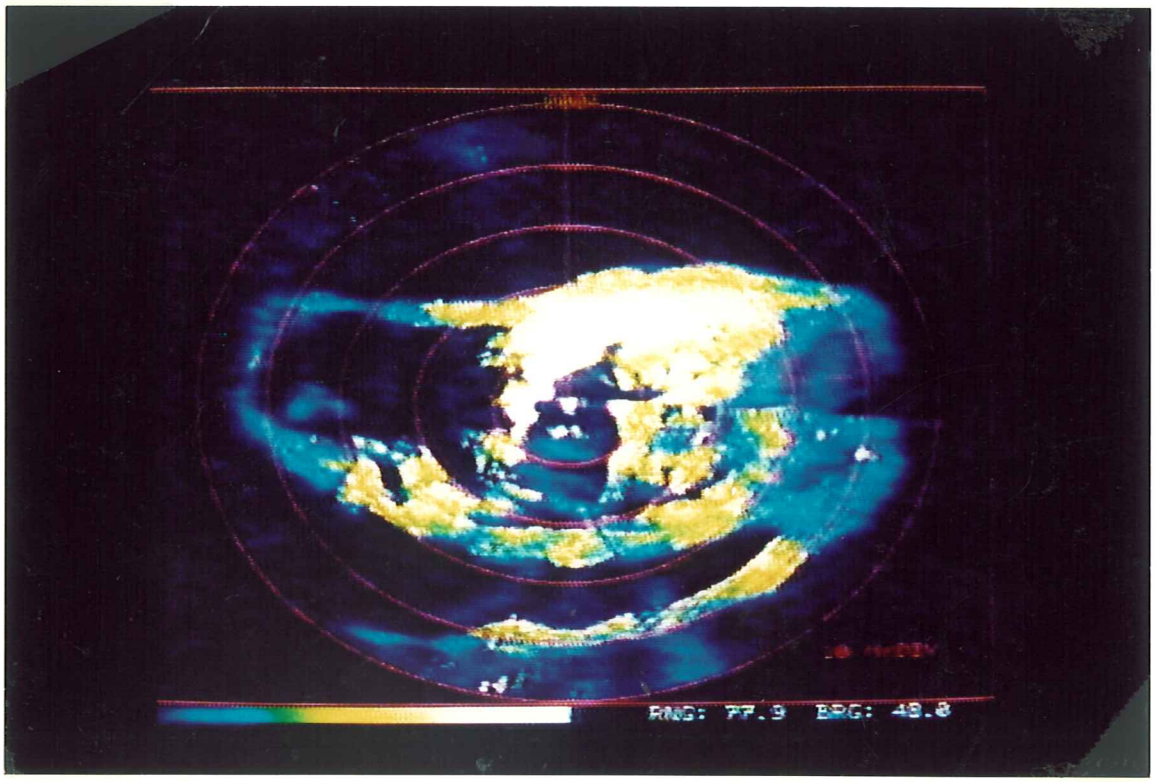


Fig 3B Sector-scanning sonar image of pit interior looking south (scan lines are 10 m intervals)

Fig 3C Berm crest with gravel lag cover, looking south into the pit.

Fig 3D Hummocky interior ridge

Fig 3E Inner berm flank and crest with gravel lag and benthic organisms.

Fig 3F Hummocky pit floor with partially buried cable.

Bowers Pit

Bowers Pit is an iceberg scour feature located on the northeastern margin of Grand Bank, approximately 12 km east-southeast of the Hibernia P-15 discovery well, in 87 m of water. Bowers Pit has been an important feature for research into the origin and significance of seabed pits. Field investigations were carried out at the pit site in 1980, 1984, 1985, 1986, 1988 and 1990.

The seafloor surrounding the pit is comprised of gravel lag and sand, with some boulders and dropstones. Sand ripples occur in some areas and are evidence of sediment mobility. Shell debris is abundant in some areas. The gravel lag occurs as an armoured layer over the sand. The sand and gravel occurring in the pit area are facies of the Grand Banks Sand and Gravel Formation and are generally less than 1 m thick. These sediments unconformably overly the Banquereau formation which consists of interbedded silts and sands and overconsolidated clays (Grant et al. 1986).

Bowers Pit has been described by Barrie et al. (1986) as having an amphitheatre-like appearance with a steep back wall, two sidewalls and a shallow-sloping entrance ramp (Fig 4, 4B). The pit is approximately 125 m long and 45 m wide with a depth, below the existing seabed, of 10 m. Submersible measurements from 1990 video data show the pit floor to be 8-9 m below the surrounding seafloor; this shallower depth may be due to sediment infill and erosion of the pit walls, or the depth measurements may have been taken from different locations within the pit. Barrie et al. (1986) describe the berm surrounding the pit as having an average height of 2 m, with isolated mounds of up to 2.5 m, and a maximum width of approximately 3 m. Observations from 1990 ROV data show that the berms are composed of gravel, sand and large boulders. Exposed pre-consolidated sediment blocks and outcroppings, which originated from strata of uncertain age, below a veneer of sand and gravel found at the seafloor, are found in Bowers Pit. These pre-consolidated sediments were described by Barrie et al.(1986) as Tertiary in age, but recent findings suggest that these sediments may be Quaternary in age. The sediment blocks and outcroppings will be referred to throughout this report as pre-consolidated sediment.

It is uncertain how much winnowing has occurred on the berm tops since earlier observations. Current winnowing of the fines from the berm tops could explain the abundance of gravel and boulders found there (Fig 4A ,4D). Pre-consolidated sediment blocks and outcroppings are rare and those that are present appear eroded; they occur mostly along the berm wall (Fig 4C). Sediment cover is thin in areas where pre-consolidated sediments outcrop. ROV coverage within the pit is limited, making it difficult to clearly determine if the abundance and nature of the pre-consolidated blocks and outcroppings have diminished significantly since Barrie et al.(1986) made their observations. The inner berm slope is low to moderately steep, often with fine gravel overlying unconsolidated sandy sediment (Fig 4F). Maximum slopes of 25^0 were measured by Barrie et al.(1986). The flat-lying pit floor is infilled with sand, some

shell debris and scattered boulders (Fig 4E). The sand infill is described by Barrie et al. (1986) as a medium to fine grained olive grey sand; wave-induced ripples were also observed. A depth of disturbance rod implanted at the centre of the pit in October, 1984 showed an increase of 3-4 mm of fine sand deposited at this location in less than a year (Barrie et al. 1986). A visual estimation of erosion and sedimentation, which may have occurred since 1984, is difficult to make from the 1990 video observations. However, if the sedimentation rates observed by Barrie et al. (1986) continued to the present then several centimetres of sand may be found within the pit. Future long term monitoring may verify this.

Recent (1990) ROV video tape observations from Bowers Pit show much of the berm top to be composed of gravel and many large boulders which are heavily colonized by benthic organisms (Fig 4A, 4D). The amount of colonization has increased since Barrie et al.(1986) observed sparse biological growth on boulders on the berm. Pocklington, (1987), suggests that the establishment of a benthic community can occur within 6 years of a scour disturbance. Barrie et al. (1986) considers the age of the pit to be measurable in tens of years (but less than 100 years). The increase in benthic biota on the berm tops suggests that Bowers Pit may be younger than this (i.e. less than 20 years). Continued observations may resolve this.

Observations from 1984 and 1985 video data, collected by the Cormorant SDL-1 submersible, show few changes in Bower's Pit between 1984 and 1990. Observed occurrences of outcropping, preconsolidated clay beds (Fig 4H and 4I) were more frequent in 1984-85 video data than in the 1990 ROV video data. Sand, gravel and boulders often directly overly the preconsolidated clay. The gravel/boulder lag (Fig 4G) armours much of the pit, protecting the underlying sediment from further erosion and adding stability to the pit. A scallop bed with shell debris, and sand infill with ripples, are clearly visible on the pit floor (Fig 4J and 4K).

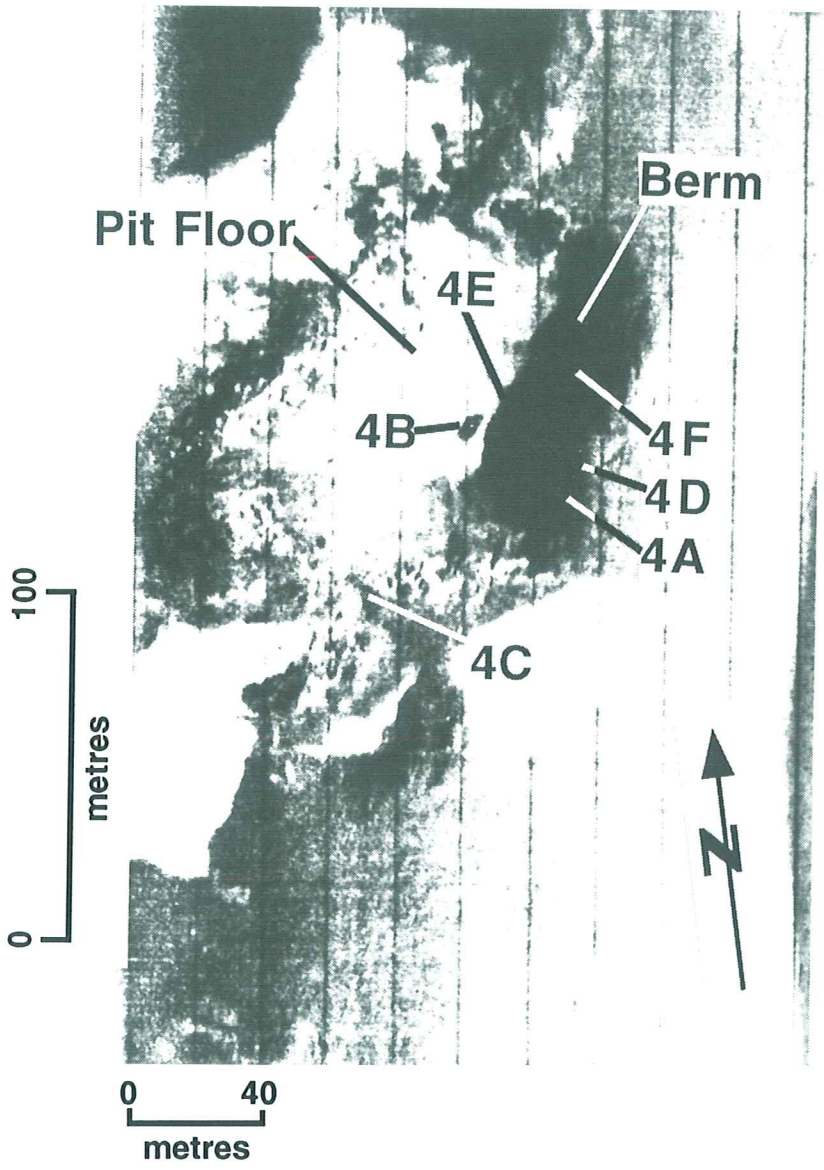


Fig 4 Sidescan sonar image of Bowers Pit, showing the location of still photos taken from video tape and presented in figures 4A-4F.

Fig 4A Berm top (stony) with an abundance of benthic organisms.

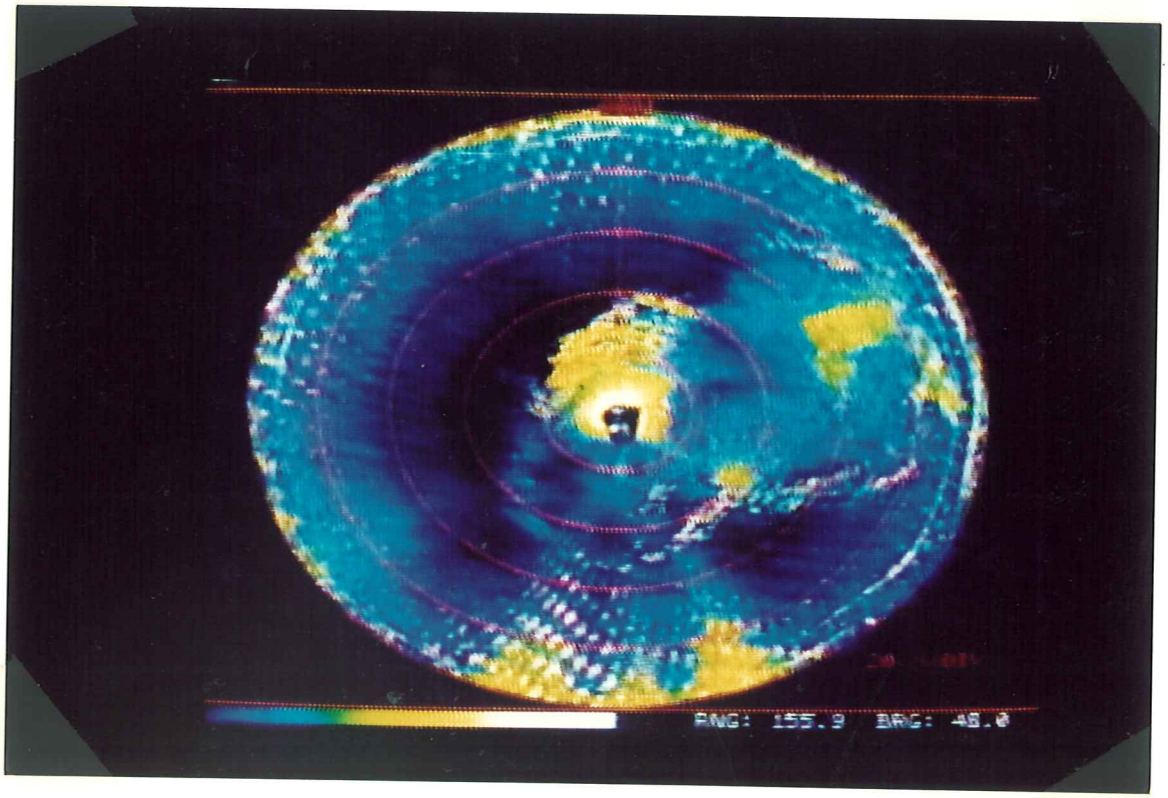


Fig 4B Sector sidescan from centre of pit looking westerly (scan lines are in 20 m intervals).

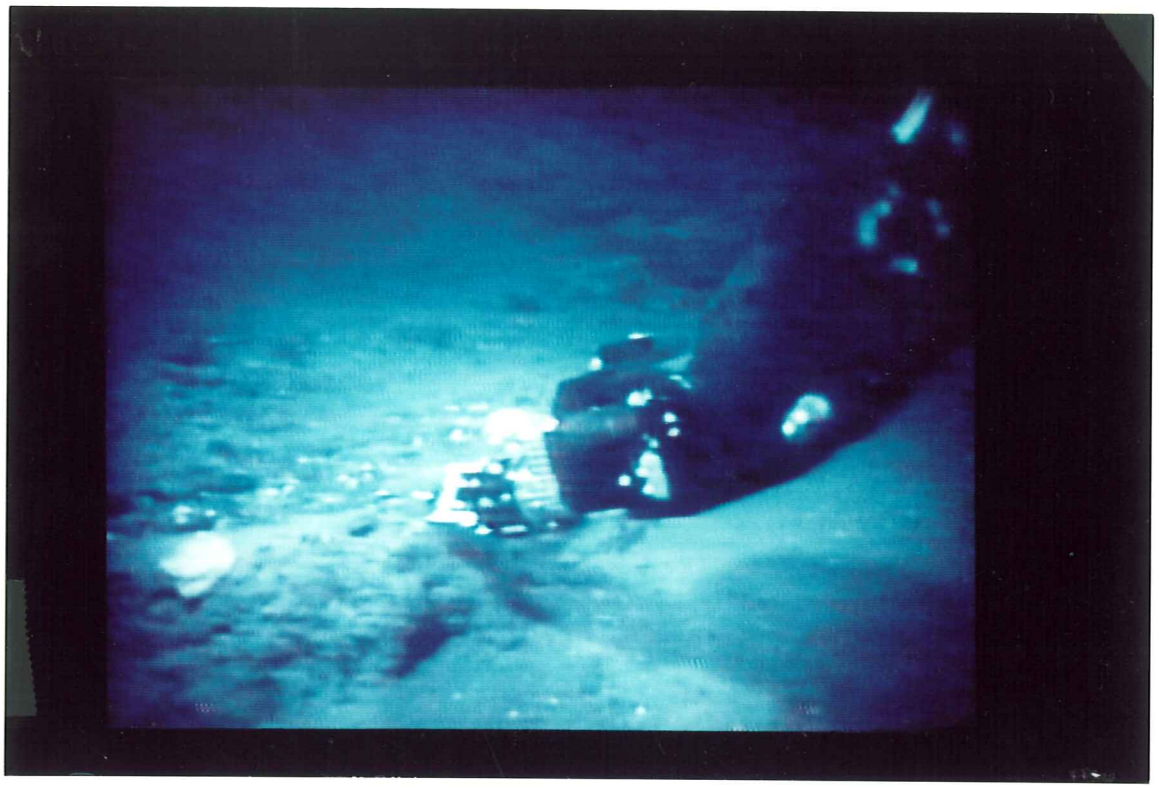


Fig 4C Outcrop of pre-consolidated sediments at seabed. (ROV arm for scale).

Fig 4D Heavy cobble and gravel cover on berm top and inner flank, colonized by benthic organisms.

Fig 4E Flat pit floor with soft sand infill and lost drill stem. Bright targets are shells, pebbles and cobbles.

Fig 4F Inner pit edge and slope with pebble and cobble cover and encrusting biology.

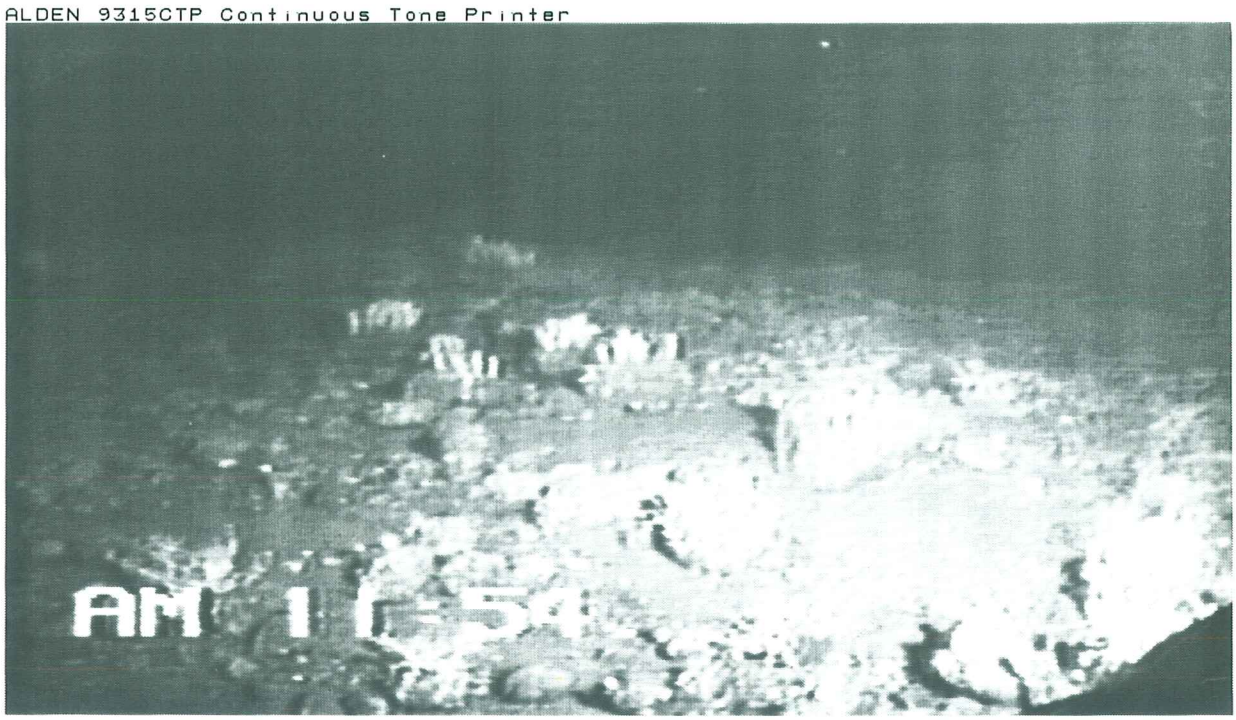


Fig 4G Pit edge with boulders and benthic biology; from 1984-1985 video data.

Fig 4H Outcropping preconsolidated clay beds; from 1984-1985 video data.

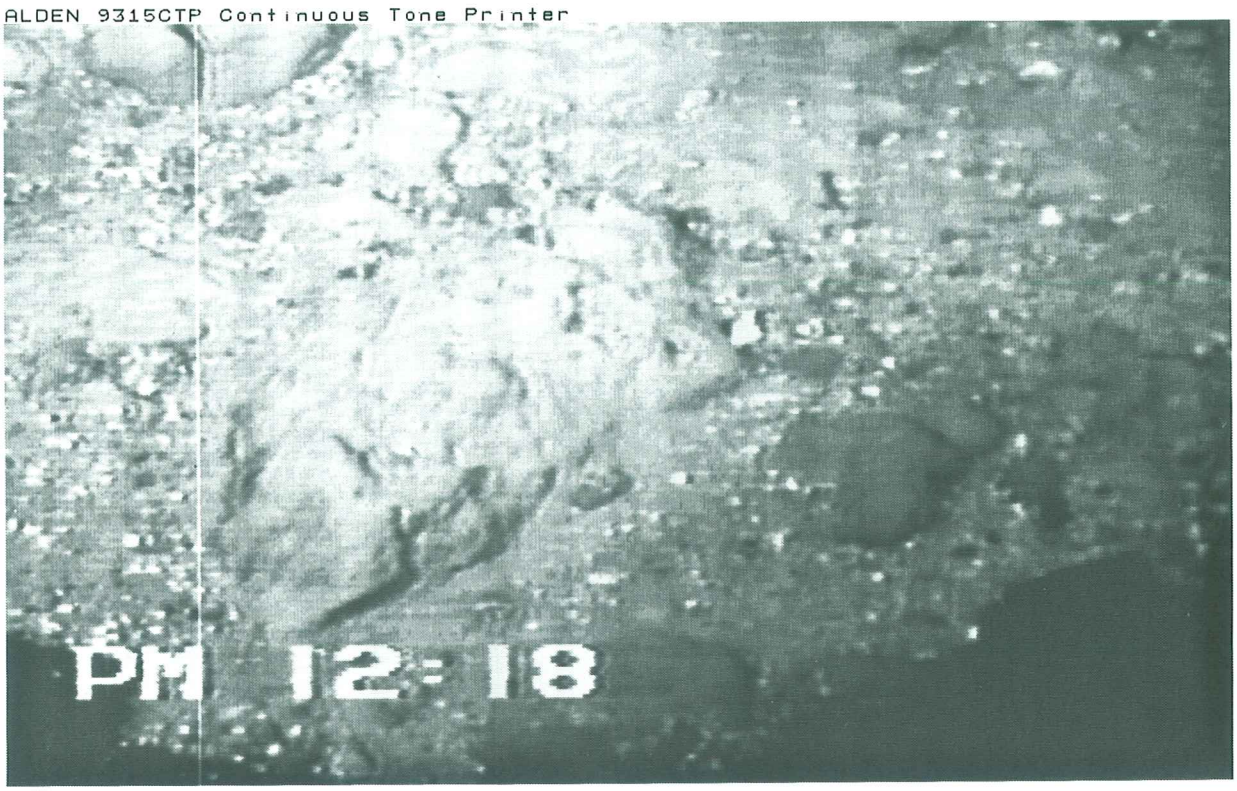


Fig 4I Outcropping preconsolidated clay beds; from 1984-1985 video data.

Fig 4J Sediment rod and sand infill on the pit floor; from 1984-1985 video data.

Fig 4K Sand ripples and shell debris on pit floor; from 1984-1985 video data.

Husky Scour

The curvilinear M-shaped 1988 Husky scour is roughly 1.2 km long, and as much as 20 m wide, and is found in 122-124 m water depth, near the Husky Whiterose E-09 wellsite, on the northeastern margin of the Grand Banks (Woodworth-Lynas, 1989; Fig 5, 5A, 5B). It is believed that the scouring and grounding event, which formed the Husky 88-01 Scour, occurred between the 9th and 13th of April 1988 (Banke 1988). Klein 100 kHz sidescan sonar data were collected over the scour site in April 1988. In September of that year, 70 kHz sidescan and Huntec DTSsubbottom profiler data were collected.

Video observations, from 1990 ROV data, show that the seafloor near the Husky scour is composed of sand with shell hash and a few dropstones (Fig 5C). The seafloor, in sandy areas, is covered with brittlestars, some sand dollars and sea urchins, with the occasional basket star. The scour berm generally has a rounded smooth crest with low relief (ca 0.5 m; Fig 5D) and is composed of sand. The berm crest has a relatively high concentration of pebbles and shell debris compared to the surrounding seafloor; this may be an indication of winnowing. The scour floor consists of silty sand (Fig 5E). Subparallel ridges, as much as 0.5 m high, are found on the scour floor and were likely formed by iceberg keel irregularities. Current induced sand waves or sand ripples were not seen in the scour. This scour appears to have changed little from 1988 to 1990.

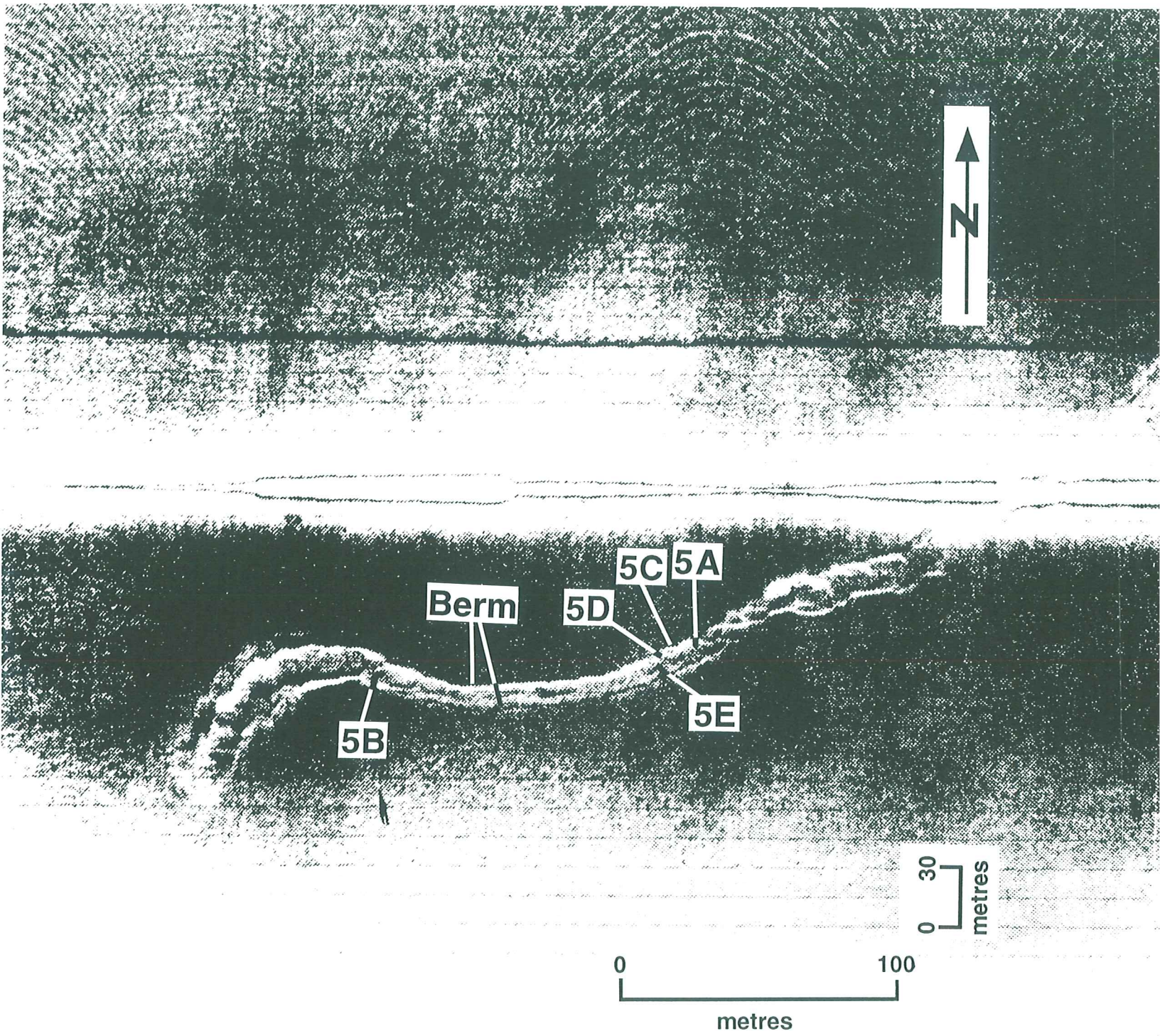


Fig 5 Sidescan sonar image of Huskie 88-01 Scour showing the location of still photos taken from video tape and presented in Figures 5A-5E.

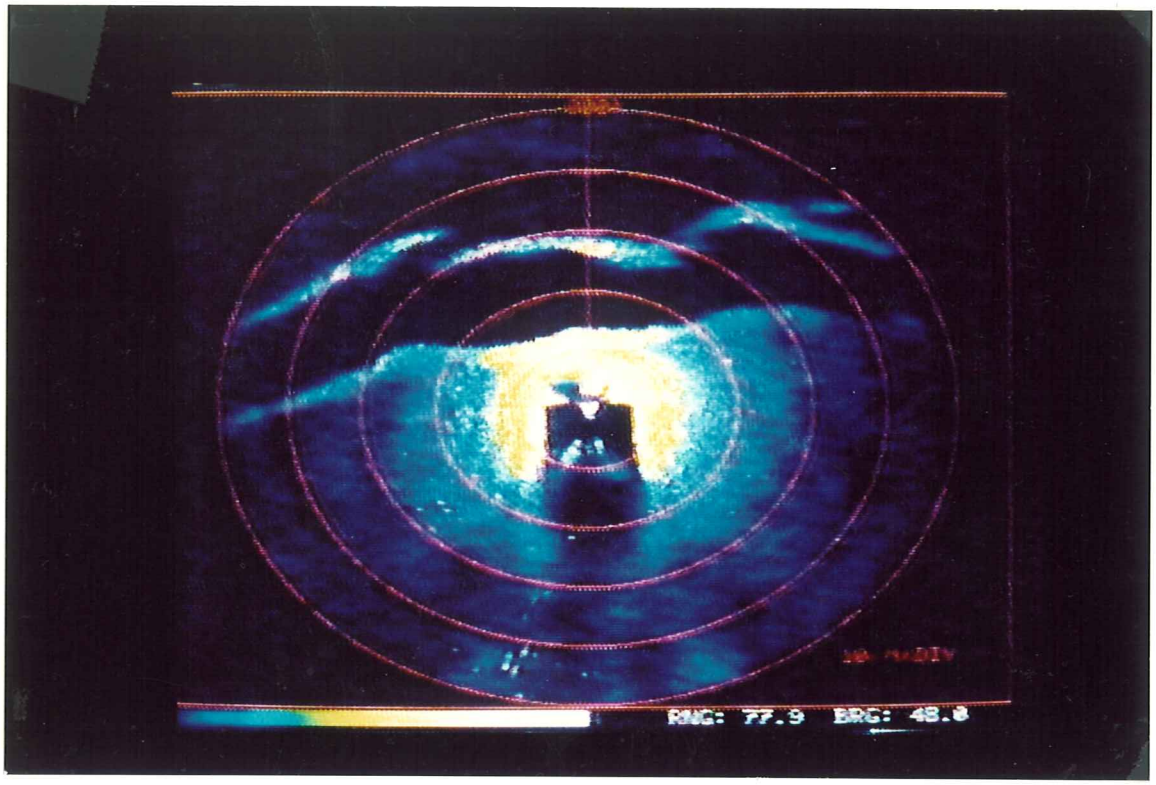


Fig 5A Sector scanning sonar image of the Husky Scour (20 m interval), illustrating the berm and flat nature of the scour floor.

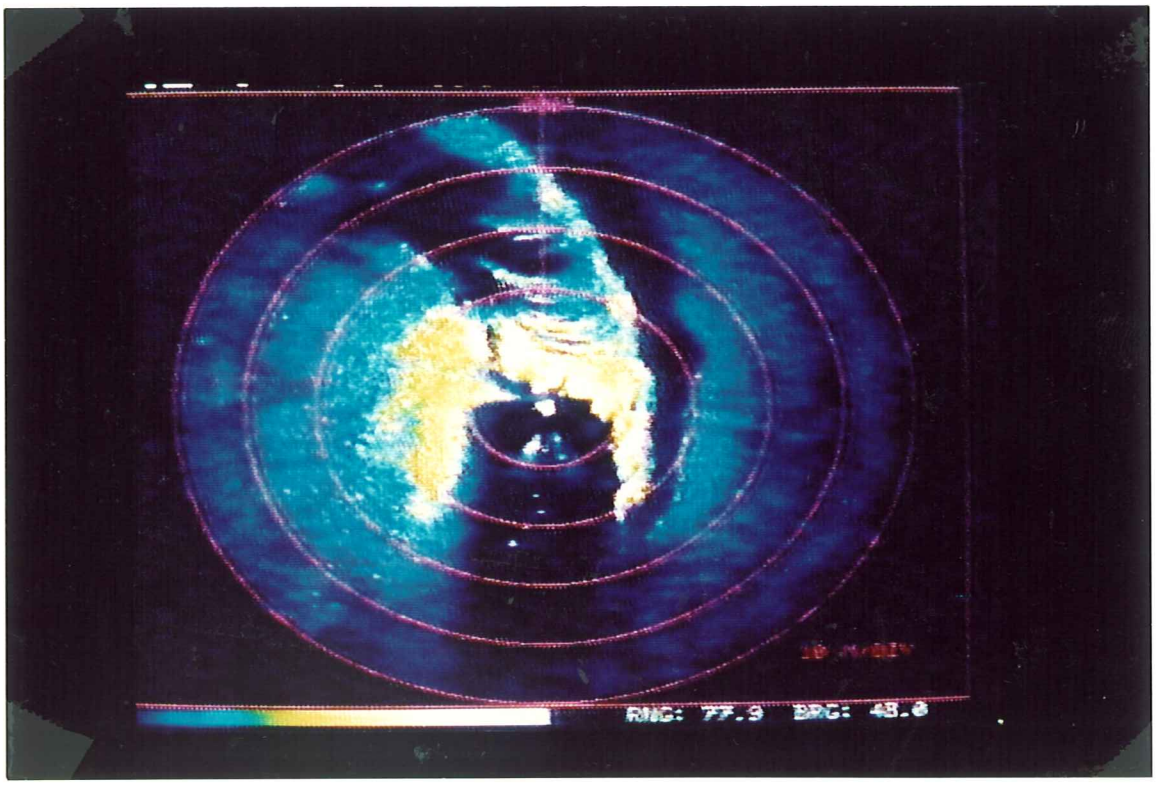


Fig 5B Sector scanning sonar image of a bend in the Husky Scour.

Fig 5C Flat sandy seafloor with some gravel near the Husky Scour.

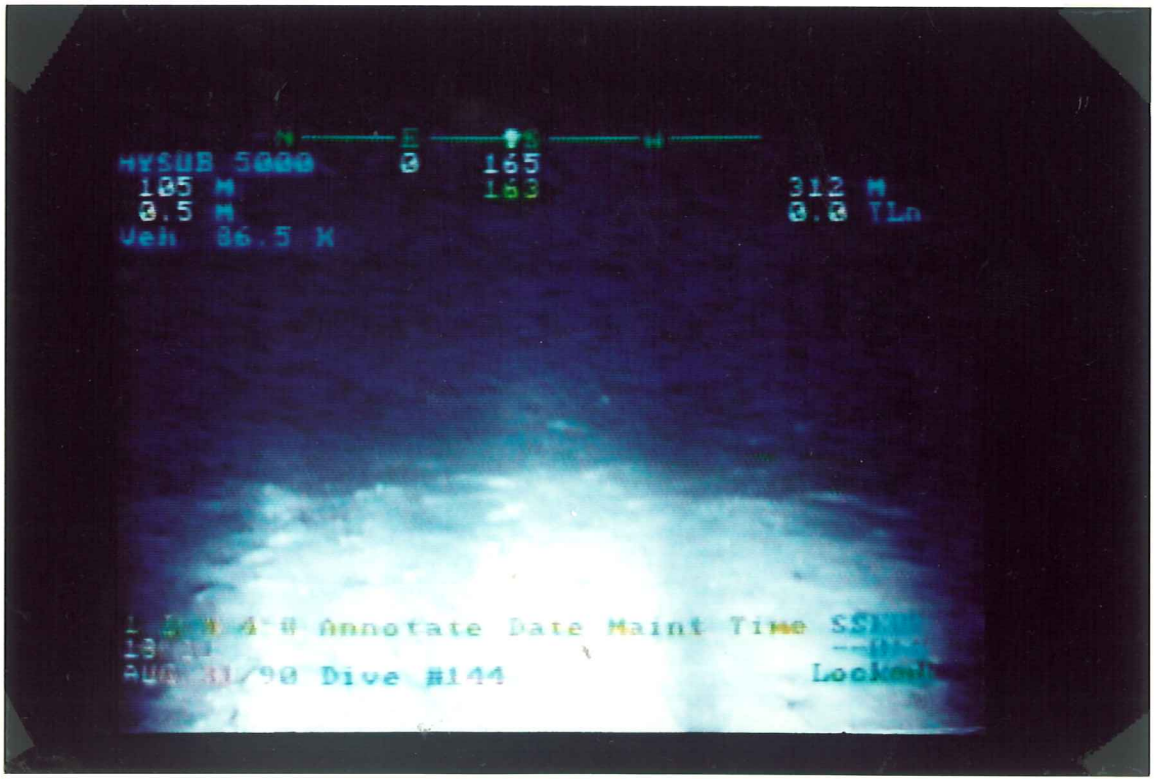


Fig 5D Berm top of the Husky Scour, slightly winnowed of fines.

Fig 5E Flat Husky Scour floor

Terra Nova Glory Hole

The Terra Nova glory hole was excavated by Petro-Canada in 1990 as a test hole for burial and protection of wellheads on the seafloor. The glory hole is 6-7 meters deep and approx. 20 m by 24 m wide (Fig 6, 6C). The seafloor near the glory hole is flat and featureless. Much of the seabed is composed of silty sand with shell hash and pebbles. Gravel lag occurs in places near and along the edge of the hole (Fig 6B, 6D).

The edge of the glory hole is sharp with no sign of a berm (Fig 6A). The walls fall steeply (near vertical) to the base where large angular sediment blocks are found. The pre-consolidated sediment blocks and outcrops which comprise much of the glory hole wall, appear fresh and angular (Fig 6G, 6H). The unconsolidated seafloor sediments, comprised mostly of silty sand, are approximately 1 m thick, and rest unconformably above stiffer, finer grained sediments. These stiff, fine grained sediments, and a "hard pan" layer found 1.5 to 2.3 m below the seafloor, have formed an overhang in places around the glory hole, just below the unconformity (Fig 6E, 6F). The "hard pan" layer consists of consolidated, possibly cemented fine grained material with numerous shell fragments. The overlying unconsolidated seafloor sediments have cascaded into the hole, and formed debris fans on the glory hole floor (Fig 6I). There is little evidence of biological growth in the glory hole. The glory hole has a slight sediment infill due to the excavation process, with little or no sign of erosion.

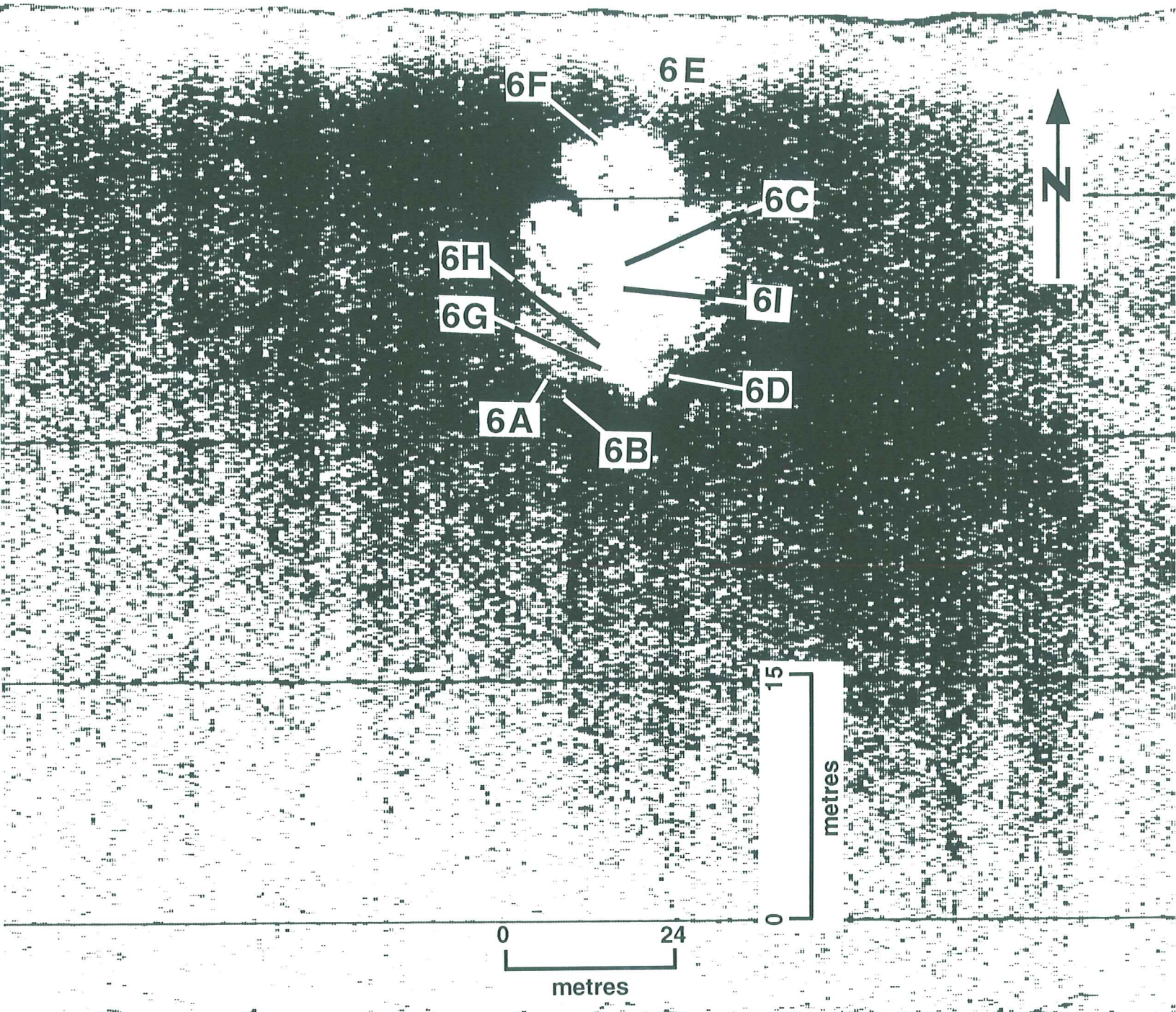


Fig 6 Sidescan sonar image of Terra Nova Glory Hole, showing the location of still photos taken from video tape and presented in Figures 6A-6I.

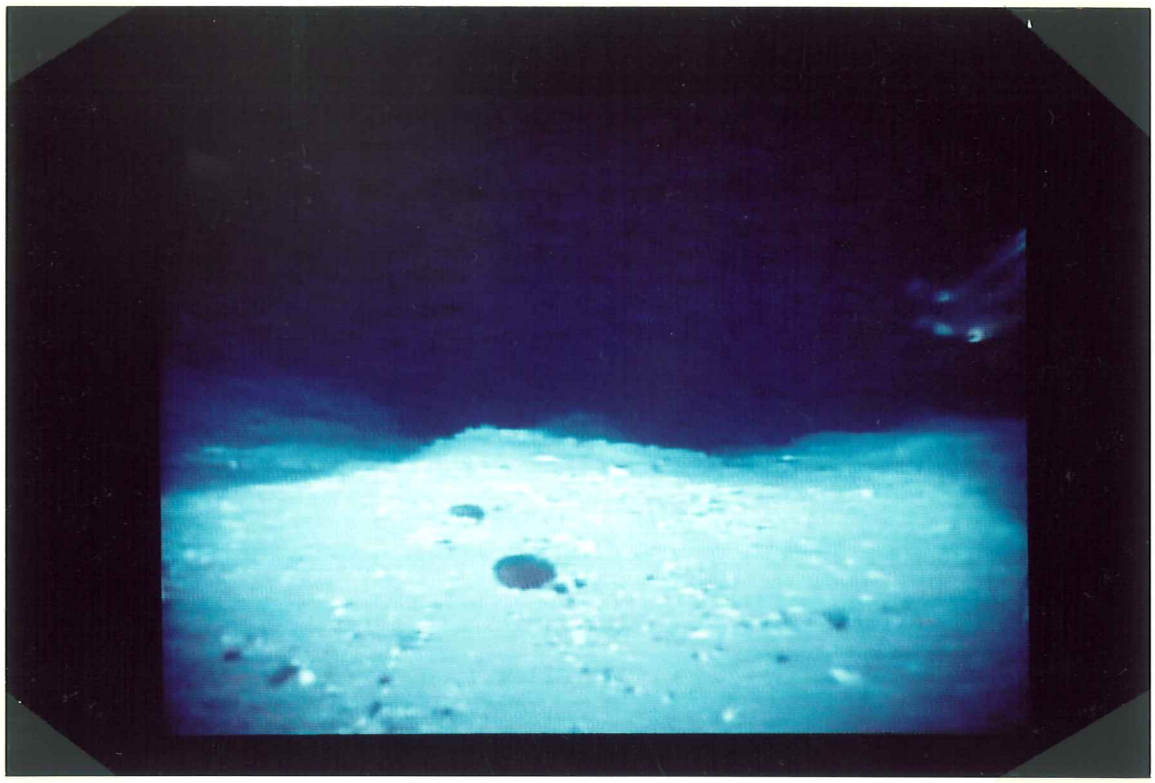


Fig 6A Edge of Terra Nova Glory Hole

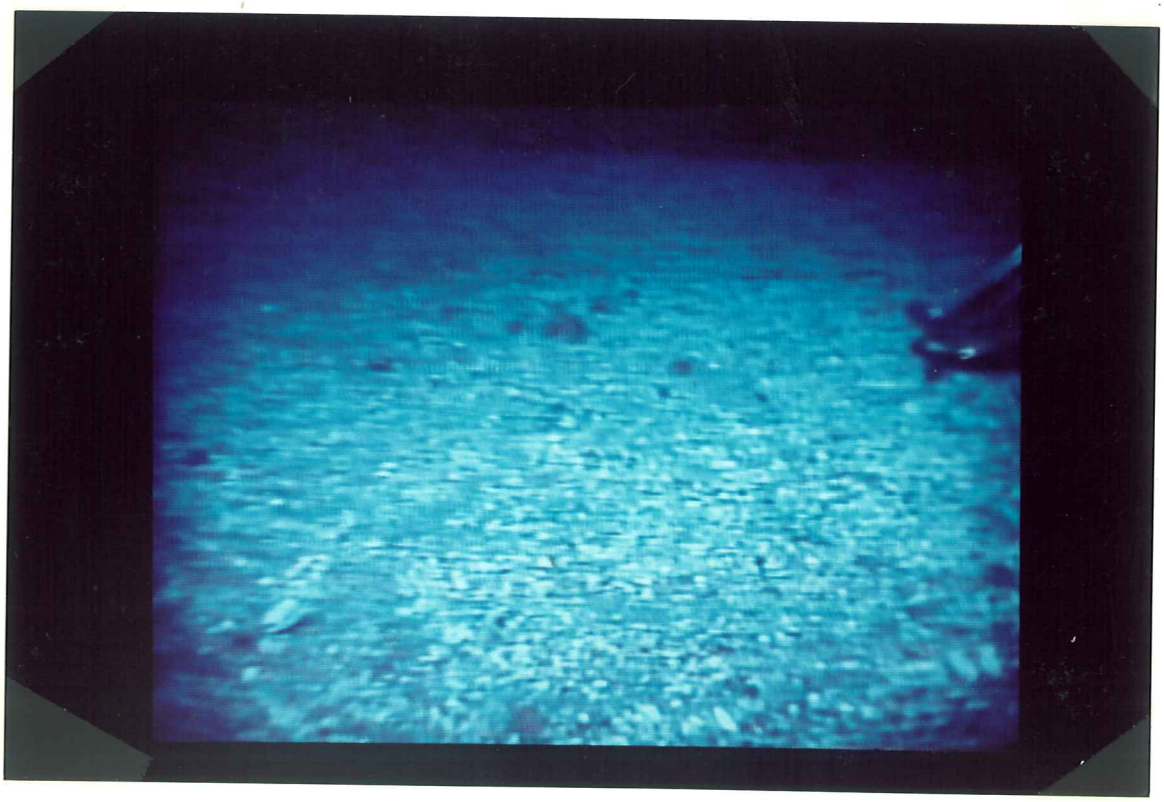


Fig 6B Fine gravel lag on seafloor near Terra Nova Glory Hole.

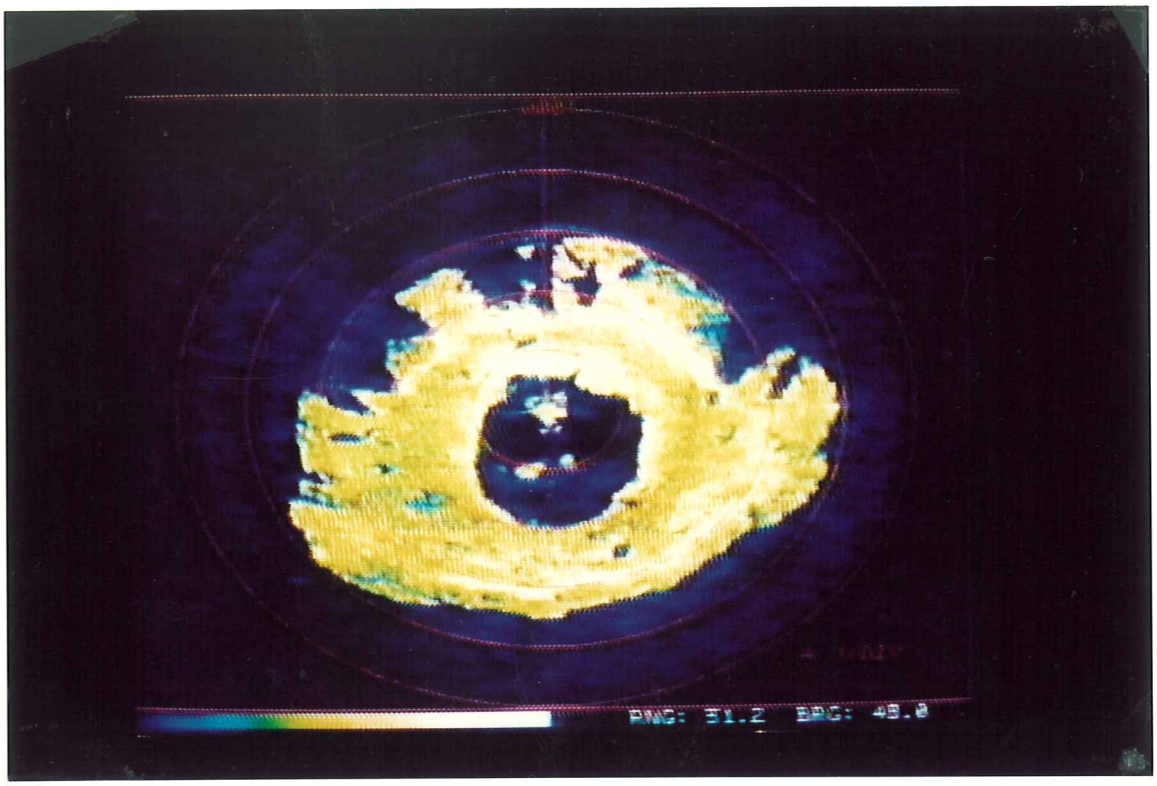


Fig 6C Sector scanning sonar image of interior of Terra Nova Glory Hole (10 m interval; looking south).

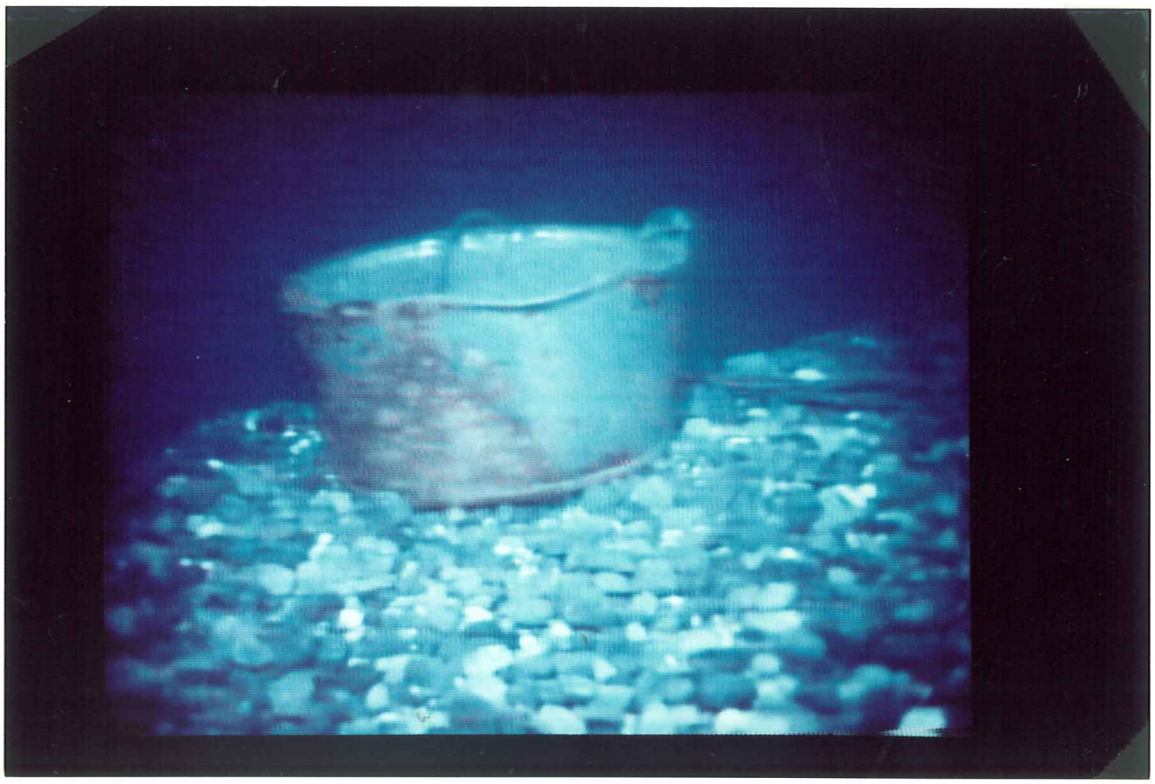


Fig 6D Seafloor sediment (gravel) and pot on edge of glory hole.

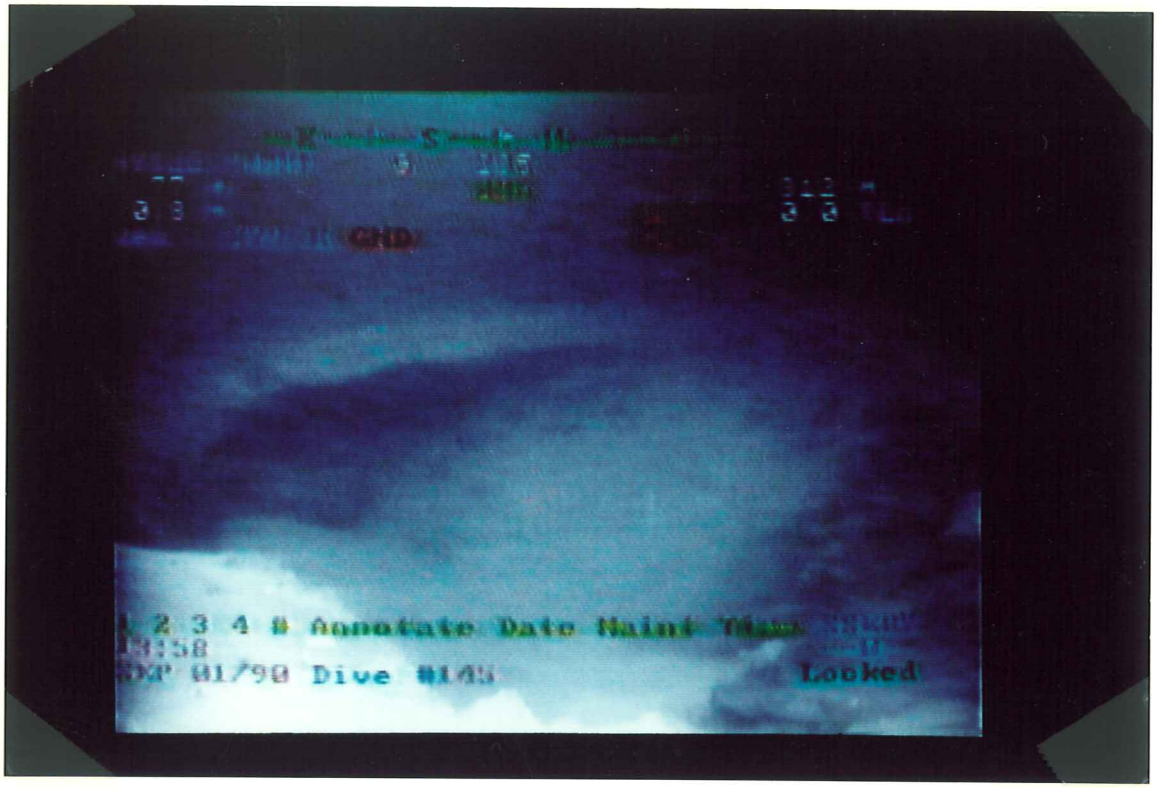


Fig 6E Northeast view of Terra Nova glory hole.

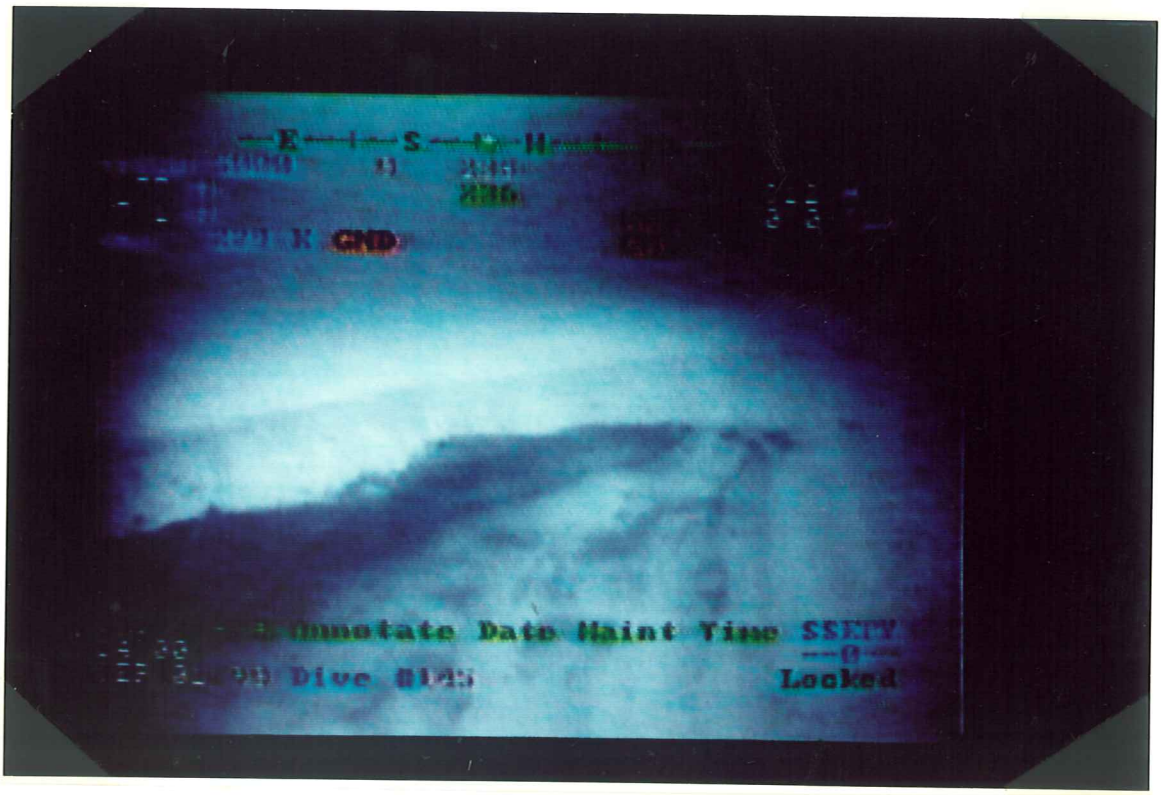
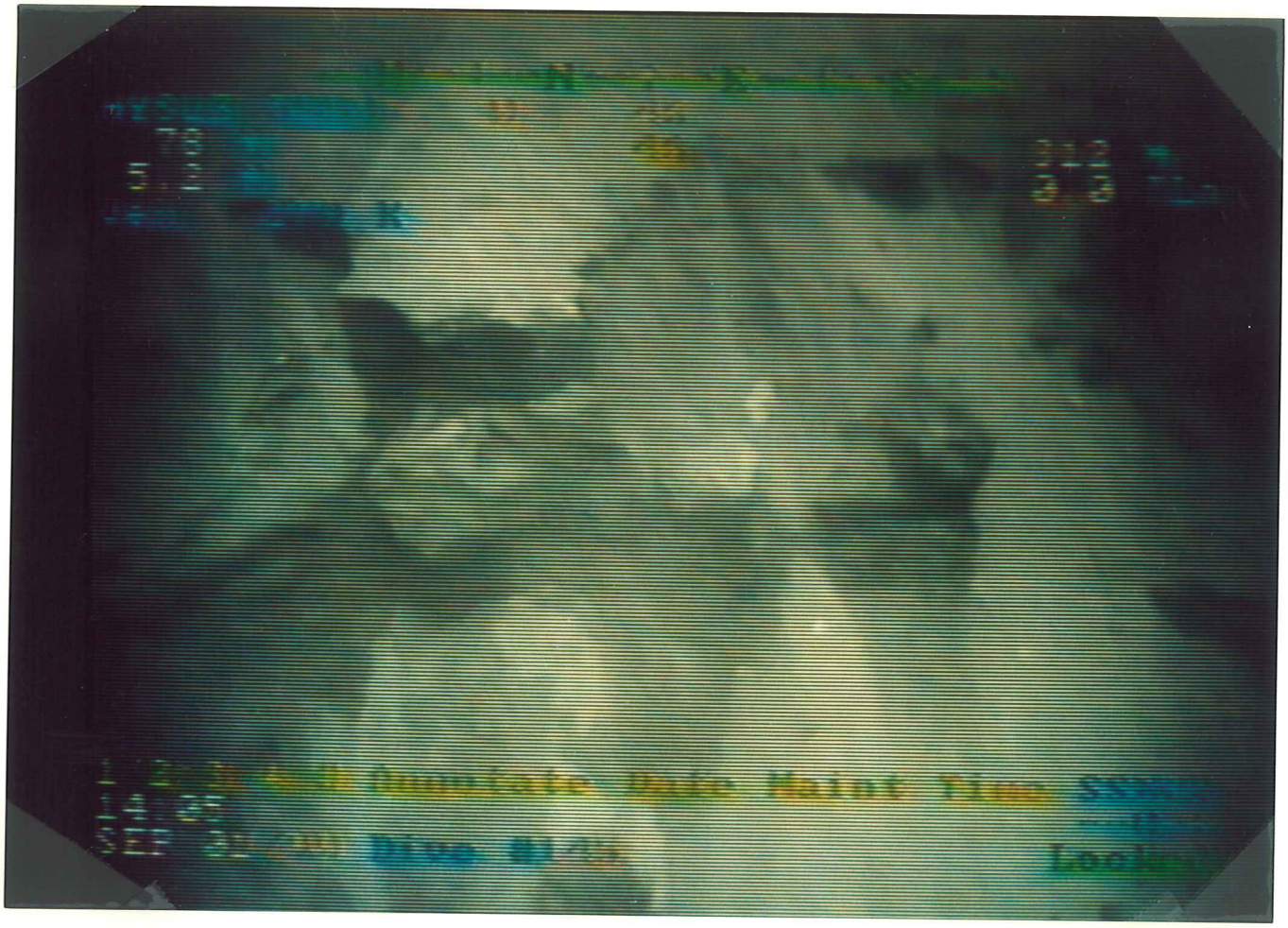


Fig 6F Overhanging beds of pre-consolidated sediment; unconsolidated sands and gravel unconformably lie above (northeast edge of glory hole).



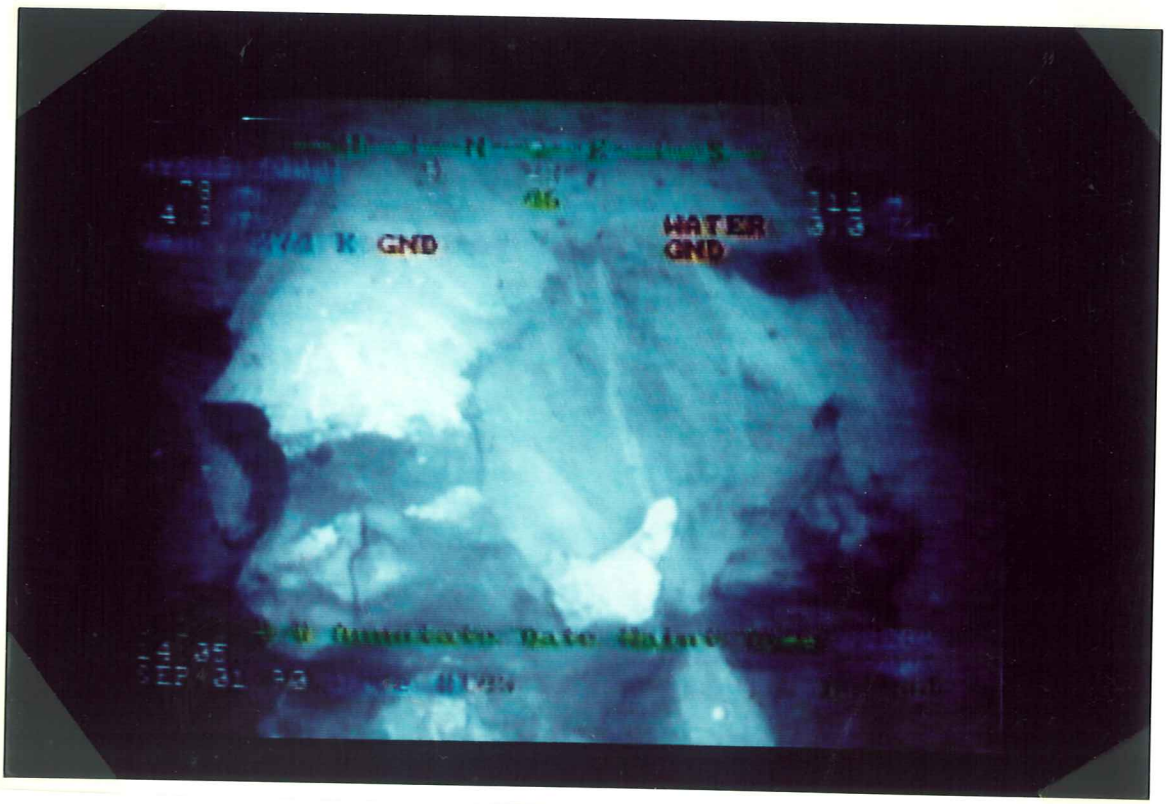


Fig 6G Fresh pre-consolidated sediment blocks on glory hole wall. The large photo was taken directly from a high resolution monitor, the smaller photo was taken from a commercially processed image.

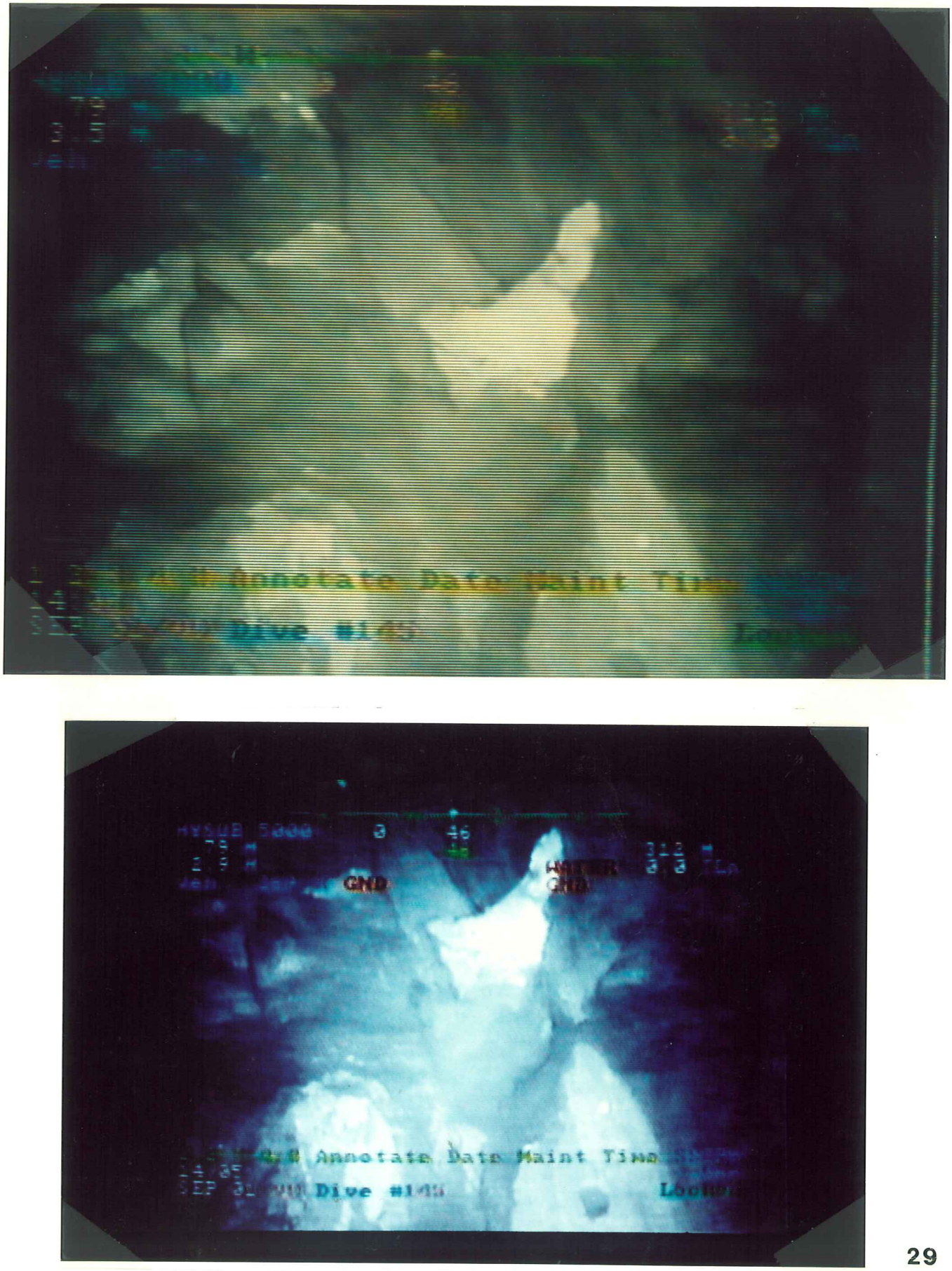


Fig 6H Closeup of pre-consolidated sediment blocks on glory hole wall (note fresh sharp edges). The large photo was taken directly from a high resolution monitor, the smaller photo was taken from a commercially processed image.

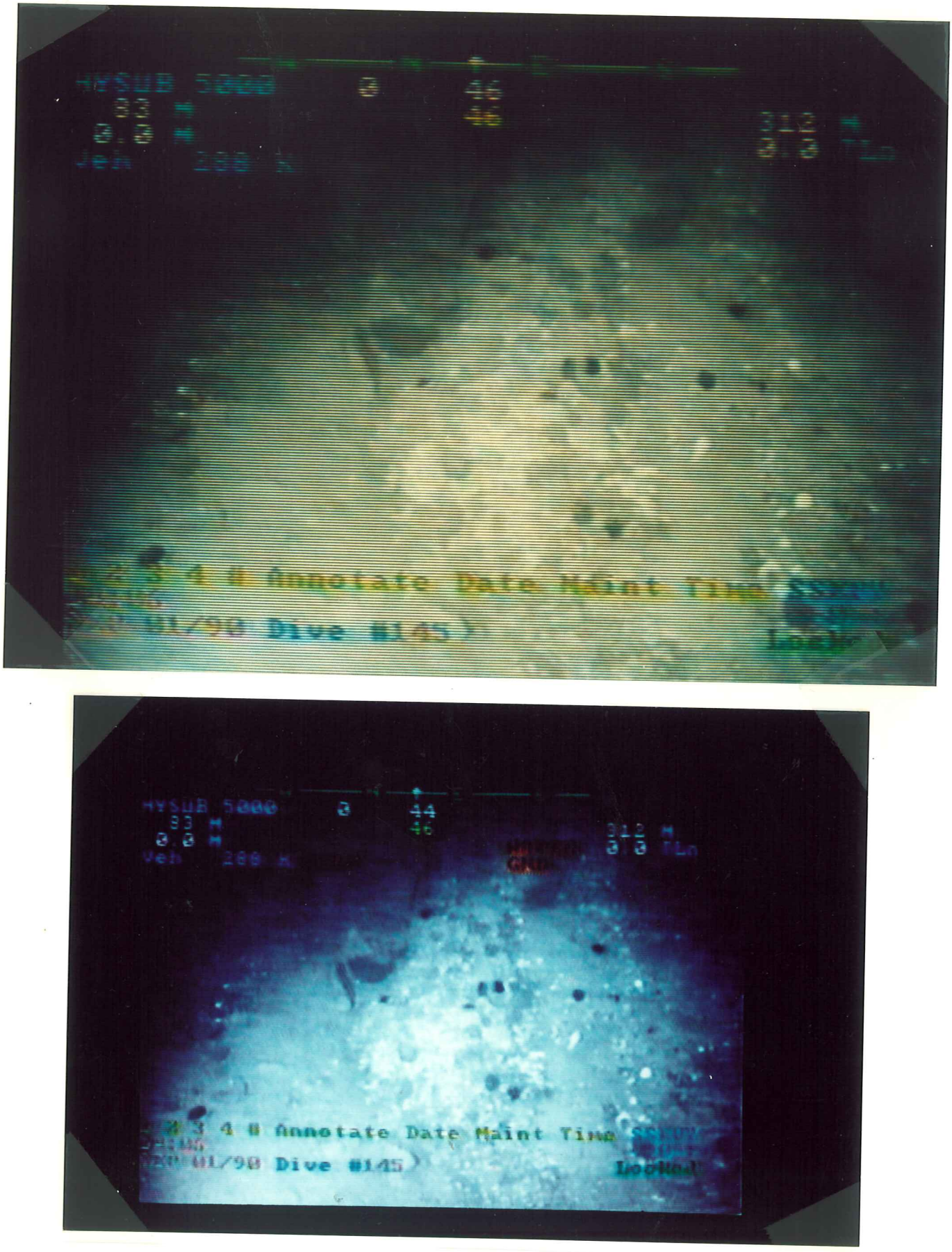


Fig 6I Sediment infill on glory hole floor. The large photo was taken directly from a high resolution monitor, the smaller photo was taken from a commercially processed image.

B-08 Glory Hole

The B-08 Glory Hole was excavated to 15 m below the seafloor by Mobil Oil, in early 1980, as a test for well head protection (Geocon, 1980). The glory hole has a present depth of 2-3 m and a width of ca 25 m (Fig 7, 7D). As much as 13 m of the hole has been infilled, mostly due to slumping of the side walls, with sediment drift contributing only minor amounts of sediment. The seafloor near the pit is covered by a gravel lag which in areas is covered by sand ripples and patches (Fig 7A, 7B). The gravel lag is thin and armours an underlying unconsolidated sand unit; these sediments are constituents of the Grand Banks Sand and Gravel Formation. Boulders are also found on the seafloor at the glory hole site. Heavy biological growth occurs on the gravel lag and boulders. The seafloor near the glory hole is littered with debris (eg. steel cable, train wheels, pieces of metal); some of this debris is partially covered by sediment and may be an indication of sediment transport. The surrounding seafloor appears disturbed in areas, and may be due to the glory hole excavation.

The edge of the glory hole is distinct but eroded, with gravel lag and sand continuing to the hole edge (Fig 7C, 7E). The glory hole walls fall moderately steeply to the floor which is infilled with loose sand. Isolated blocks of semi-consolidated sediment are found within the glory hole, surrounded by loose seabed sands and gravel (Fig 7F). These silty sediment blocks are similar to those found at Terra Nova, but appear less fresh and are heavily eroded (Fig 7G, 7H). These blocks can be several meters wide and as much as 0.5 meters high; large outcroppings, such as those found at Terra Nova, do not occur here.

Video data, collected in 1985 by the Cormorant SDL-1 submersible, show the B-08 Glory Hole in a less advanced state of erosion and infill than is observed in 1990 video data. The hole appears to be deeper than the 2-3 m observed in the 1990 video data (Fig 7I), and maybe between 3-10 meters in depth; less sediment infill occurs within the glory hole. Compared with 1990 video observations, more and relatively larger outcroppings of preconsolidated sediment occur along the glory hole walls (Fig 7J and 7K). Broken blocks of preconsolidated sediment are also found on the floor of the hole. These exposures appear moderately fresh with some signs of erosion and bioturbation. The B-08 glory hole has infilled and changed greatly over the last 10 years, and differs greatly from the fresh appearance of the Terra Nova Glory Hole.

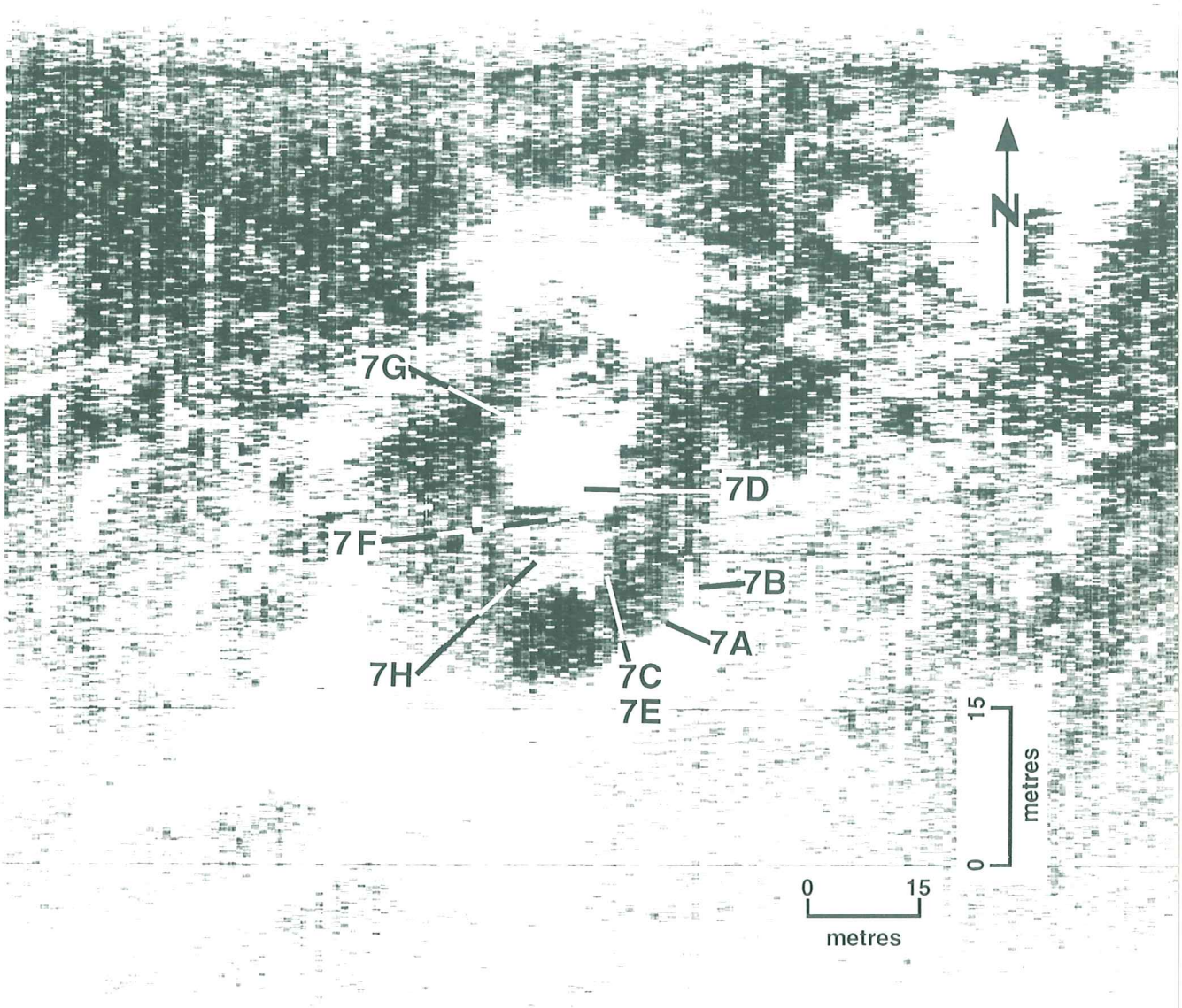


Fig 7 Sidescan sonar image of B-08 Glory Hole, showing the location of still photos taken from video tape and presented in Figures 7A-H

Fig 7A Seafloor and benthic biota near B-08 Glory Hole.

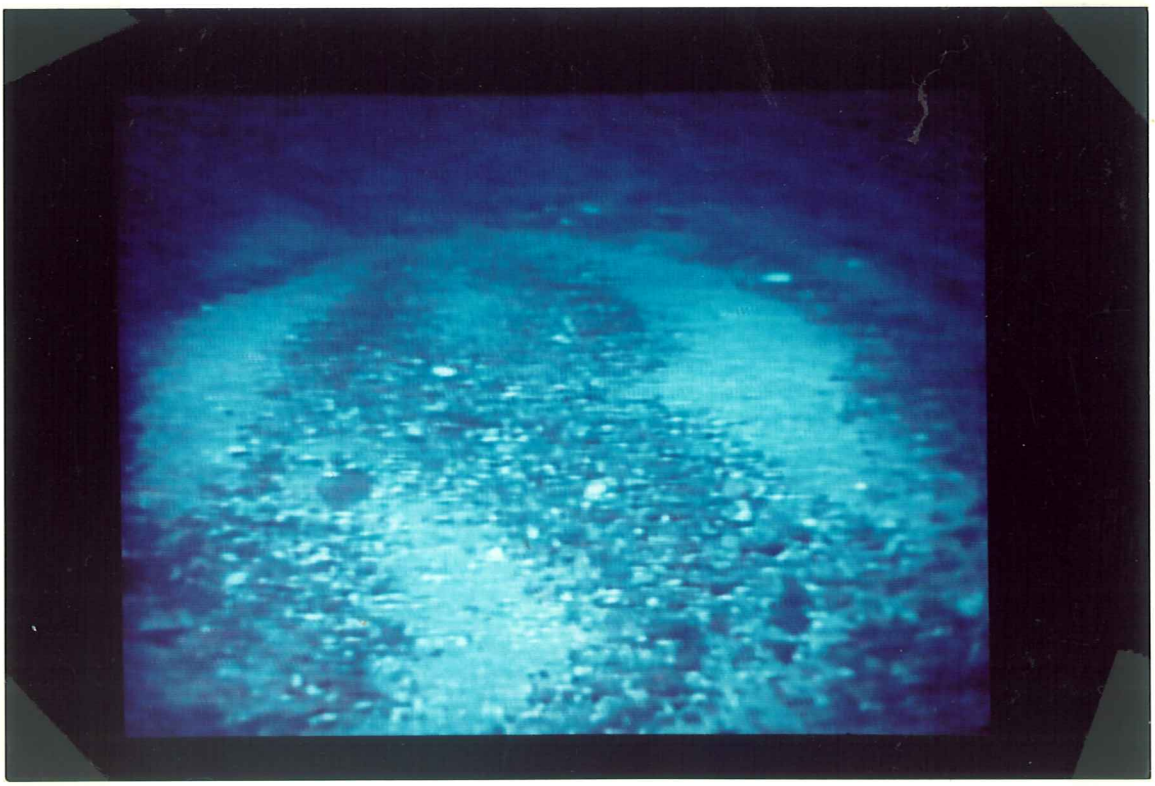


Fig 7B Sandwaves on gravel lag near glory hole.

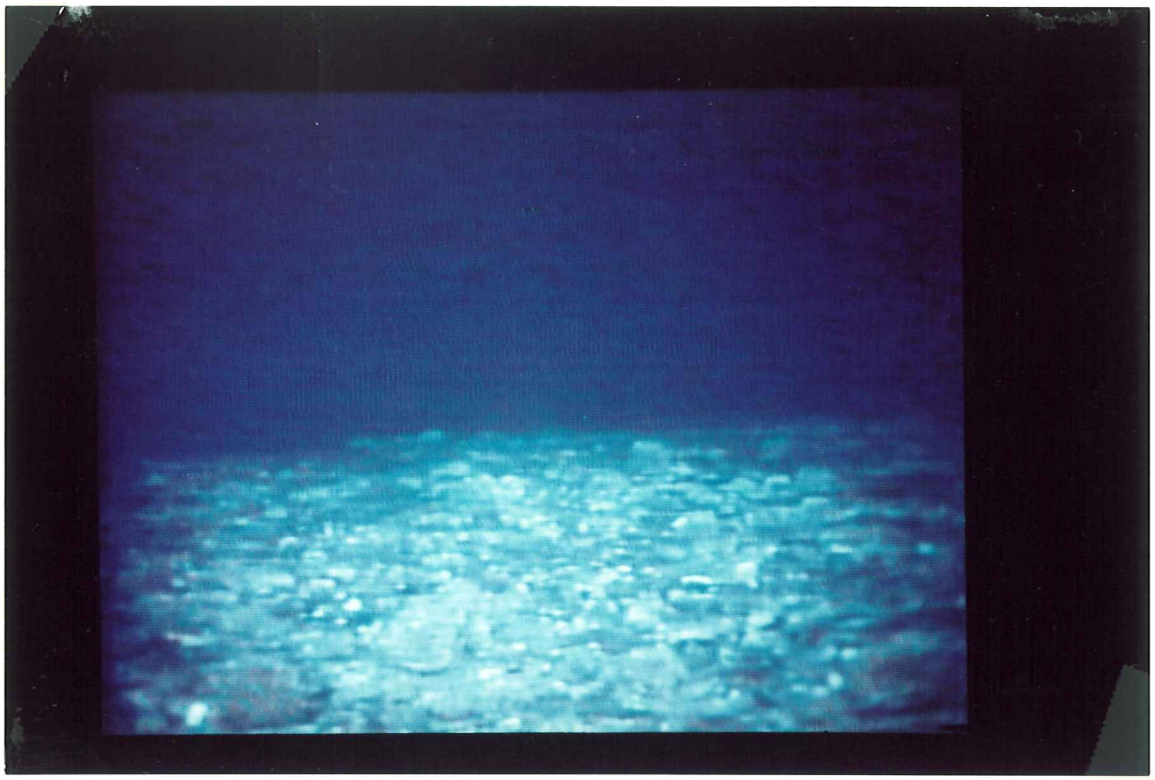


Fig 7C Glory hole edge and seafloor sediment type (gravel lag).

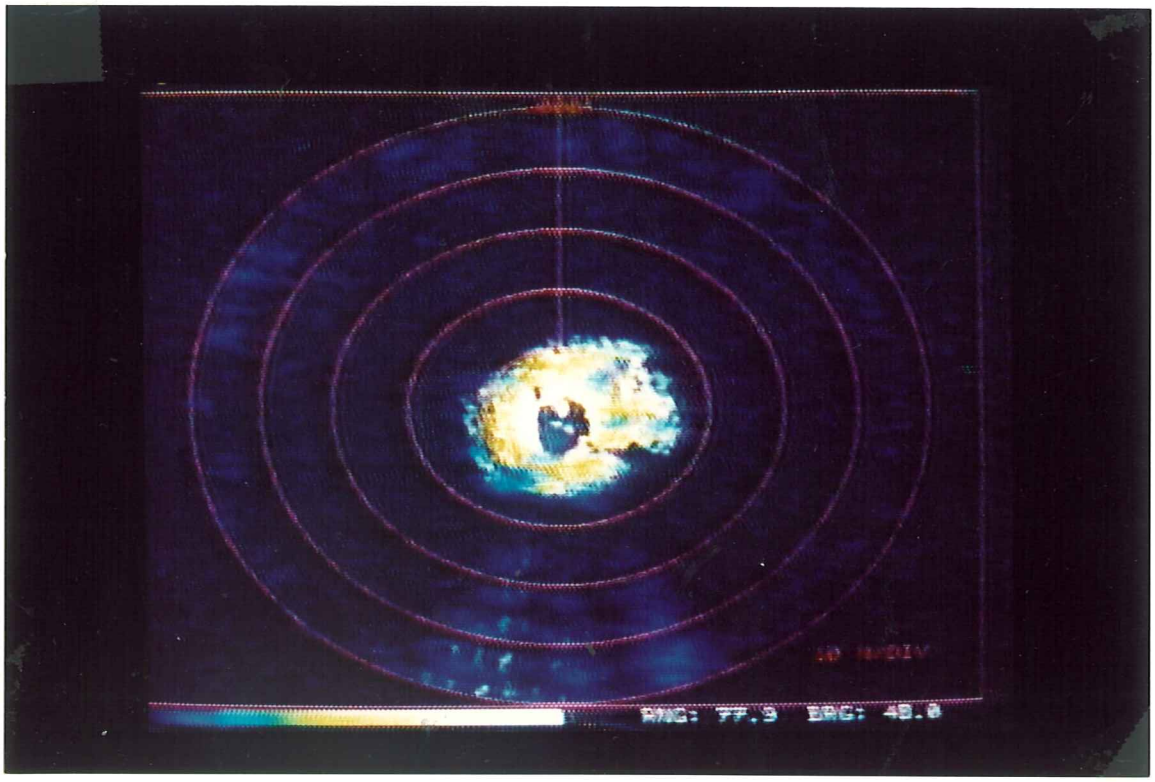


Fig 7D Sector scanning sonar image of B-08 Glory Hole interior.

Fig 7E The heavy gravel lag armouring the seafloor, near the glory hole edge, is encrusted with benthic organisms.

Fig 7F Glory hole floor, infilled with sand and sediment blocks.

Fig 7G Eroded pre-consolidated sediment block.

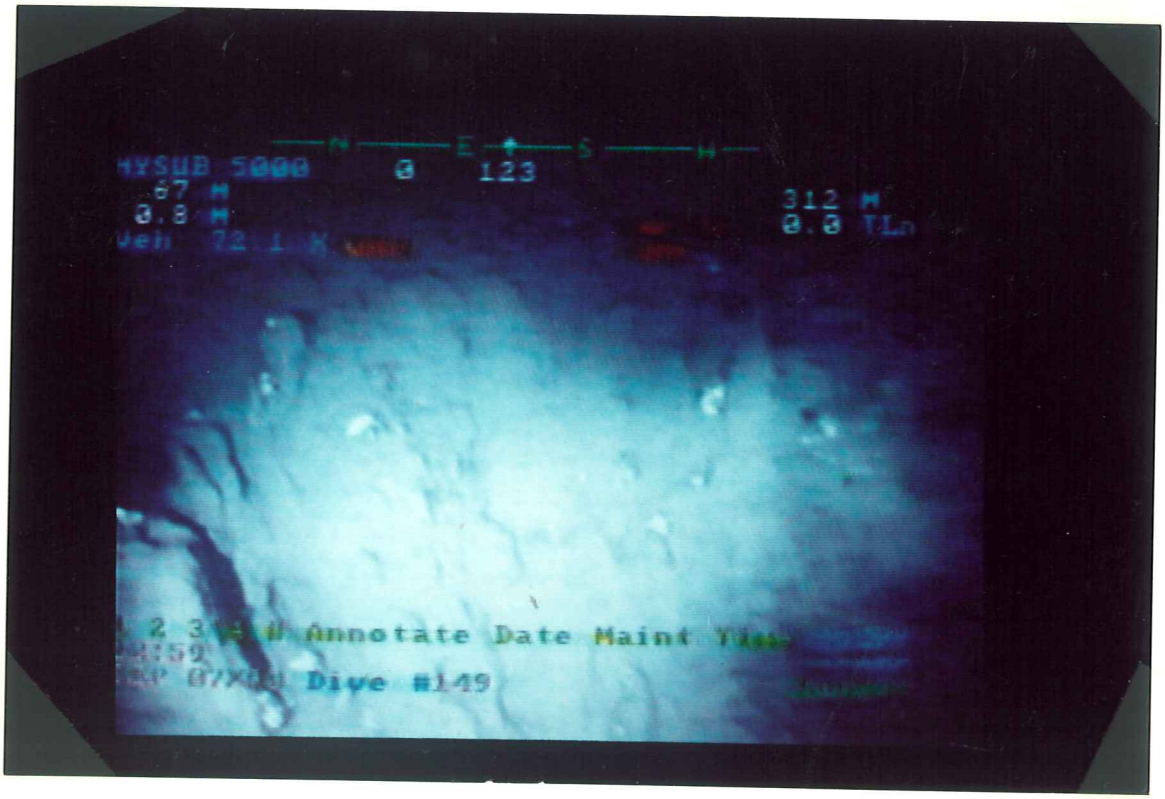


Fig 7H Eroded pre-consolidated sediment block on edge of glory hole.

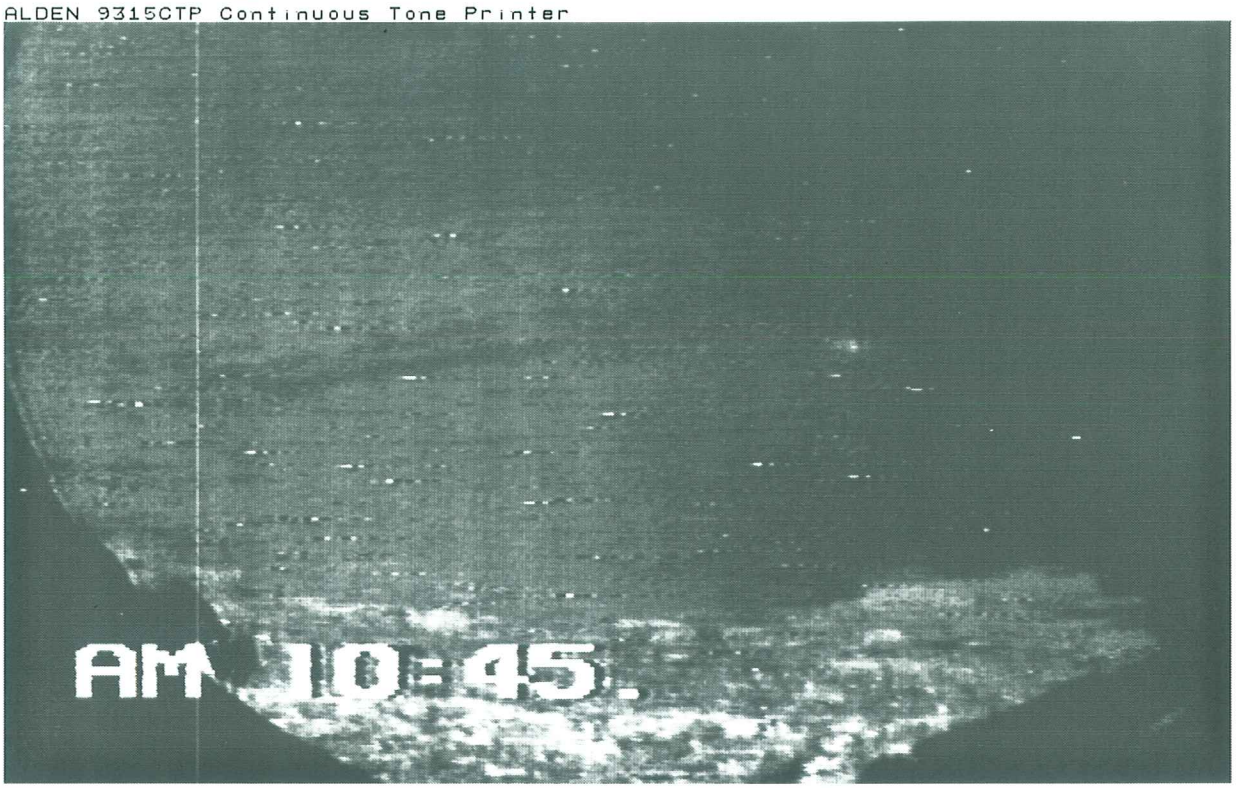


Fig 7I Glory hole edge showing pit interior; from 1984-1985 video data.

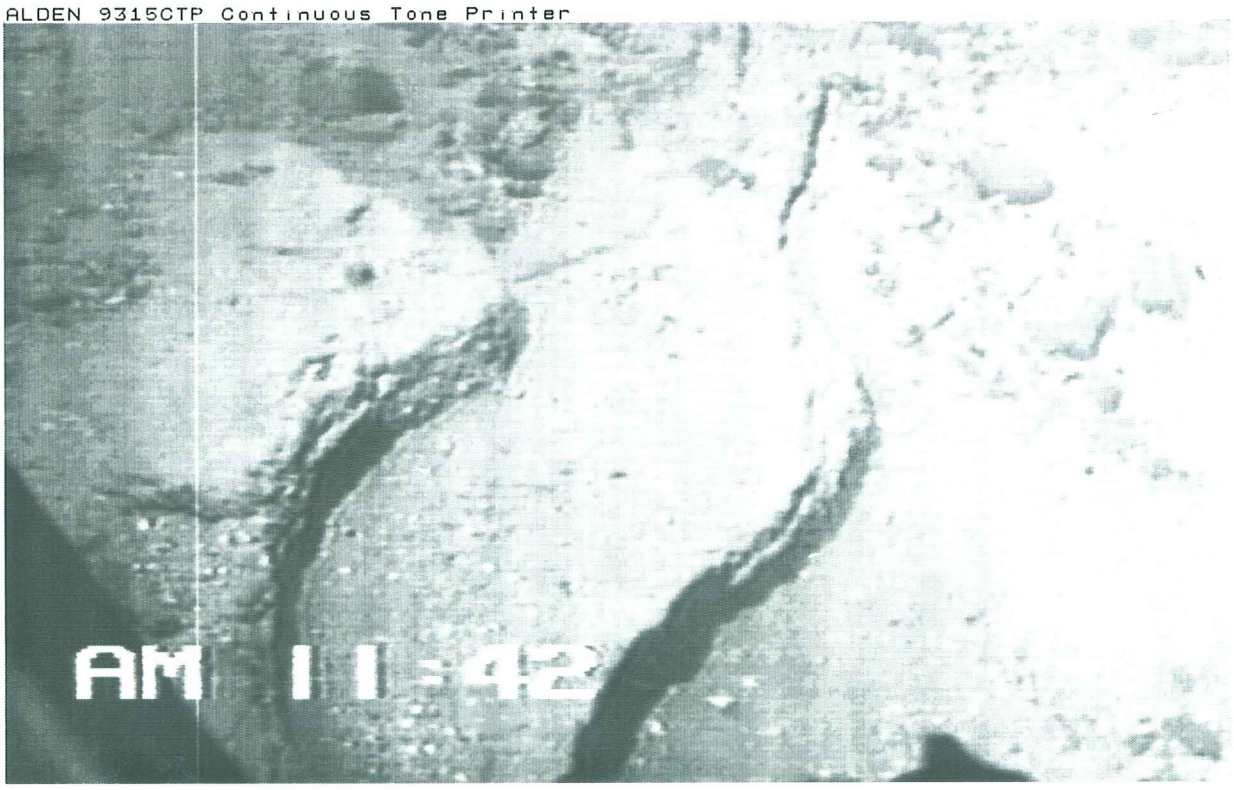


Fig 7J Outcropping preconsolidated clay beds on glory hole wall; from 1984-1985 video data.

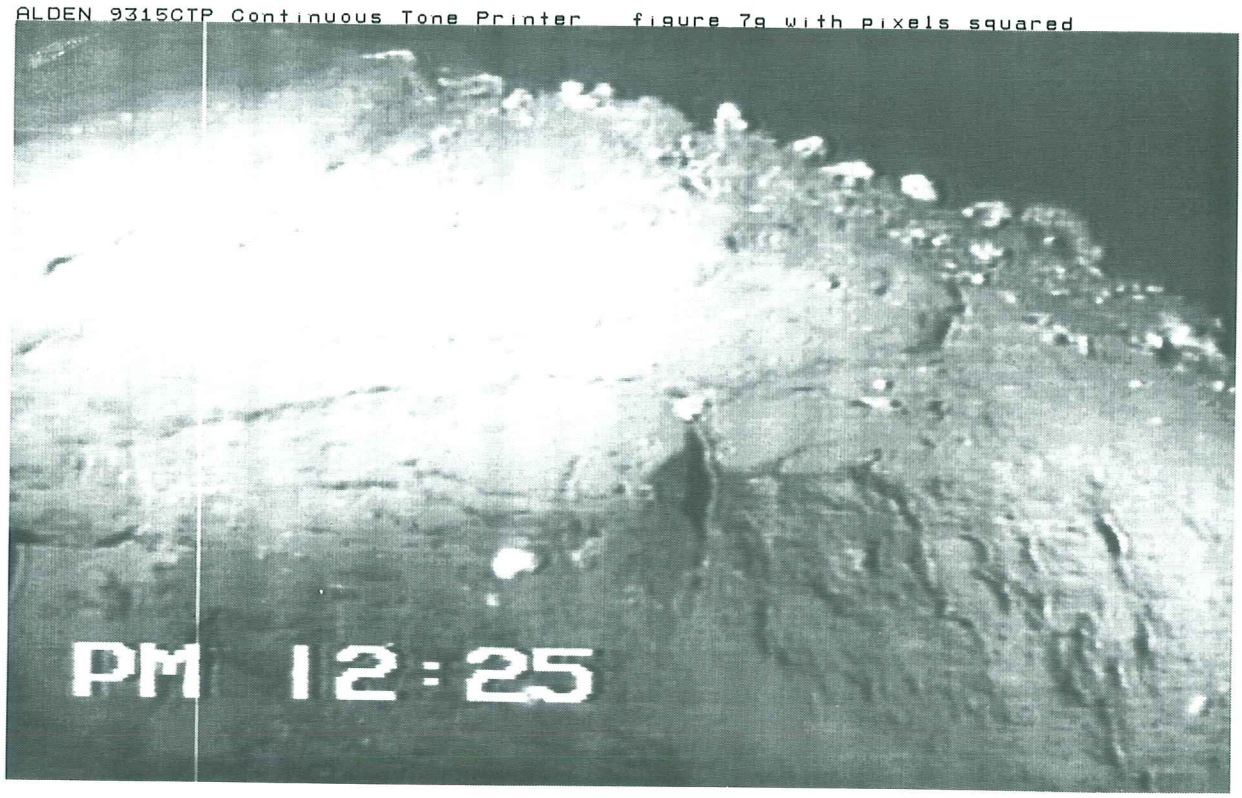


Fig 7K Outcropping preconsolidated clay beds on glory hole wall; from 1984-1985 video data.

Technical

First attempts at capturing hard copy photographs of video images were made using a Panasonic video cassette player (nv-8750), and a Polaroid freeze frame video recorder, with a 35 mm camera adaptor. Freeze frame or frame memory techniques, using the aforementioned equipment, gave unsatisfactory results. Video image processing improved the hard copy output (photographs), but was expensive, with an average cost of approx. $10 per print. Photographs taken directly from a high resolution monitor screen gave satisfactory results, and often revealed more detail (at little cost) than the processed and more expensive images mentioned above (see Figs 6G, 6H, 6I).

The most satisafactory results were achieved by frame-grabbing the video imagery using an Amiga 1000 computer and a third-party framegrabber (640*400 pixel resolution) and then importing the resulting digital files to Adobe PhotoShop. The imagery could then be enhanced, cropped, etc. and saved in an appropriate format for printing. Figures created by this method for this report were printed on a 256 grey-scale printer.

If a computerized frame grabber is unavailable then it is recommended that the direct photographic technique from a high resolution screen be used.

Conclusions and Recommendations

Texaco Scour and Pit 89-01:

-Increased biological growth, and some winnowing of fines, are the only identified changes which have occurred in the Texaco Pit over a one year period.

Bowers Pit:

-The pit is shallower than previous measurements. This may be due to sediment infill or to a difference in measurement locations.

-Preconsolidated sediment blocks and outcroppings appear eroded.

-Biological colonization has increased greatly since Barrie et al. (1986) made their observations.

-The pit is estimated to be younger than 20 years, based on benthic organism recolonization data.

-Video data collected in 1985 by the Cormorant SDL-1 submersible show that Bowers Pit has changed little over time.

Husky 88-01 Scour:

-Some winnowing may have occurred on the berm top.
-The Husky Scour has changed little since the initial analysis and data collection in 1988.

Terra Nova Glory Hole:

-Preconsolidated fine grained sediment blocks and outcroppings occurring within the Terra Nova Glory Hole, appear fresh and angular and may often form sediment overhang.

-The glory hole has minimal sediment infill with little or no sign of erosion.

B-08 Glory Hole:

-Isolated preconsolidated sediment blocks, found within the glory hole, are heavily eroded.

-Sediment slumping, along with minor amounts of transported sediment, has infilled the glory hole by as much as 13 m.

-Video data collected in 1985 by the Cormorant SDL-1 submersible, show that the B-08 Glory Hole has infilled and changed greatly over the past 10 years.

Suggestions:

-Better navigation for the ROV's position is necessary.

-Overlay of still and video camera views would improve analysis and data quality in the future.

-A dense survey grid, with spacing that would allow video camera field of view overlap, would improve data quality.

-A more accurate pressure transducer would improve water depth measurements.

-Video data collected by the manned Cormorant SDL-1 submersible is superior in quality to similar data collected by the Hysub 5000 ROV. It is suggested, when possible, that a manned submersible be used.

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Appendix

Cormorant SDL-1 1984-1985 Video, North-East Grand Banks.

Cormorant SDL-1 submersible dives, on the Grand Banks, recorded seabed data on 5 video cassette tapes, 4 at Bower's Pit and one at the B-08 Glory Hole. Of the 5 video tapes, 3 are from 1984 and 2 are from 1985. The 1984 video data were collected on October 3rd (dive 3), 7th (dive 5) and 9th (dive 6), at Bowers Pit. The 1985 video data was collected on August 25th (dive 5), at Bowers Pit and on August 27th (dive 6), at the B-08 Glory Hole.

Features of Interest:
High quality video, detailing features on the seabed, exists for Bowers Pit and B-08 Glory Hole. Video observations were made using the Toshiba-DA4 video cassette recorder. The tape count is time based in hours, minutes and seconds.

1. Location: Bowers Pit (Dive 3/October 3, 1984/tape 1 of 1)

Tape count (hr, min, sec)	Feature Description
0,28,59	boulder and heavy gravel lag
0,33,33	sand ribbons/patches near pit
0,53,03	pit floor; gravel lag and sand
0,56,32	shell hash and gravel lag
1,03,50	ice scour (?) with gravel ridges

2. Location: Bower's Pit (Dive 5/October 7, 1984/tape 1 of 1)

Tape count (hr, min, sec)	Feature Description
0,05,14	fine gravel lag near pit
0,06,58	sandy bottom with small depressions
0,08,42	boulders on sandy seabed
0,14,53	scallop bed (pit floor)
0,28,09	sand ripples
0,28,56	pit edge (boulders and gravel)
0,32,59	sand ribbons on inner pit wall
0,34,08	heavy stone cover on inner pit wall

3. Location: Bower's Pit (Dive 6/October 9, 1984/tape 1 of 1)

Tape count (hr, min, sec)	Feature Description
0,18,19	boulders on pit edge with some biological growth.
0,43,26	sand ribbons and shell hash
0,49,21	large boulders on inner pit wall
1,00,00	sediment rod (pit centre)
1,06,07	outcropping preconsolidated sediment

4. Location: Bower's Pit (Dive 5/August 25, 1985/tape 1 of 1)

Tape count(hr, min, sec)	Feature Description
0,06,19	pit edge with boulders and benthic biota
0,07,13	closeup of boulders and biology
0,18,30	outcropping preconsolidated clay beds
0,24,17	outcropping preconsolidated clay beds
0,32,23	sediment rod (nearly one year later)

5. Location: B-08 Glory Hole (Dive 6/August 27, 1985/Tape 1 of 1)

Tape count(hr, min, sec)	Feature Description
0,13,40	B-08 well-head structure on seabed
0,19,03	sand ripples over gravel lag, near glory hole
0,20,14	edge of glory hole
0,28,11	outcropping preconsolidated clay beds, on glory hole wall
0,41,25	outcropping preconsolidated clay beds, on glory hole wall