BATHYMETRIC AND MARINE GEOLOGICAL SURVEYS IN SUPPORT OF NATIONAL MARINE PROTECTED AREAS OF GWAII HAANAS-RESULTS OF CRUISE GWAII-97

Prepared by

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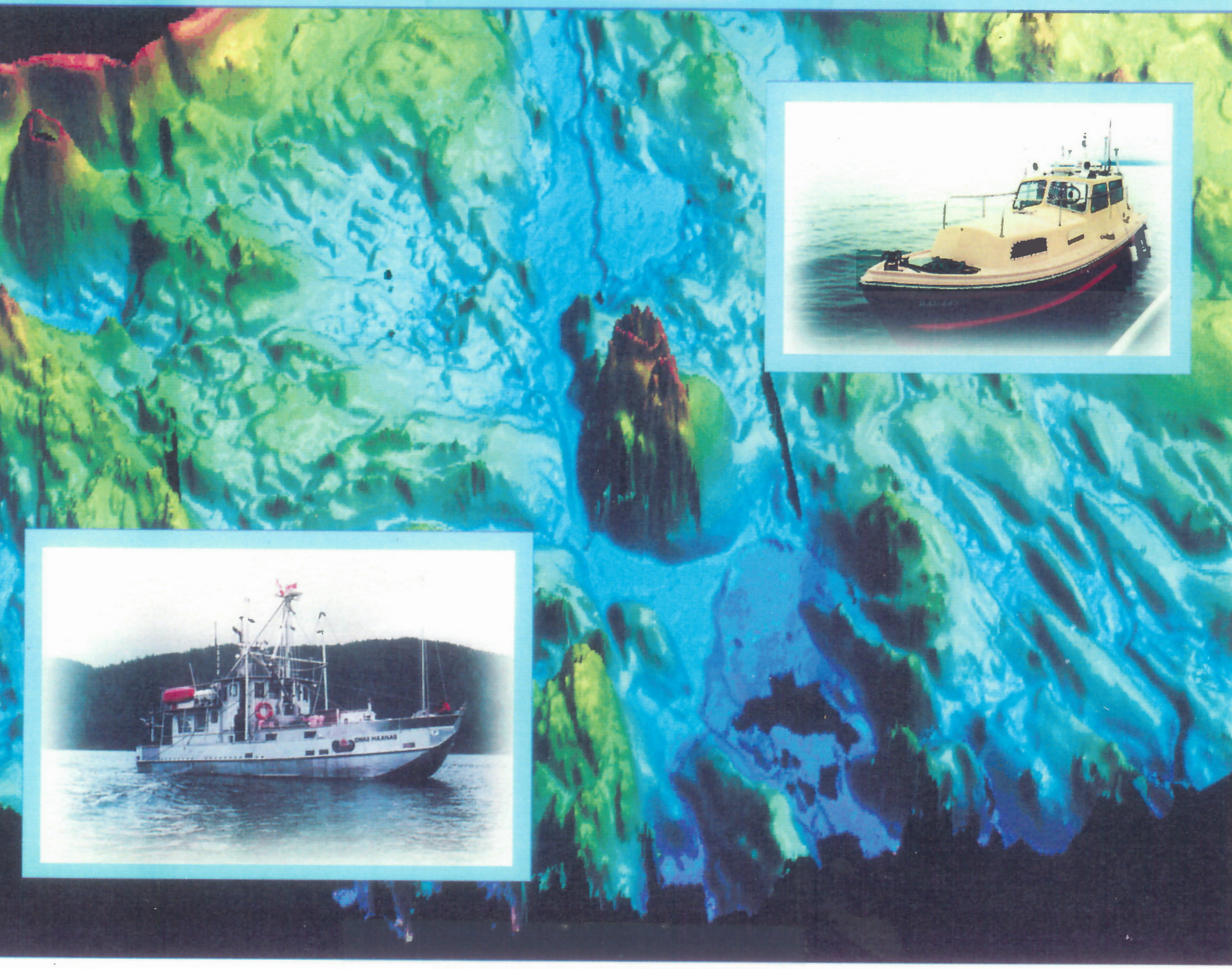
G.S.C. open file 3585



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INTRODUCTION

Fisheries habitat studies on both Canadian coasts have seen increased activity with the declaration of numerous National Marine Protected areas (NMPA). Recent studies have shown that fisheries habitat is influenced by many elements including variations in sea-floor morphology and sediment composition. Geomorphic influence on fisheries habitat varies in scale from centimetres to kilometres thus highlighting the need for both regional and site specific knowledge of seabed morphology and composition.

The 1997 field program was intended to investigated the relationships between benthic organisms and seabed character in the Queen Charlotte Islands using a variety of mapping tools. Multibeam bathymetric mapping covers 100% of the seafloor and was collected to provide the basic geomorphic baseline data. High-resolution sidescan sonar data were collected to provide more detailed seabed morphology and to define textural variations. Bottom samples were collected to ground truth the sidescan data.

A second objective of the field program was to collect high resolution seafloor data in the vicinity of Skung Gwaii and Hotspring Anchorages to assess to impact of anchor drag marks..

FIELD PROGRAM AND DATA PROCESSING

The Gwaii 1997 multidisciplinary program collected baseline seabed information from Juan Perez Sound and the approaches to Skang Gwaii. The field program was undertaken from June 5-15, 1997. The program included a team of 4 hydrographers from the Canadian Hydrographic Service of the Department of Fisheries and Oceans, a marine geologist from the Geological Survey of Canada and an archaeologist from Parks Canada. The hydrographic program employed a state of the art EM 3000 multibeam bathymetric mapping tool mounted on a 10m hydrographic launch (figure 1). Site specific (Differential Global Positioning System) navigation systems and tidal stations were included in the hydrographic program. This nearshore system collected bathymetric data to a depth of 150m and illuminated a swath equivalent in width to 3X water depth. The digital sounding data were displayed as 3D shaded-relief maps of the seafloor. The EM 3000 system collected 100% bottom coverage with a vertical accuracy of 30-50cm and a spatial accuracy of +/- 50cm. Complete bottom coverage was collected in Burnaby Strait, Werner Bay and around Hotsprings Island. The bathymetric data were subsequently processed (by Geological Survey of Canada staff) into digital terrain images which illustrate the seabed terrain much like an aerial photograph. The swath data were gridded into bins which varied between 5m and 50cm along the horizontal axis. The EM 3000 data were also processed to extract backscatter information to define variations in seafloor texture.

Representative Digital terrain images are included in this report (figures 37-50) and are also available in larger map format and as photographic slides. Digital CD copies of these images reside with Parks Canada and at the offices of the Geological Survey of Canada (Atlantic). Additional copies can be supplied on request to the author.

RESULTS AND INTERPRETATIONS

The digital terrain images reveal drowned rivers, abandoned streams, paleo-deltas, paleo beaches and drowned lakes. Geomorphic interpretations of these terrain images suggest an episode of river erosion to a depth of 153m. These interpretations directly support previous marine geological studies (Josenhans et al, 1995,1997) which describe the sea-level history of the study area. These earlier studies indicated this maximum lowering occurred shortly after glacial retreat, about 13,000 years ago. The terrain images indicate a meandering and migrating river system with associated river bank levee deposits. Levee deposits at different elevations and therefore of different ages are recognized and could be sampled to determine the relative ages of these drowned river systems. Existing studies have defined the age and rate of sea-level rise but nothing is known about when sea-level fell to the low-stand level of -153m, or for how long. The digital terrain images reveal ideal target sites for dating levee deposits of different ages. A sampling program of vibracores and large volume grab samples is proposed to determine the timing of sea-level lowering immediately after glaciation. Precise identification and location of drowned river banks, paleo deltas and former shorelines will also provide the detailed geomorphic data for a focused archaeological sampling program.

These digital terrain images also provide insight into seabed processes and seabed composition. The images clearly resolve areas of: bedrock outcrop, river sediment, marine muds and areas of seafloor erosion by bottom currents. This definition of substrate composition provides important baseline information for fisheries habitat description. The interpretation of seabed processes such as recognition of active sandwaves or areas of sea-floor erosion is also important for understanding substrate (habitat) stability. The sidescan sonar (Klein 595 system, figure 2), seismic reflection profiles and bottom samples collected as part of the geological program add a higher resolution insight into seabed morphology than achieved by the multibeam bathymetry images alone. The sidescan system resolves seabed features as small as 30cm. The sidescan sonar profiles (figures 51-61) show: anchor drag marks off Gordon Islands, seabed furrows in Burnaby Narrows (possibly caused by Gouey-duck fishing or anchor drag marks) and the seabed character at the Hotspring Island, Skangwaii and Murcheson Island anchorages. The sidescan data have been digitally rectified for slant range correction, georeferenced and compiled into mosaic format as shown in figures 6, 7, 24, 25, 26 and 27. These mosaics represent an overview of the seabed relief but detailed information at specific areas is best seen on the original field records which are stored at GSCA offices. Detailed images may also be seen on enlarged representations of the digital Corel draw files. An interpretation of the seabed morphology and texture at the Hotspring and Skung Gwaii anchorages is shown in map form at a variety of scales and projections (see appendix maps). The Skung Gwaii interpretation is based on the sidescan mosaic and bottom sample description. The Hotspring seabed interpretation is based on an integration of the sun illuminated swath bathymetry(DTM) data, sidescan mosaic and bottom sample descriptions.

The bottom samples provide ground truth for the remotely sensed images and will provide bottom texture information when analyzed for grain size. The samples were photographed in the field as shown in figures 12 -20 and 29-36. Biological subsamples were sieved from the seabed samples and stored in a solution of buffered Formalin. Subsequent biological analysis will provide an inventory of the infauna habituating the many substrates observed in this study.

SKANGWAII ANCHORAGE INTERPRETATION

Sidescan imagery (1995, 1997), photography (1995) and bottom sampling (1997) at both the north and south anchorages indicate areas of sand waves and rocky sea floor. This high energy environment has areas of bedrock outcrop, occasional boulders and cobbles and patches of shell hash which are continually reworked and swept clear by strong bottom currents. There is no evidence (within the resolution of the sidescan sonar) of sea floor disturbance from historic use as anchorages. This lack of observed seabed disturbance contrasts with the anchorage on the central east coast of the Gordon Islands where anchor drag marks are numerous in what appear to be relatively stable sand and gravel sediments. At the Gordon Islands anchorage, one boulder field area appears to be good holding ground with little or no evidence of anchor dragging. At Skangwaii, the rocky bottom produces good holding ground and high-energy currents appear to rework any evidence of anchor dragging.

HOTSPRINGS ANCHORAGE INTERPRETATION

The 1997 marine geology/environment studies included swath bathymetry coverage surrounding Hotspring Island as well as sidescan imagery and bottom sampling of marine areas south and east of the island. As with Skungwaii there is no evidence of sensitive features and no evidence of sea floor damage from historic use as anchorages. The sea floor is much less dynamic than Skungwaii with more extensive fine sand to shell hash matrix and more restricted areas of bedrock. Areas of bedrock outcrop are illustrated as red patches superimposed on the digital terrain models. These are illustrated in appendix 6.

FIGURE CAPTIONS

Figure 1
Survey vessels used in the1997 field program. The Gwaii Haanas was used to collect sidescan sonar profiles and Van Veen bottom samples and the 10m Hydrographic launch was equipped with an SIMRAD EM 3000 swath mapping system. Navigation was provided by DGPS for Gwaii Haanas and a dedicated shore based navigation system for the launch.

Figure 2
Field configuration of Klein 595 sidescan sonar system with 100 and 500Khz configuration.

Figure 3
Van Veen bottom sampling configuration on foredeck of Gwaii Hanaas. Bottom samples were described visually and washed through a fine sand sized sieve. Biological specimens were stored in 4% buffered formalin for subsequent identification and description.

Figure 4
Track chart of sidescan sonar lines in Approaches to Anthony Island.

Figure 5
Detailed track chart of sidescan sonar lines around Anthony Island

Figure 6
Location map of sidescan Sonar mosaic around Anthony Island.

Figure 7 High resolution print of mosaic around Anthony Island. A large format version (1:5000) of this image is available for detailed inspection/interpretation in digital format as corel draw files.

Figure 8
Detailed track chart of sidescan sonar lines around Gordon Islands

Figure 9
Location map of sidescan Sonar mosaic around Gordon Islands

Figure 10
High resolution print of mosaic around Gordon Islands. A large format version (1:5000) of this image is available for detailed inspection/interpretation in digital format as corel draw files

Figure 11
Sample location map around Skung Gwaii and Gordon Islands. Samples were collected by Van Veen bottom grab. They were washed through a sand sized sieve, described visually and will be analyzed for detailed grain size and infauna.

Figure 12-20
Photographs of Van Veen seabed samples taken on deck prior to sieving and subsampling for infauna.

Figure 21
Regional sidescan sonar track plot within Juan Perez Sound.

Figure 22
Detailed track plot of sidescan lines in Burnaby Strait.

Figure 23
Detailed track plot of sidescan lines around Hotspring Island.

Figure 24
Location map of sidescan sonar mosaic around Hotspring Island.

Figure 25
High resolution print of mosaic around Hotspring Island. A large format version (1:5000) of this image is available for detailed inspection/interpretation.

Figure 26
Location map of sidescan Sonar mosaic west of Hotspring Island.

Figure 27
High resolution print of mosaic west of Hotspring Island. A large format version (1:5000) of this image is available for detailed inspection/interpretation.

Figure 28
Sample location map around Hotspring Island. Samples were collected by Van Veen Bottom grab. They were described visually and will be analyzed for texture and infauna.

Figures 29-36
Photographs of Van Veen seabed samples taken on deck prior to sieving and subsampling for infauna.

Figure 37
Hydrographic map showing Burnaby Strait and Werner Bay of southern Juan Perez Sound with superimposed EM 3000 multibeam bathymetry processed into a sun illuminated digital terrain model. A meandering paleo-river system extends from south to north and terminates at a paleo-delta at a depth of 153m.

Figure 38
Digital Terrain model of same area as figure 37 as seen looking south.

Figure 39
Digital terrain model of Burnaby Strait showing meandering drowned river valley and river terrace.

Figure 40
Digital terrain model of drowned river and delta systems near All Alone Stone Island in Southern Juan Perez Sound. The terrace scarp is interpreted to have been cut by a river as sea-level fell shortly after deglaciation of the area about 13,500 years ago. The delta plain is presently in 130m water depth. Black gaps are areas of no data.

Figure 41
Digital terrain model of Werner Bay showing drowned delta plain and paleo-rivers at mouth of Matheson Inlet.

Figure 42
Digital terrain model of approaches to Matheson Inlet in south western Juan Perez Sound. The rough terrain with shadows represents areas of bedrock outcrop at the seafloor. The drowned river system emanating from Matheson inlet has shifted over time in response to lowering sea-levels after deglaciation about 13500 years ago. We interpreted the older river to have been abandoned as sea-level fell and the younger river to have migrated to a new outlet position at a lower sea-level, The preserved terraces may yield excellent sites for dating the age of the river. They may also have been ideal habitation sites for early humans.

Figure 43
Digital terrain model of Werner Bay and approaches looking south west.

Figure 44
Digital terrain model of Burnaby Strait looking north, showing the paleo-river system between Parks island and Moresby Island. This drowned river once flowed into Burnaby Strait.

Figures 45-46
Digital terrain models of meandering drowned river system in Burnaby Strait between Moresby and Huxley Islands.

Figures 47-49
Digital Terrain model around Hotsprings Island in Juan Perez Sound. The images show areas of bedrock outcrop with a deeply incised paleo-river channel emanating from Ramsey Island. Although Bedrock outcrop at the seafloor is dominant within the area, ponded shelly sandy mud is found between the bedrock ridges.

Figure 50
Digital Terrain model around Hotsprings Island in Juan Perez Sound showing seafloor morphology around the anchorage sites. The corrugated pattern in the lower right is an artifact due to incorrect vessel heave compensation.

Figure 51
Sidescan sonar profile off entrance to Skung Gwaii showing areas of bedrock outcrop and sand waves.

Figure 52
Sidescan sonar profile off entrance to Skung Gwaii showing areas of bedrock outcrop at entrance to Skung Gwaii .

Figure 53
Sidescan sonar profile off Gordon Islands showing large boulders at seabed and anchor marks.

Figure 54
Sidescan sonar profile off Gordon Islands showing anchor marks.

Figure 55
Sidescan sonar profile from north end of Burnaby Narrows.
The lineal furrows are interpreted as anchor drag or dredge marks.

Figure 56,57
Sidescan sonar profiles off south east corner of Hotspring Island near can buoy showing areas of bedrock outcrop and smooth seafloor.

Figure 58-60
Sidescan sonar profiles from Murcheson anchorage showing areas of bedrock outcrop, smooth seafloor and can buoy anchors and ground tackle.

REFERENCES

Heiner Josenhans, Daryl Fedje, Reinhard Pienitz and John Southon, Early Humans and Rapidly Changing Holocene Sea-Levels in the Queen Charlotte Islands- Hecate Strait, British Columbia, Canada. SCIENCE. VOL. 277. July 1997 pp 71-74

Heiner Josenhans, Daryl Fedje, Kim Conway and Vaughn Barrie, Post glacial sea levels on the Western Canadian continental shelf: evidence for rapid change, extensive subaerial exposure, and early human habitation, Marine Geology Vol. 125 1995 pp 73-94

APPENDIX MAPS

APPENDIX 1

Hydrographic map showing Burnaby Strait and Werner Bay of southern Juan Perez Sound with superimposed EM 3000 multibeam bathymetry processed into a sun illuminated colour enhanced digital terrain model (DTM). A meandering paleo-river system extends from south to north and terminates at a paleo-delta at a depth of 153m in the north central area of the DTM. The superimposed depth contour lines are based on the multibeam soundings.

APPENDIX 2

Hydrographic map showing Burnaby Strait and Werner Bay of southern Juan Perez Sound with superimposed EM 3000 multibeam bathymetry processed into a sun illuminated digital terrain model. A meandering paleo-river system extends from south to north and terminates at a paleo-delta at a depth of 153m. The superimposed depth contour lines are based on the multibeam soundings.

APPENDIX 3

Digital terrain model of approaches to Matheson Inlet in south western Juan Perez Sound. The contour interval is 5m and contours are based on the multibeam data. The rough terrain with shadows represents areas of bedrock outcrop at the seafloor. The drowned river system emanating from Matheson inlet (embayment south of Gottlob pt.) has shifted over time in response to lowering sea-levels after deglaciation about 13500 years ago. We interpreted an older river to have been abandoned as sea-level fell and a younger river to have migrated to a new outlet position to the north east in response to a lower sea-level. The preserved terraces may yield excellent sites for dating the age of the river. They may also have been ideal habitation sites for early humans.

APPENDIX 4

Digital terrain model of drowned river and delta systems near All Alone Stone Island in Southern Juan Perez Sound. Contour interval is 5m. The terrace scarp in the centre of the map is interpreted to have been cut by a river as sea-level fell shortly after deglaciation of the area about 13,500 years ago. The delta plain is presently in 130m water depth. Black gaps are areas of no data.

APPENDIX 5

Digital Terrain model around Hotsprings Island in Juan Perez Sound with superimposed depth contours and bottom sample descriptions. The images show areas of bedrock outcrop with a deeply incised paleo-river channel emanating from Ramsey Island situated at the southern margin of the map. Although bedrock outcrop at the seafloor is dominant within the area, ponded shelly sandy mud is found between the bedrock ridges.

APPENDIX 6

Sun illuminated Digital Terrain model around Hotsprings Island in Juan Perez Sound with superimposed depth contours and bottom sample descriptions. The red areas represent bedrock outcrop and ponded shelly, sandy mud is found between the bedrock ridges.

APPENDIX 7

Sun illuminated Digital Terrain model around Hotsprings Island in Juan Perez Sound with superimposed depth contours and bottom sample descriptions. The data were digitally gridded to 1m horizontal bin size.

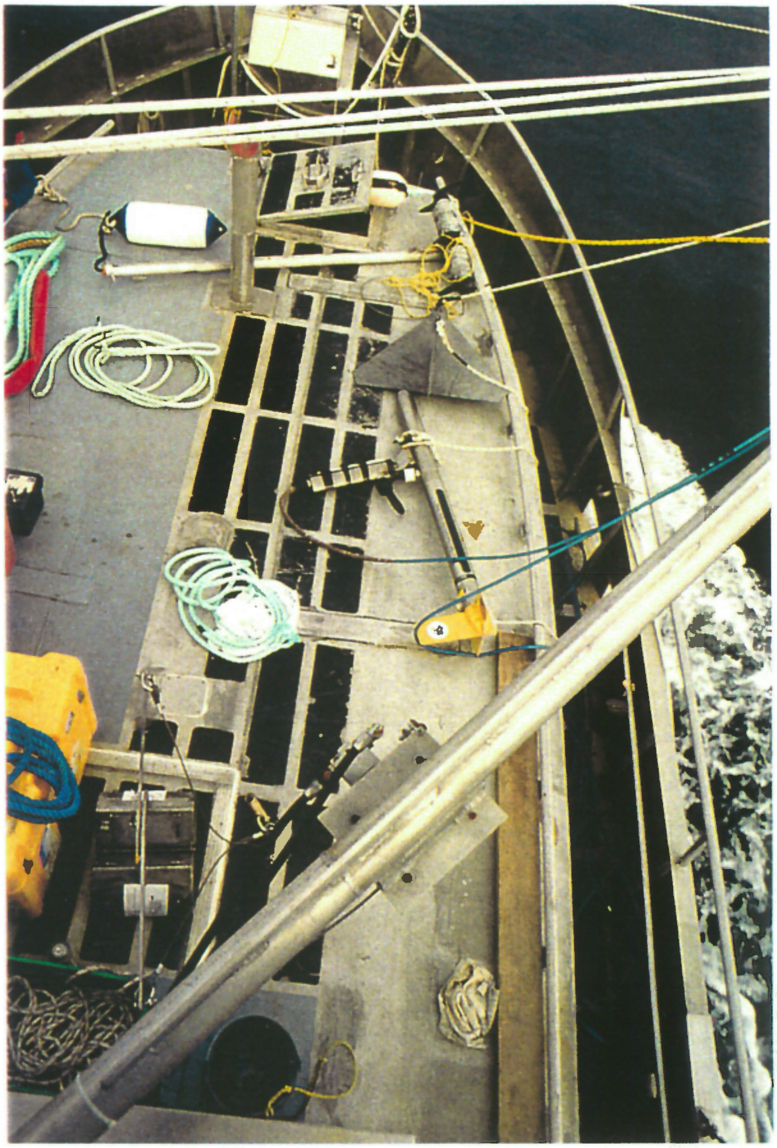
APPENDIX 8

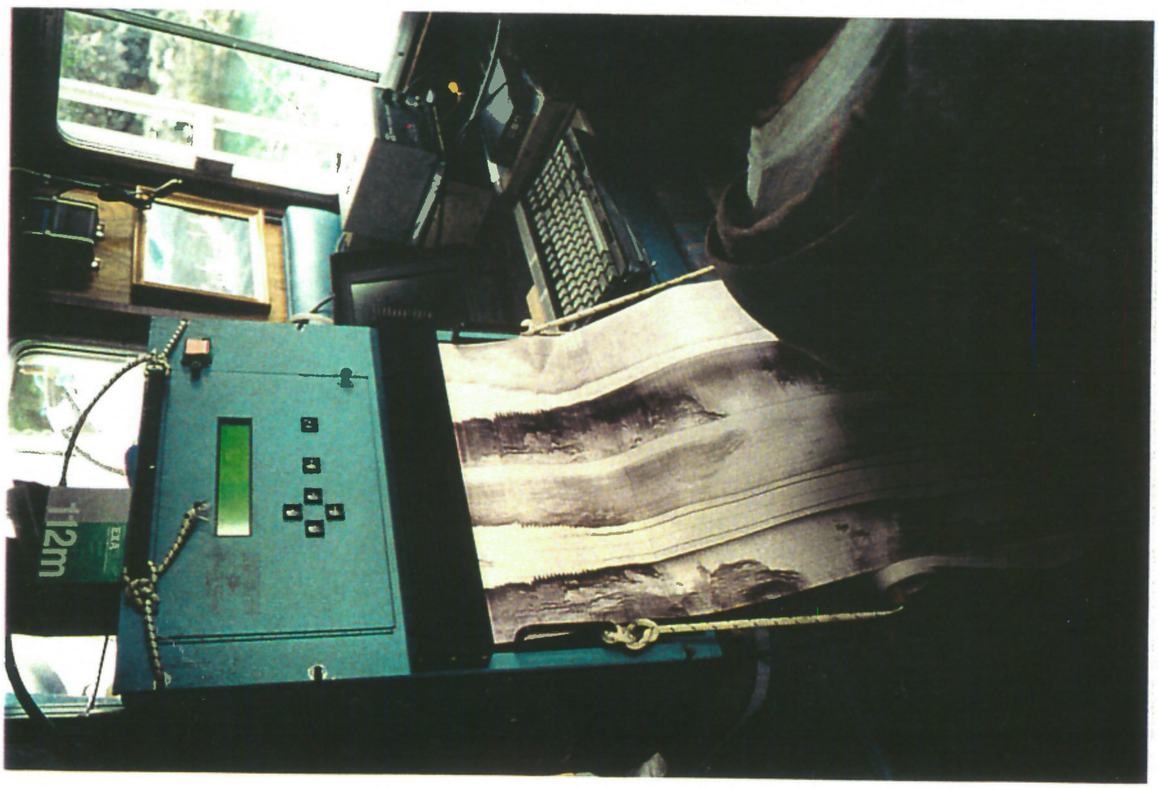
Sun illuminated Digital Terrain model around Hotsprings Island in Juan Perez Sound with superimposed depth contours and bottom sample descriptions. The data has been gridded to 50 cm horizontal bin size which represents the maximum horizontal resolution. Note the increased clarity of individual bedrock outcrops compared to the 2m horizontal grid size for the same area shown in Appendix 6. This increased resolution also highlights individual beam errors, ship motion and water velocity artifacts.

APPENDIX 9

Sidescan sonar mosaic seaward of Skan Gwaii village with superimposed sample description. Red areas represent bedrock outcrop. This overview mosaic shows the extent of sidescan coverage. For detailed investigations of seabed character the reader is referred to an enlarged view of this digital image (Corel draw file available from author) or to the original sidescan sonar records which resolve seabed features as small as 30cm horizontal scale.

Fig 1





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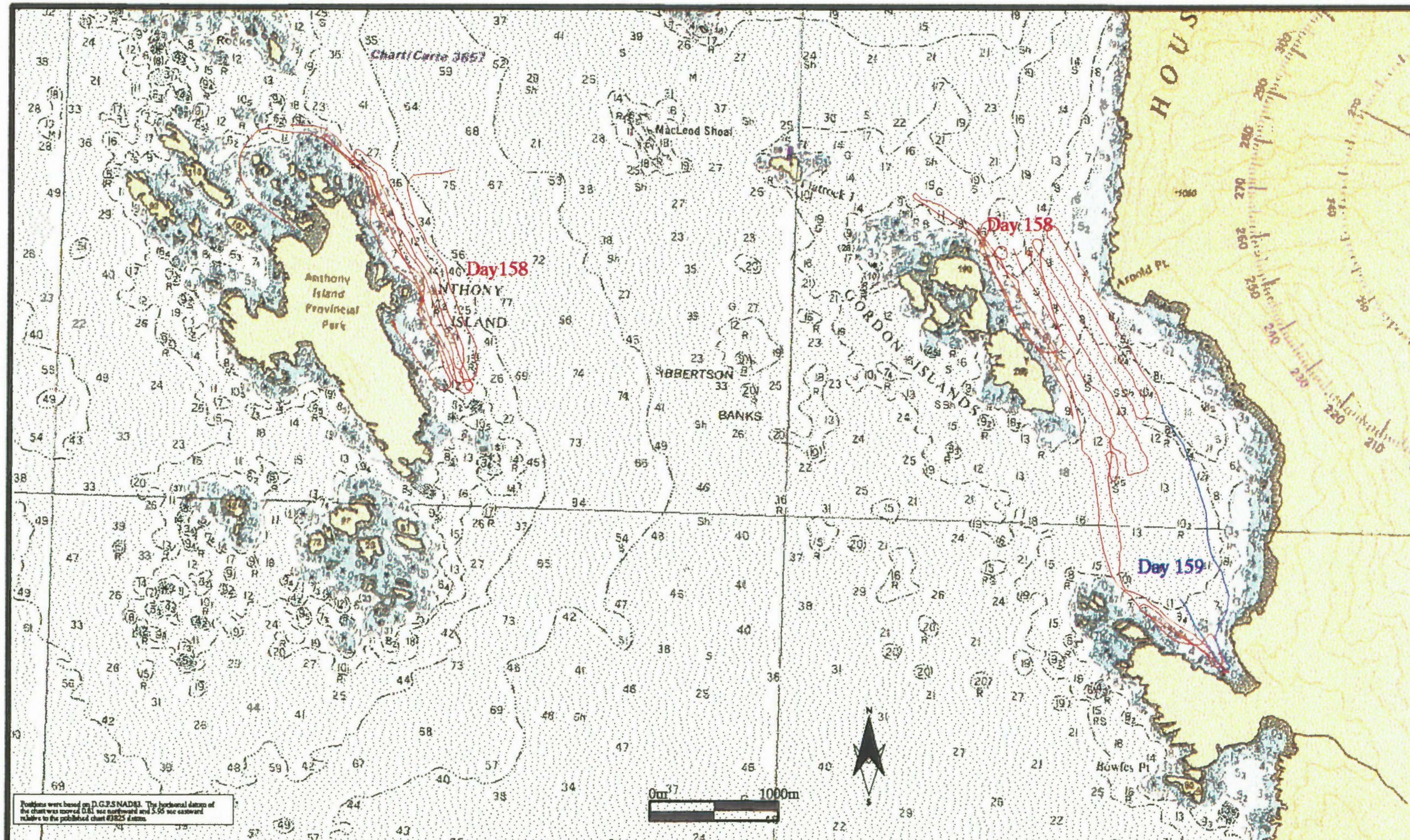
Side Scan Sonar Tracks
Skung Gwaii
-GWAI97



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Side Scan Sonar Track Adjacent to Anthony Island –GWAI97

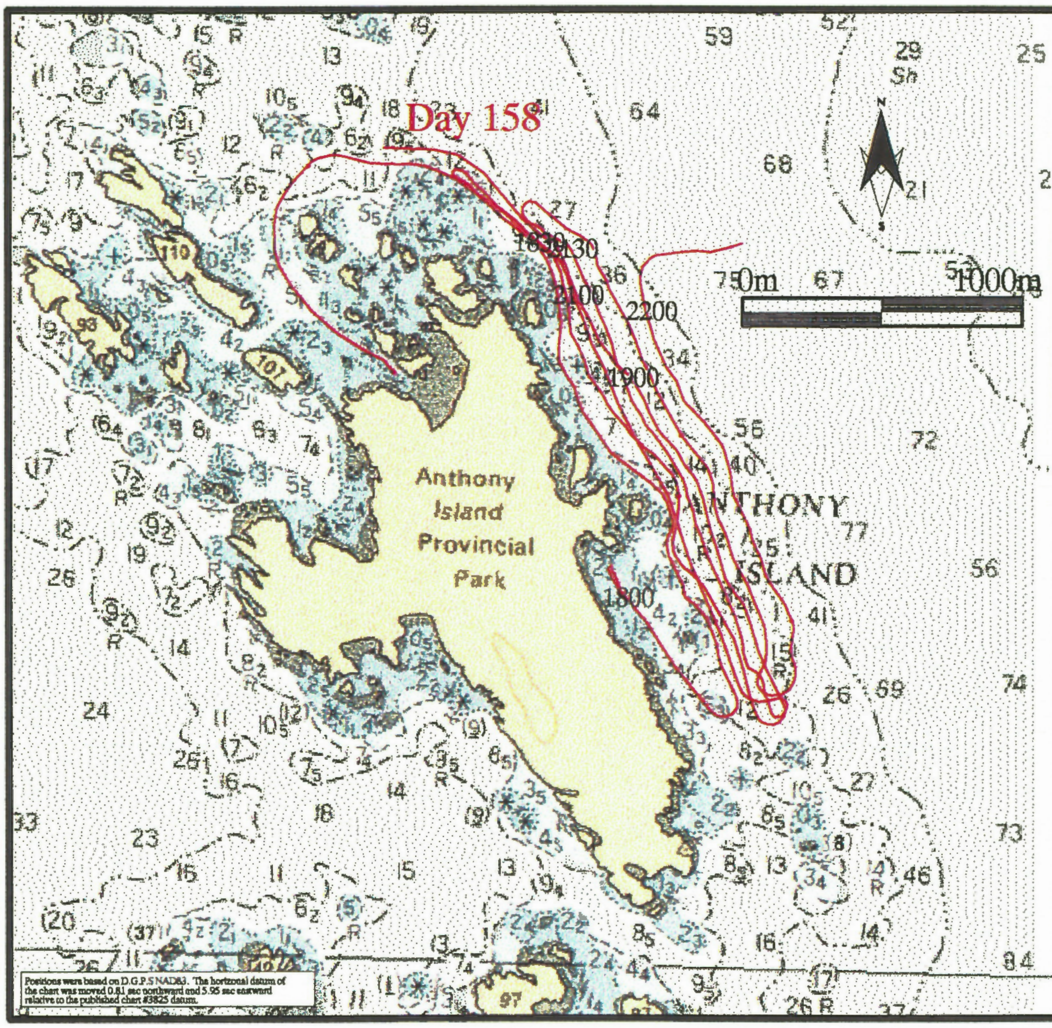

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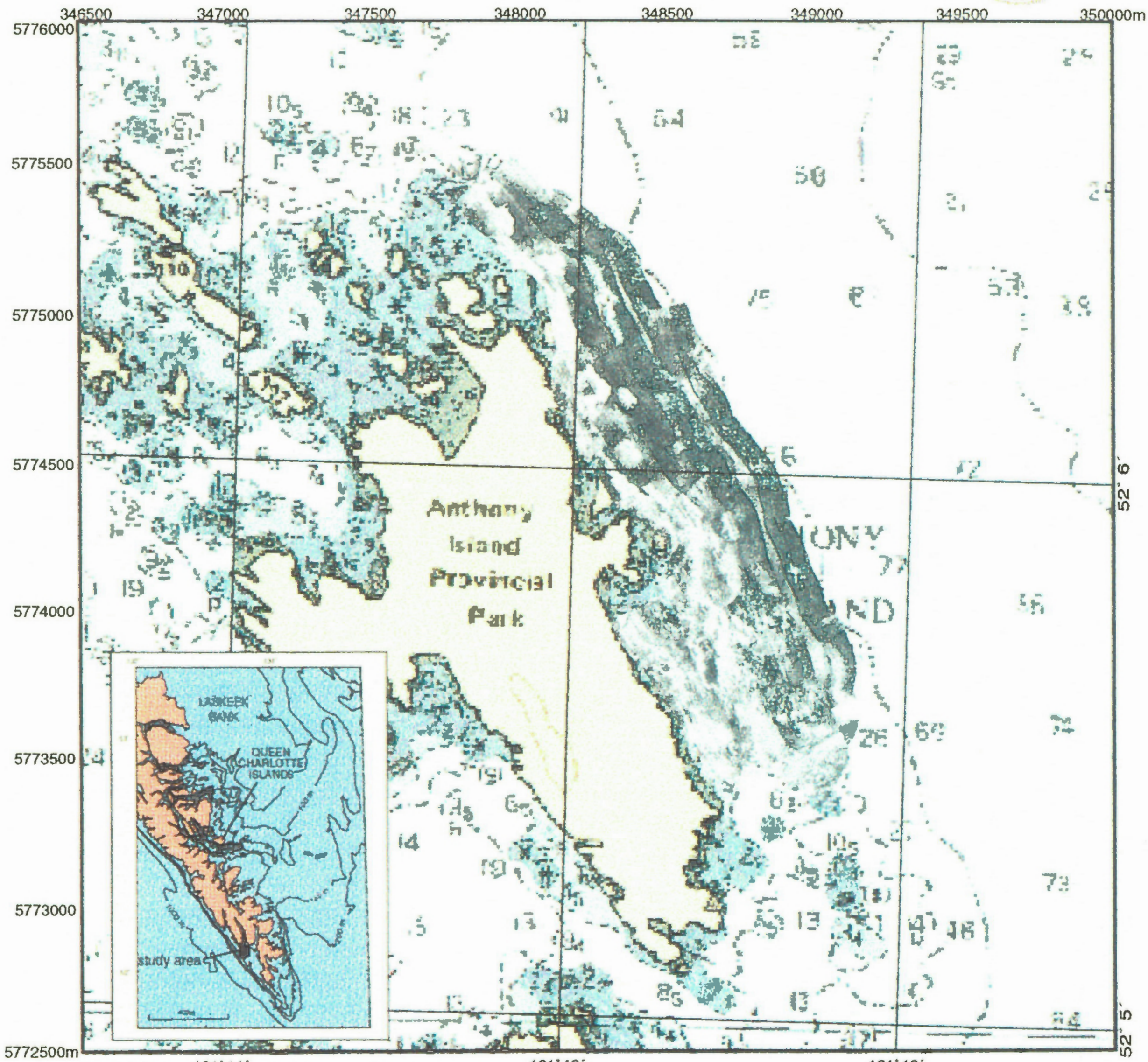
Fig 5

Sidescan Sonar Mosaic
East of Anthony Island



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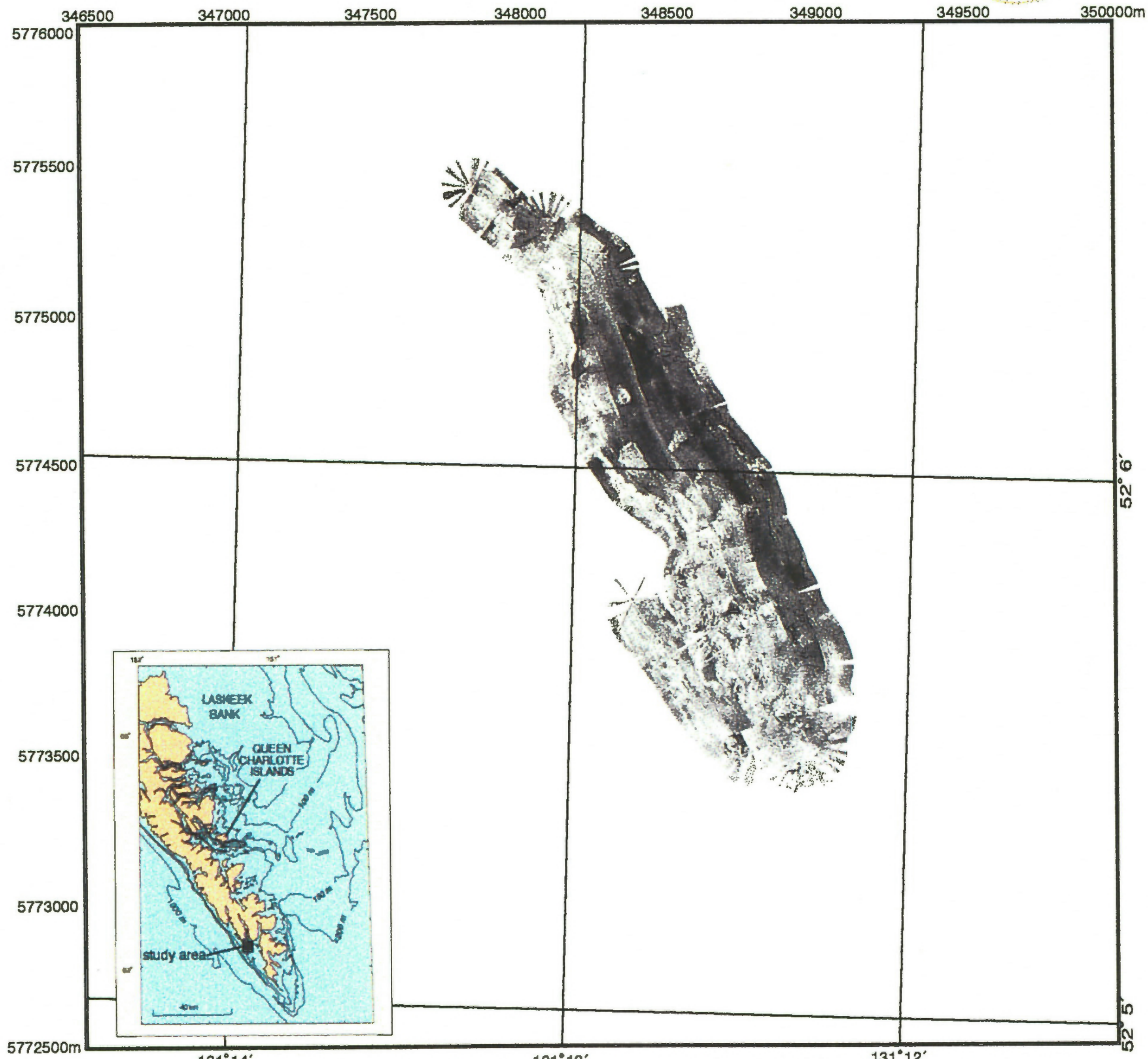
Date: June 8, 1997.
Instrument: Kline 595 Sidescan sonar recorded with AGCDIG
Gridding Interval: 1m
* For detailed sidescan sonar data see analogue field records

Map Data
Projection: UTM, Zone 9
Datum: Mapsheet coverted to NAD27 from NAD83
Sidescan navigation is referenced to NAD83 with 10m layback
Scale: 1:5000

Canadian Heritage Parks Canada
Natural Resources Canada

Digitally compiled by J. Harding

Sidescan Sonar Mosaic
East of Anthony Island



Survey Data

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Date: June 8, 1997.
Instrument: Kline 595 Si lescan sonar recor le l with AGCDIG
Gri l ling Interval: 0.5m
* For detailed sidescan sonar data see analogue field records

Map Data

Projection: UTM, Zone 9
Datum: Mapsheet coverte l to NAD27 from NAD83
Si lescan navigation is reference l to NAD83 with 10m layback
Scale: 1:5000

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Side Scan Sonar Tracks Adjacent to Gordon Islands -GWAI97

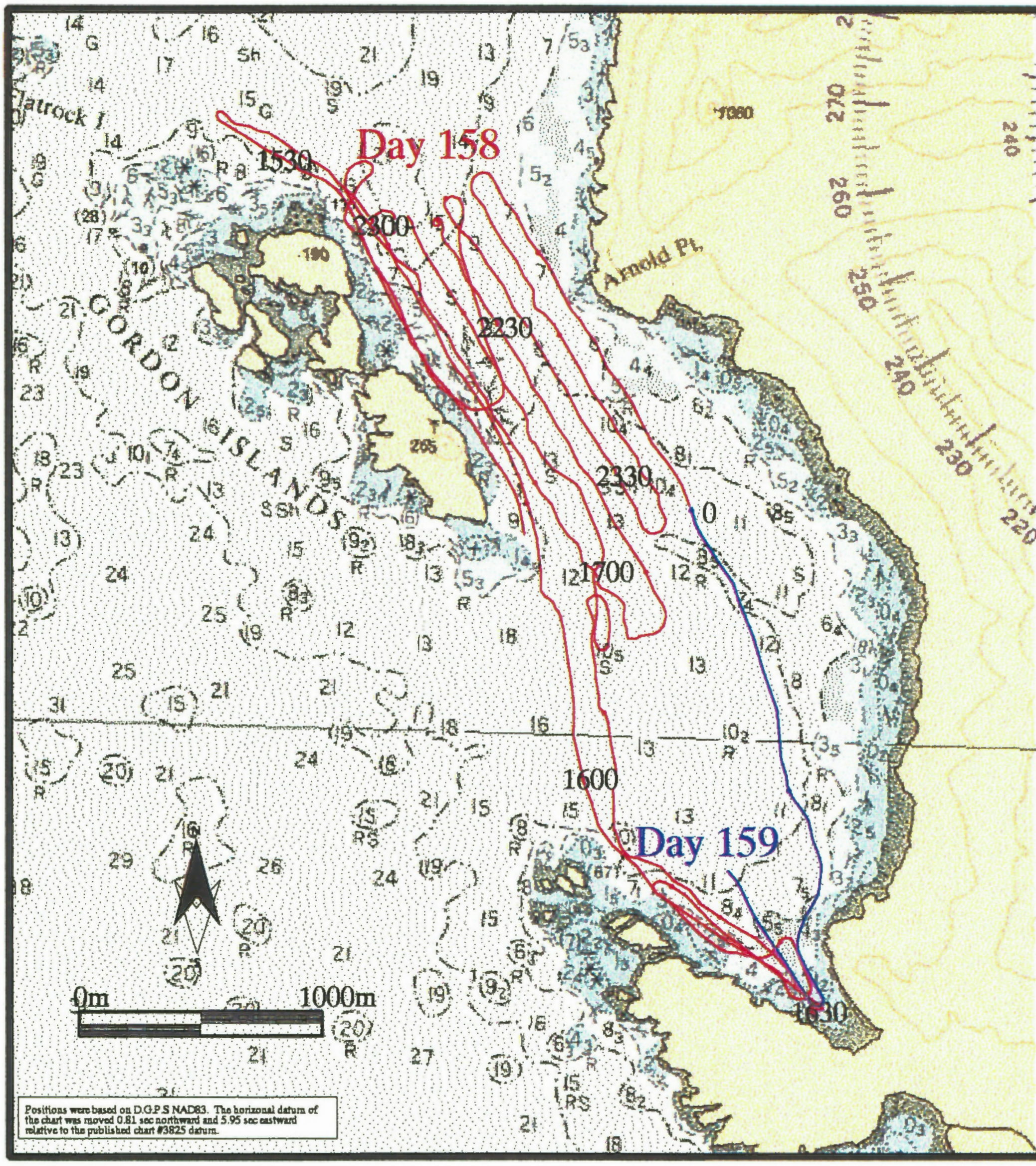

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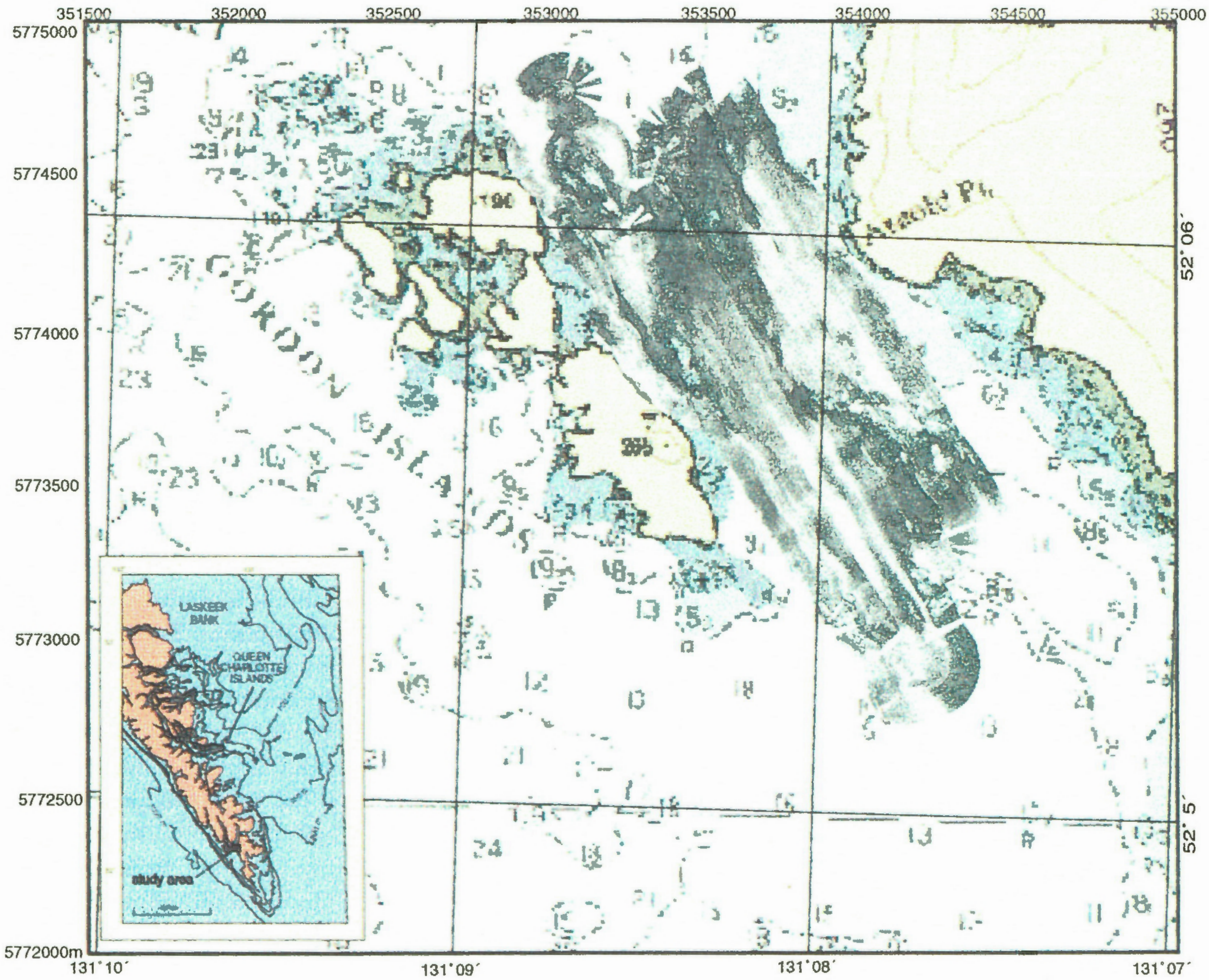
Fig 8

Sidescan Mosaic Adjacent to Gordon Islands



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Instruments: Kline 595 Sidescan sonar recorded with AGCDIG
Gridding Interval: 1m
* For detailed sidescan sonar data see analogue field records

Mapping Data

Projection: UTM, Zone 9
Datum: Chart converted from NAD27 to NAD83, using conversion from Mapsheet 3808
Sidescan navigation is referenced to NAD83 with 10m layback
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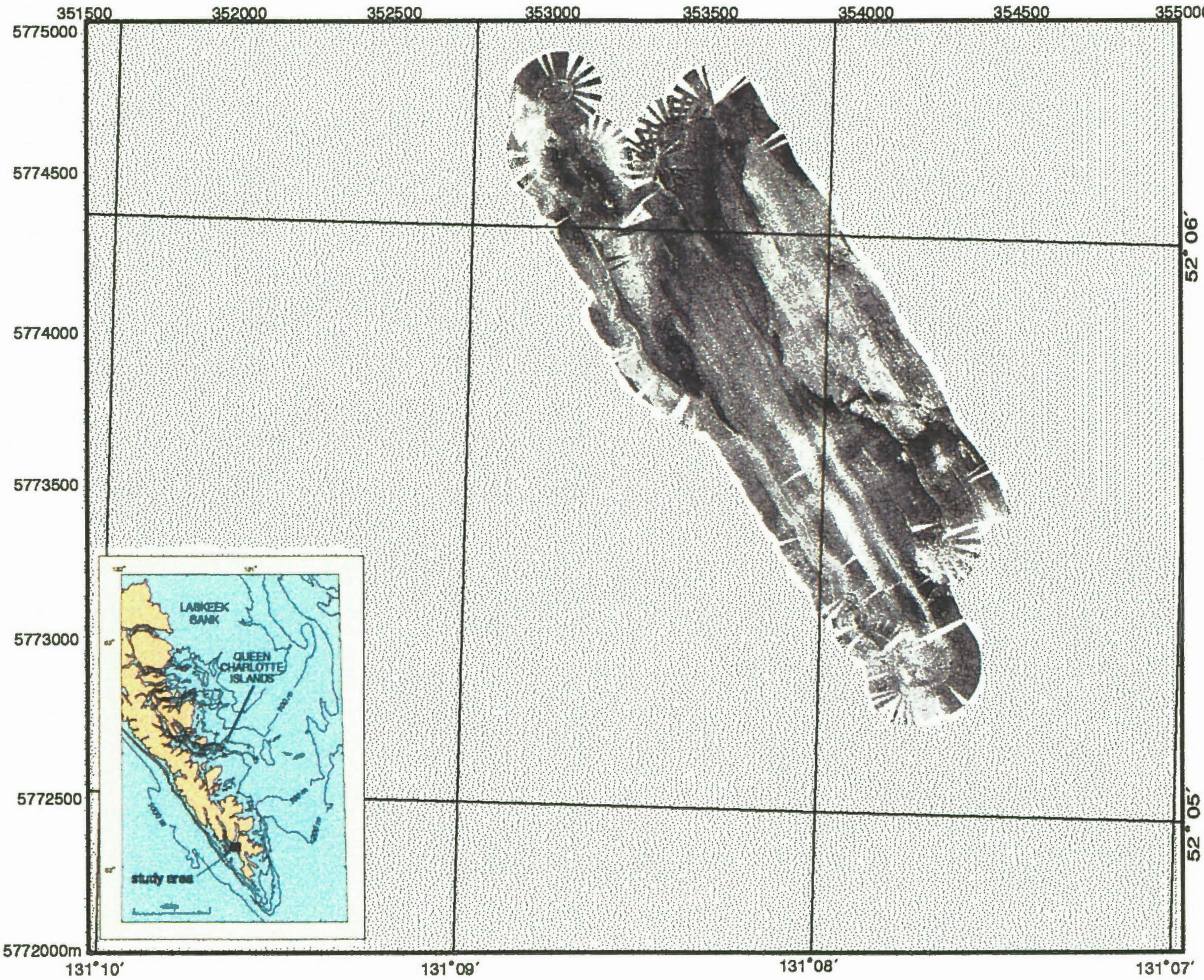
Fig 9

Sidescan Sonar Mosaic Adjacent To Gordon Islands



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Instruments: Kline 595 Si lescan Sonar recor le l on AGCDIG
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* For detailed Sidescan Sonar records see analogue field records

Mapping Data

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Si lescan navigation is reference l to NAD83 with 10m layback
Scale: 1:5000

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Fig 10

Sample Locations Around Skung Gwaii -GWAI97

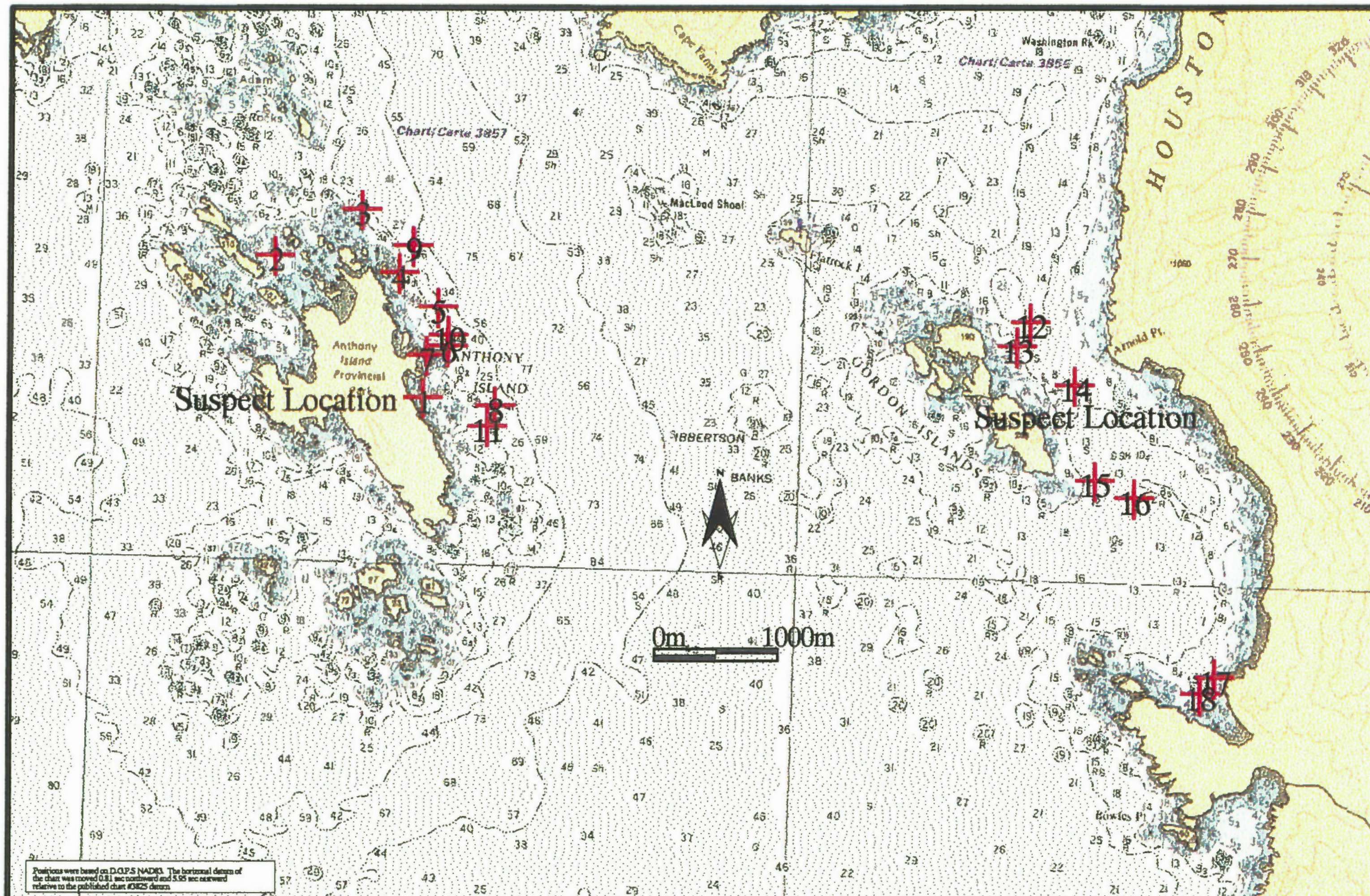

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Fig. 4


Sample
001

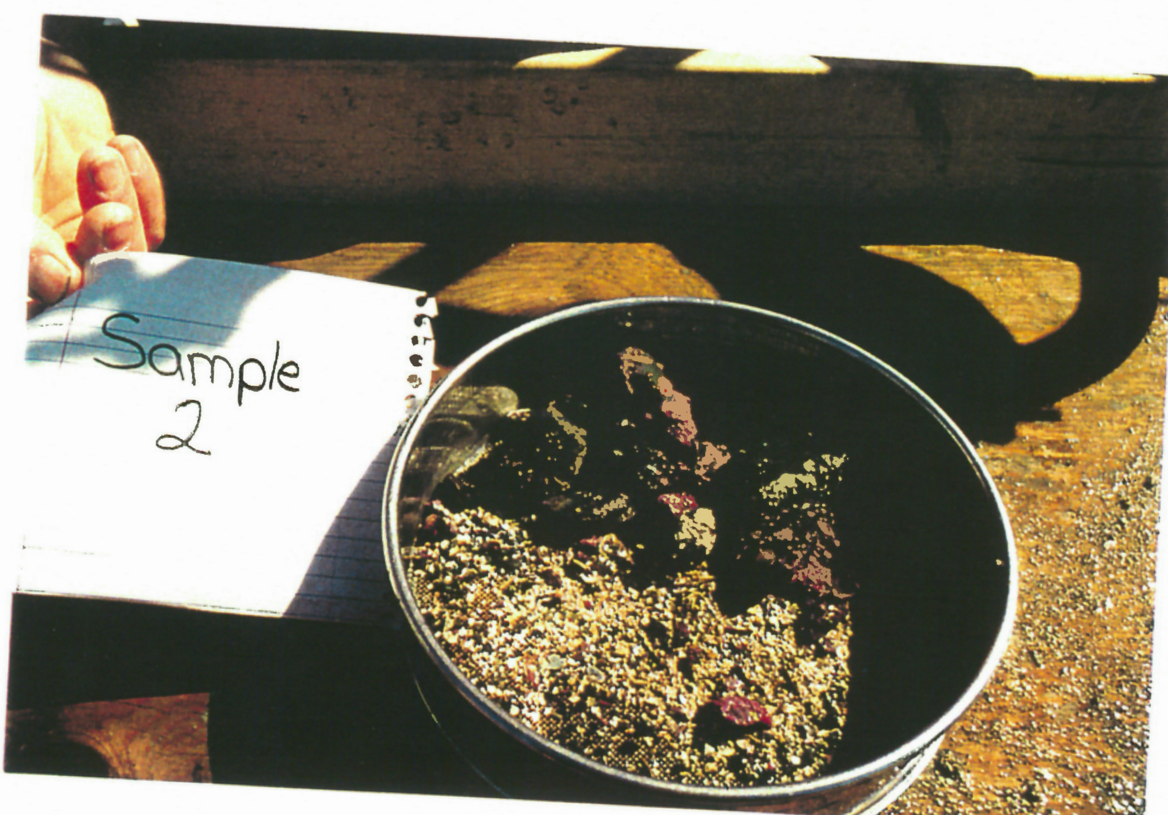

Sample
2

Fig 13

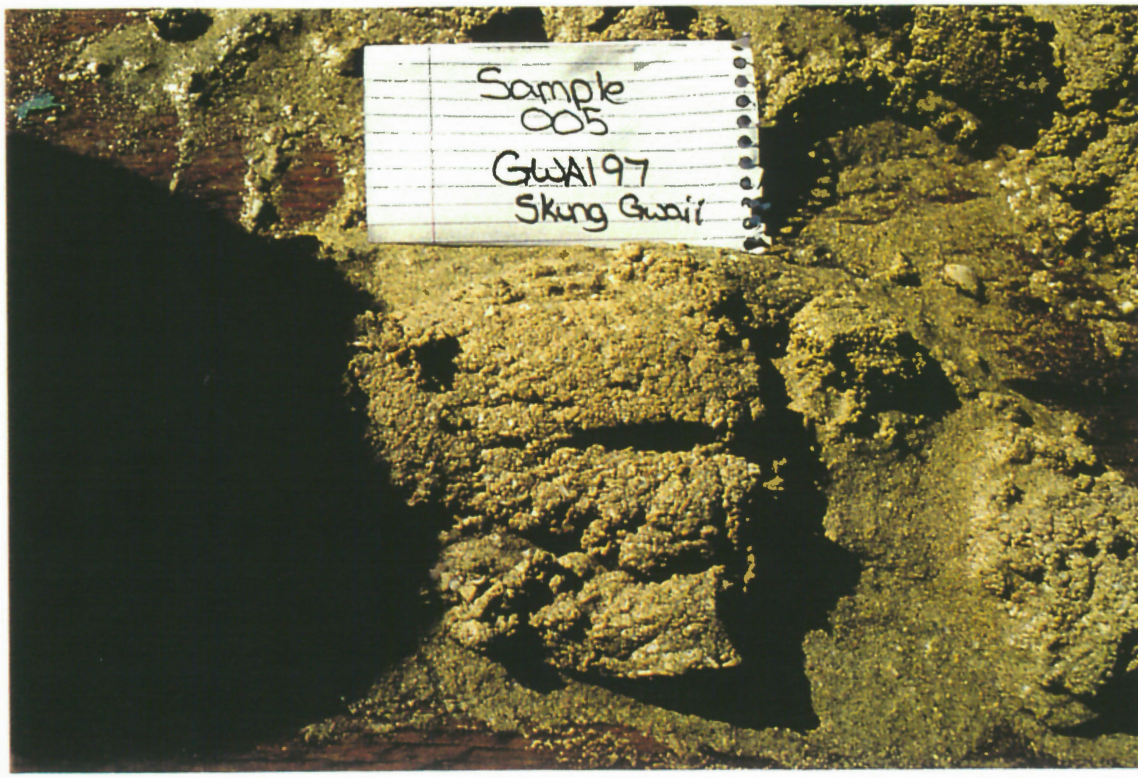


Fig 14

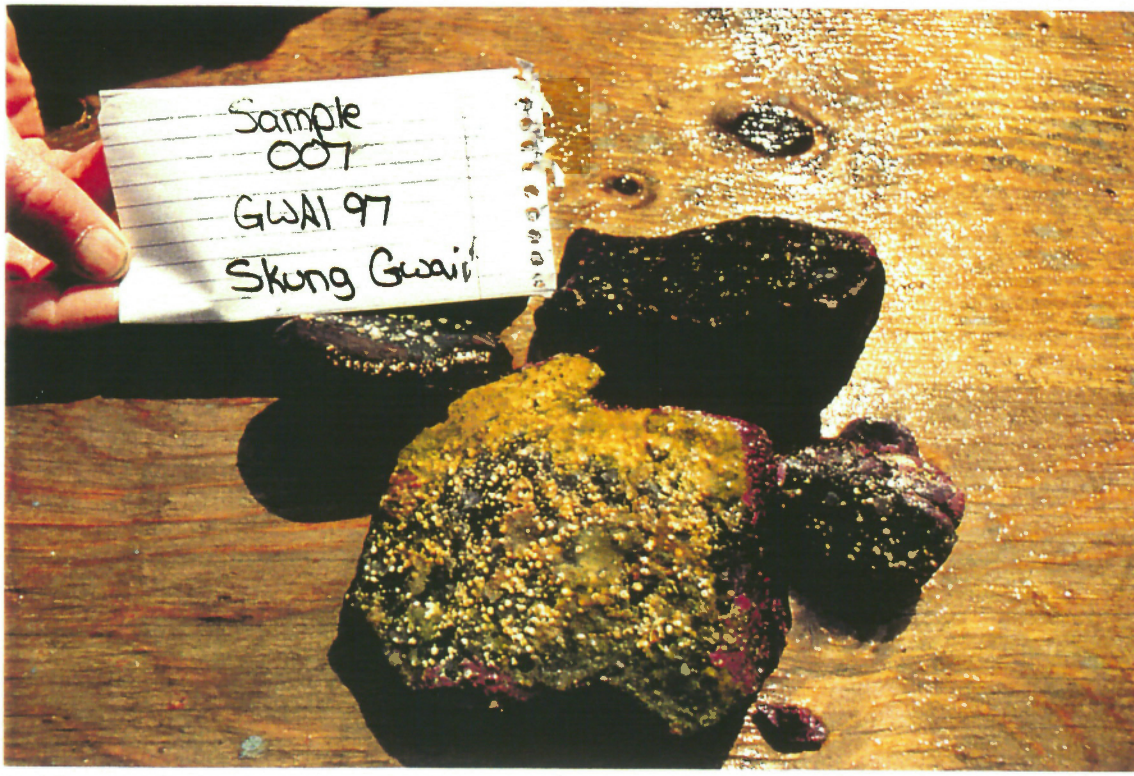
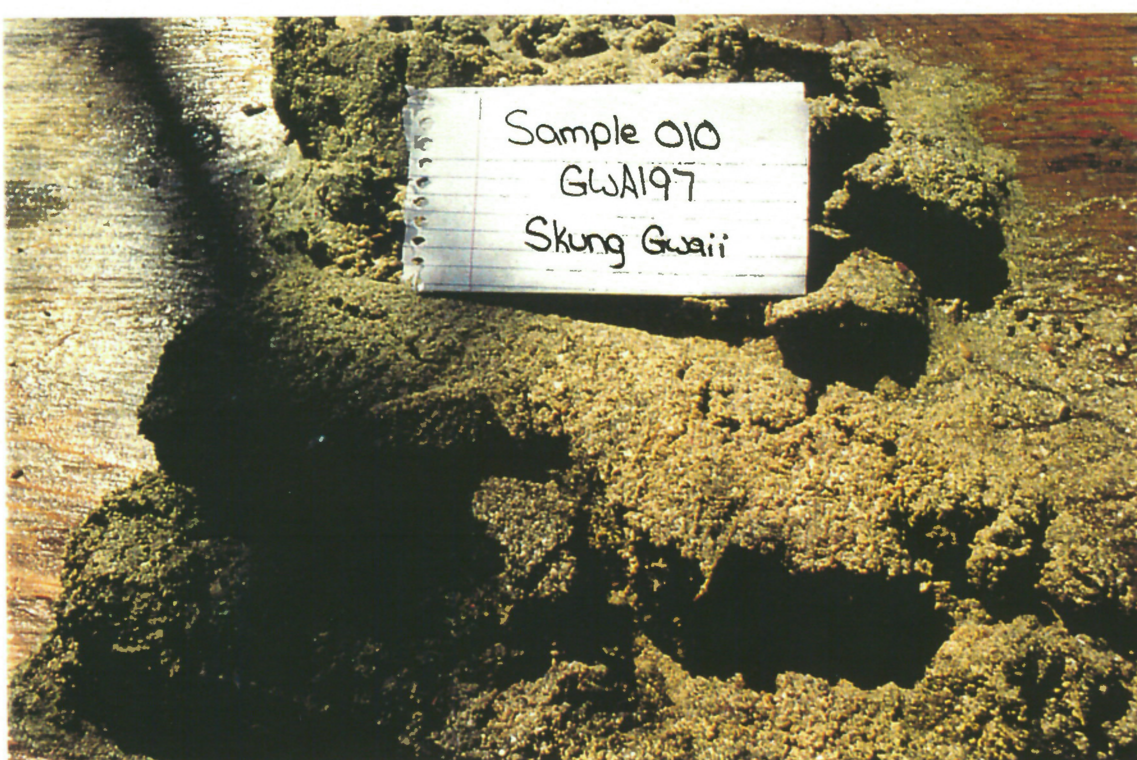


Fig 15


Sample
009
GWA197
Skung Gwaii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GWA197
Skung Gwaii

Fig 16

Fig 17

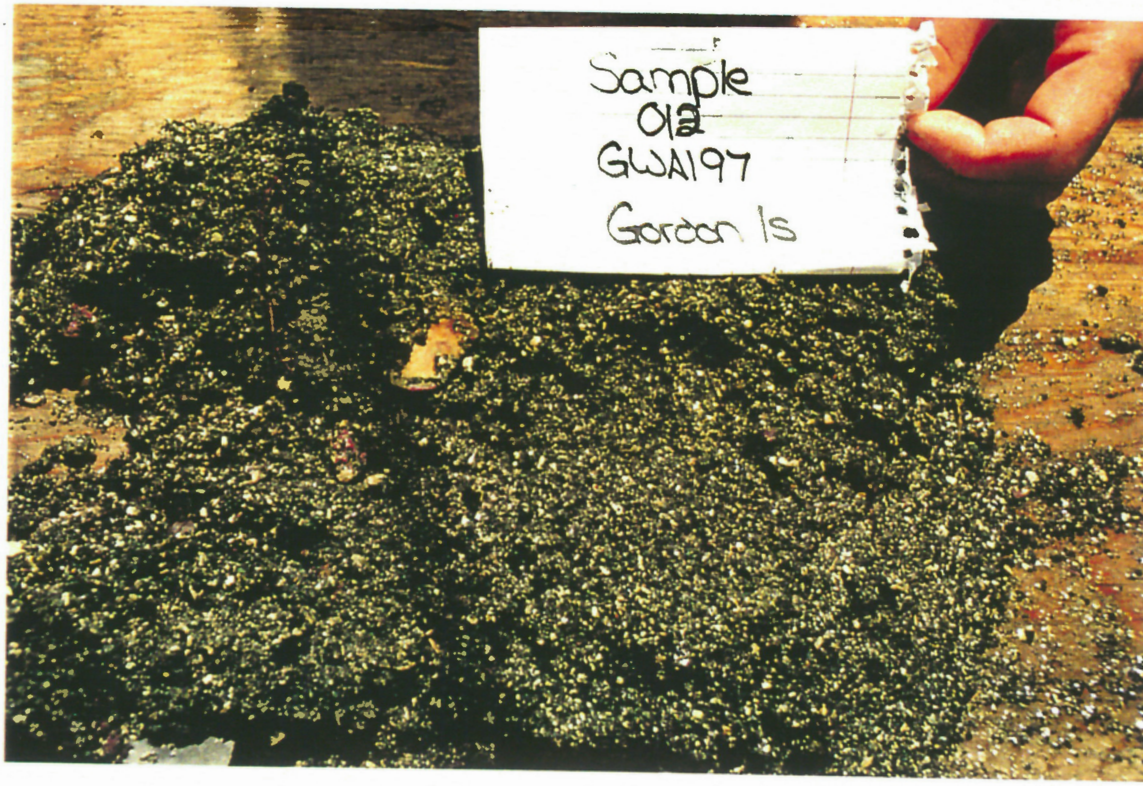

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Fig 19

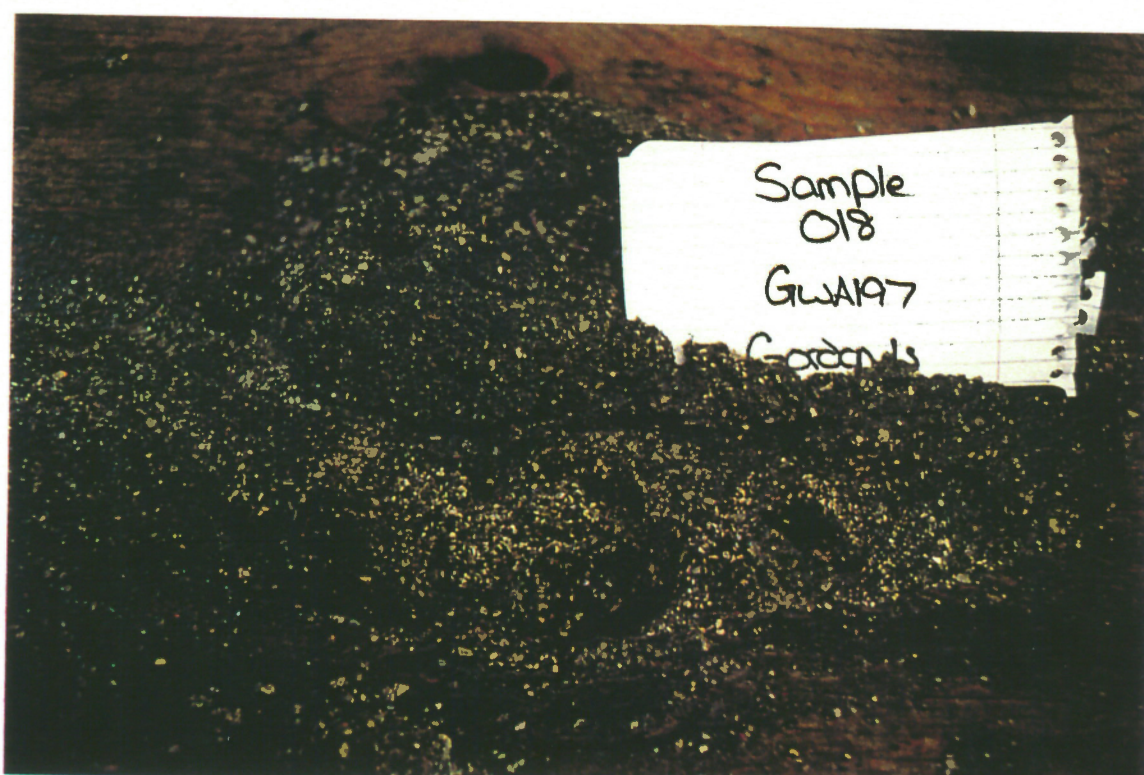

Fig 20

Side Scan Sonar Tracks
Juan Perez Sound
-GWAI97

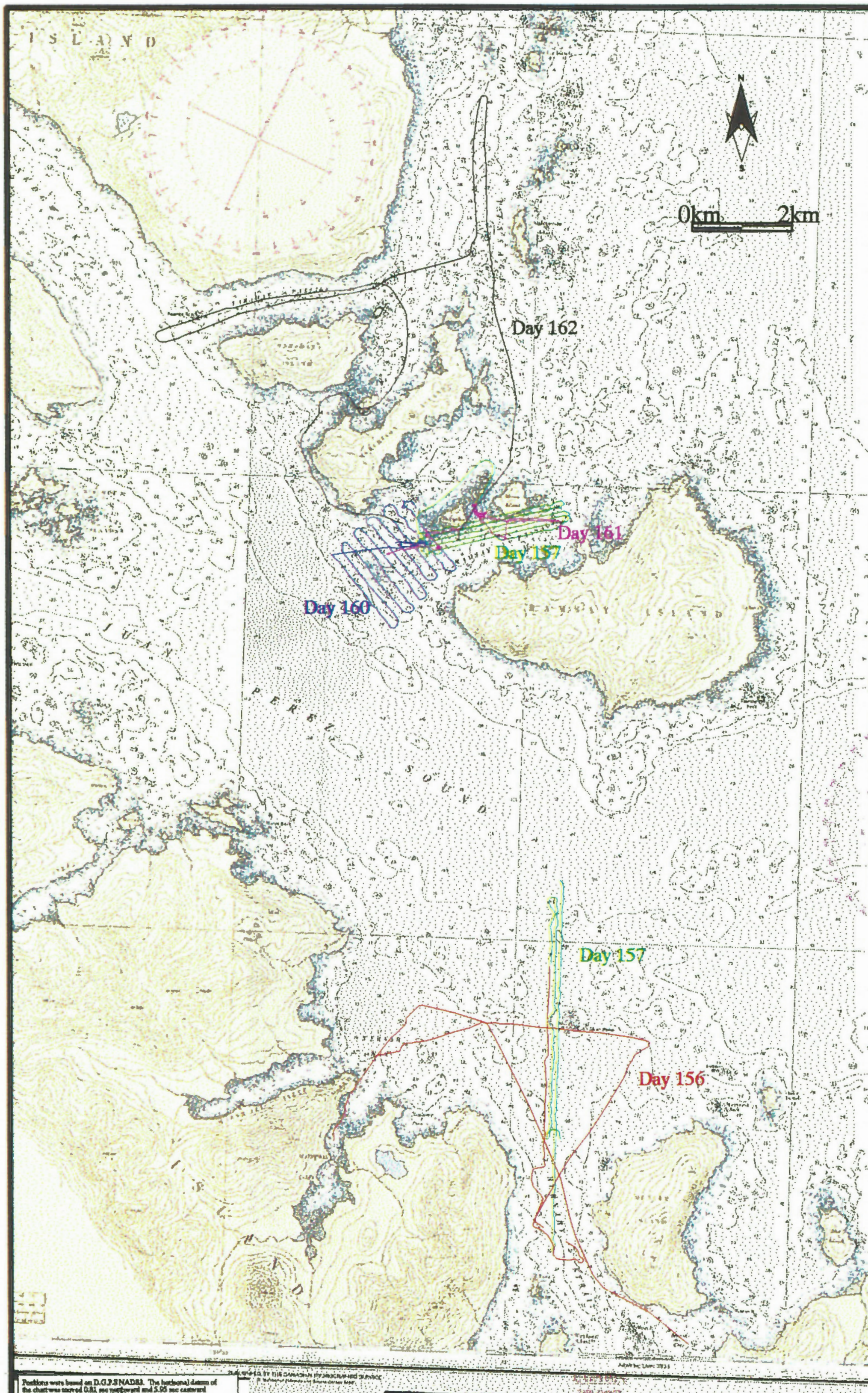

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Fig 21

Side Scan Sonar
All Alone Stone
–GWAI97

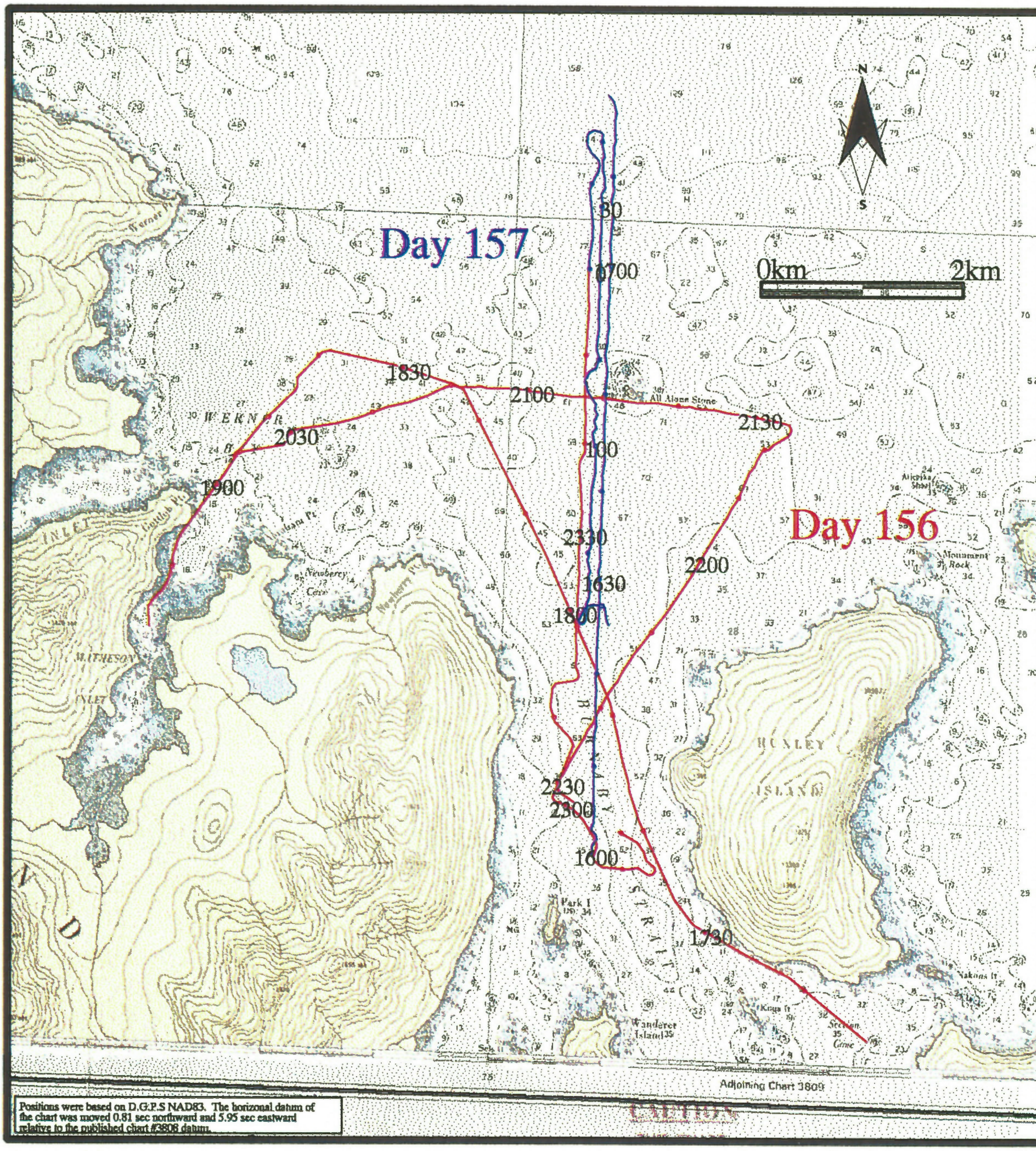

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Fig 22

Side Scan Sonar Tracks Around Hotspring Island -GWAI97

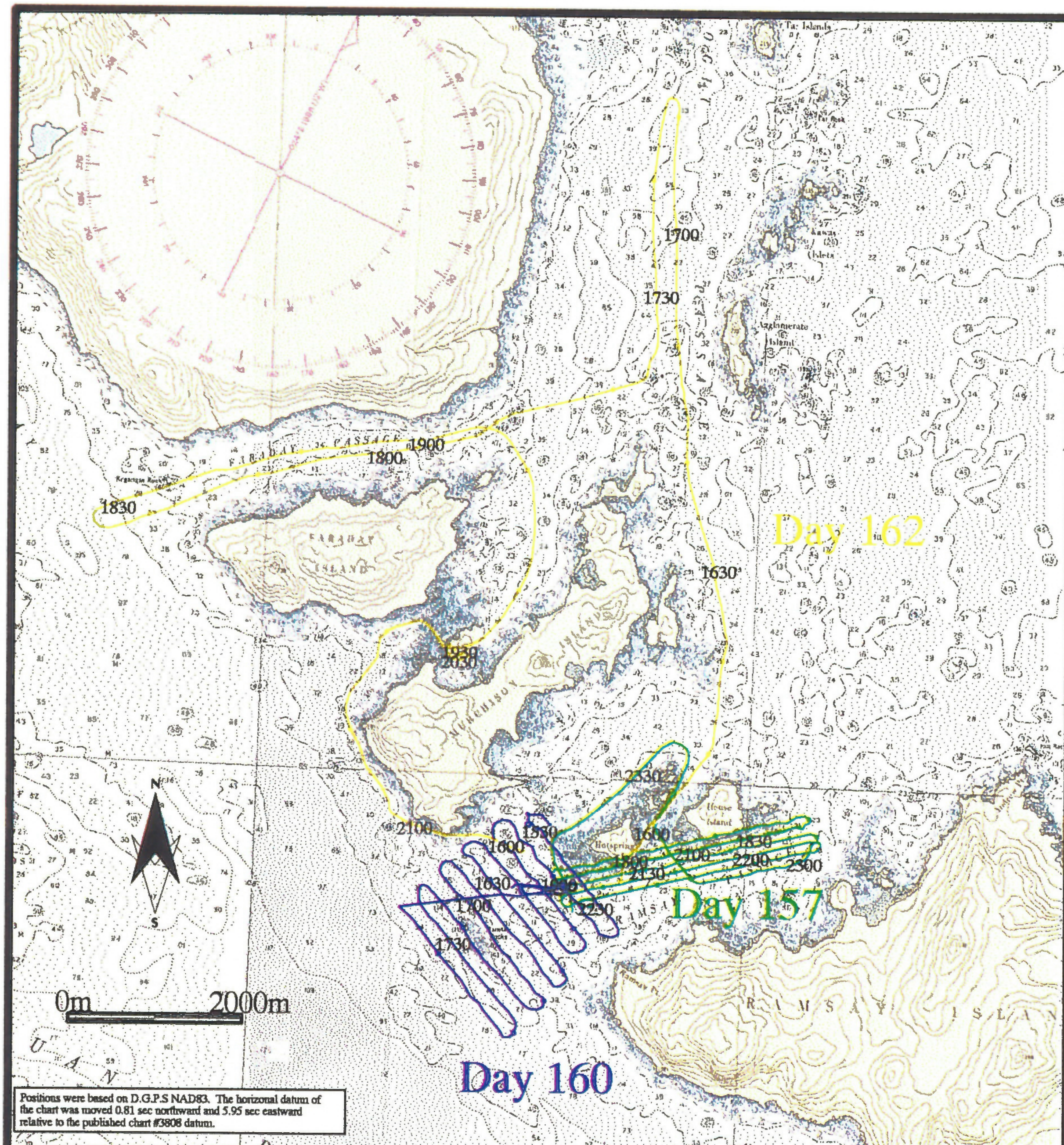

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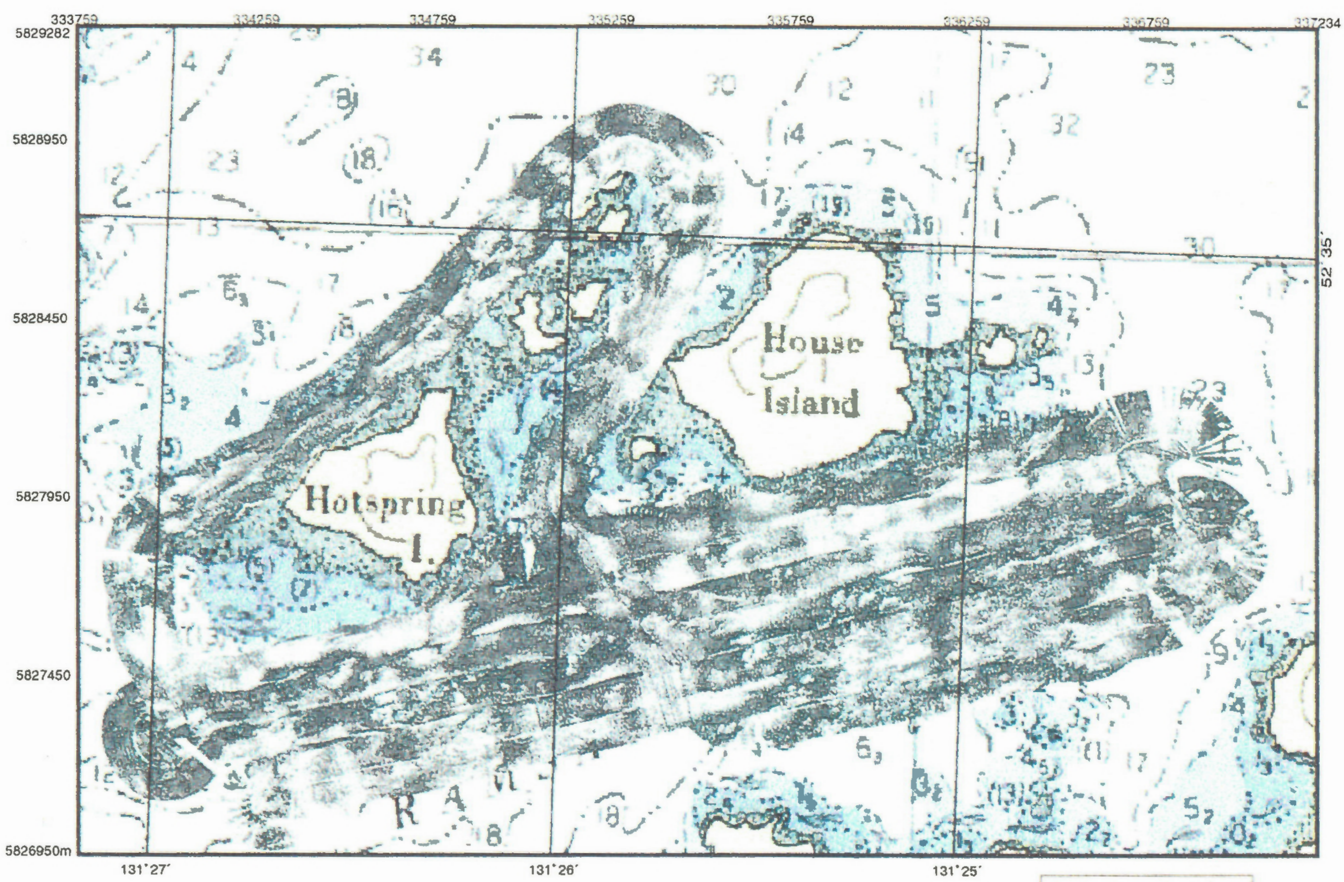
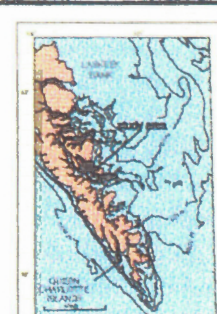
Fig 23

Sidescan Mosaic South East Of Hot Spring Island





Survey Data

Ship: Gwaii Haanas
Date: June 7, 1997.
Instruments: Kline 595 Sidescan Sonar recorded on AGCDIG
Gridding Interval: 1m

* For detailed sidescan sonar data see analogue field records

Mapping Data

Projection: UTM, Zone 9
Datum: Chart converted from NAD27 to NAD83, using conversion from Mapsheet 3808
Sidescan navigation is referenced to NAD83 with 10m layback
Scale: 1:5000

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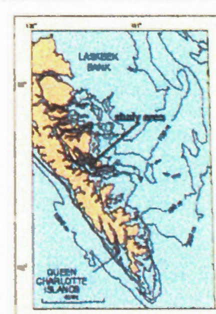
Fig 24

Sidescan Mosaic South East Of Hot Spring Island



Survey Data

Ship: Gwaii Haanas
Date: June 7, 1997.
Instruments: Kline 595 Si lescan Sonar recor le l on AGCDIG
Gri l ling Interval: 0.5m

* For detailed sidescan sonar data see analogue field records

Mapping Data

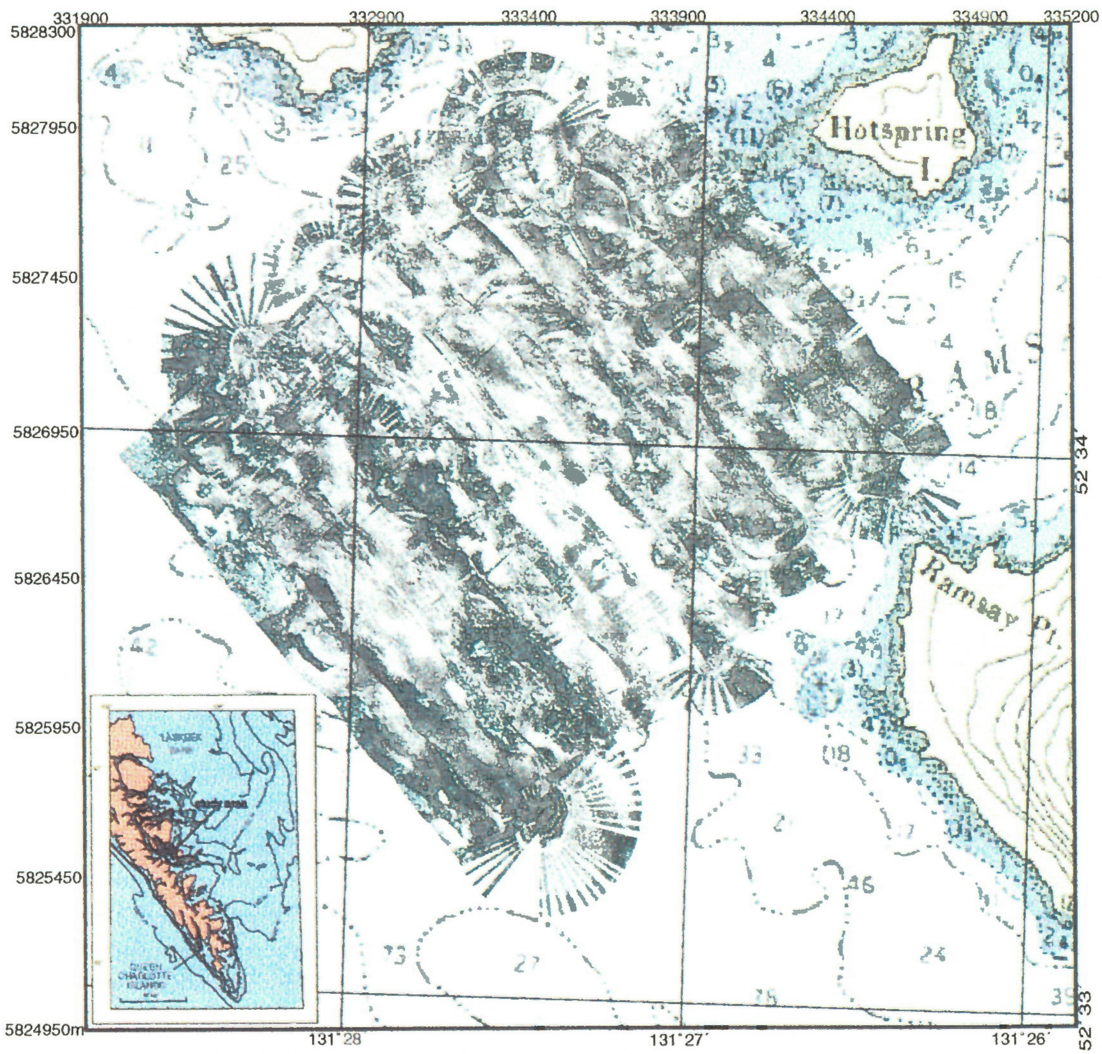
Projection: UTM, Zone 9
Datum: Chart converte l from NAD27 to NAD83, using conversion from Mapsheet 3808
Si lescan navigation is reference l to NAD83 with 10m layback
Scale: 1:5000

Natural Resources Canada
Canadian Heritage Parks Canada

Digitally compiled by J. Harding

Fig 25

Sidescan Sonar Mosaic
South of Hot Springs Island



Survey Data

Ship: Gwaii Haanas
Date: June 10, 1997.
Instruments: Kline 595 Sidescan Sonar recorded on AGCDIG
Gridding Interval: 1m
* For detailed Sidescan Sonar records see analogue field records

Mapping Data

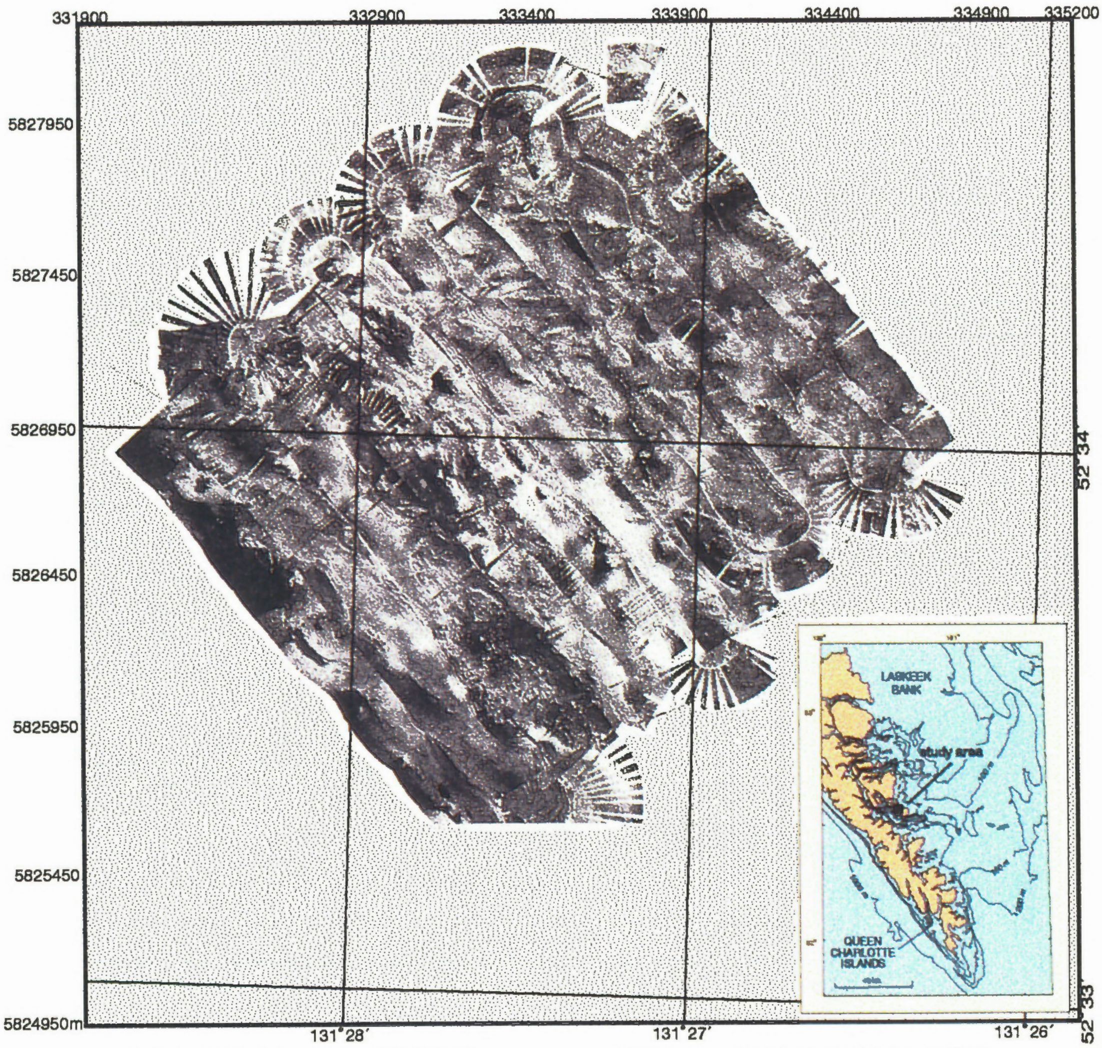
Projection: UTM, Zone 9
Datum: Chart converted from NAD27 to NAD83, using conversion from Mapsheet 3808
Sidescan navigation is referenced to NAD83 with 10m layback
Scale: 1:5000

Canadian Heritage Parks Canada
Natural Resources Canada

Digitally compiled by J. Harding

Fig 26

Sidescan Sonar Mosaic
South of Hot Springs Island



Survey Data

Ship: Gwaii Haanas
Date: June 10, 1997.
Instruments: Kline 595 Si lescan Sonar
recor le l on AGCDIG
Gri l ling Interval: 0.5m
* For detailed Sidescan Sonar records
see analogue field records

Mapping Data

Projection: UTM, Zone 9
Datum: Chart converte l from NAD27
to NAD83, using conversion from
Mapsheet 3808
Si lescan navigation is reference l to
NAD83 with 10m layback
Scale: 1:5000

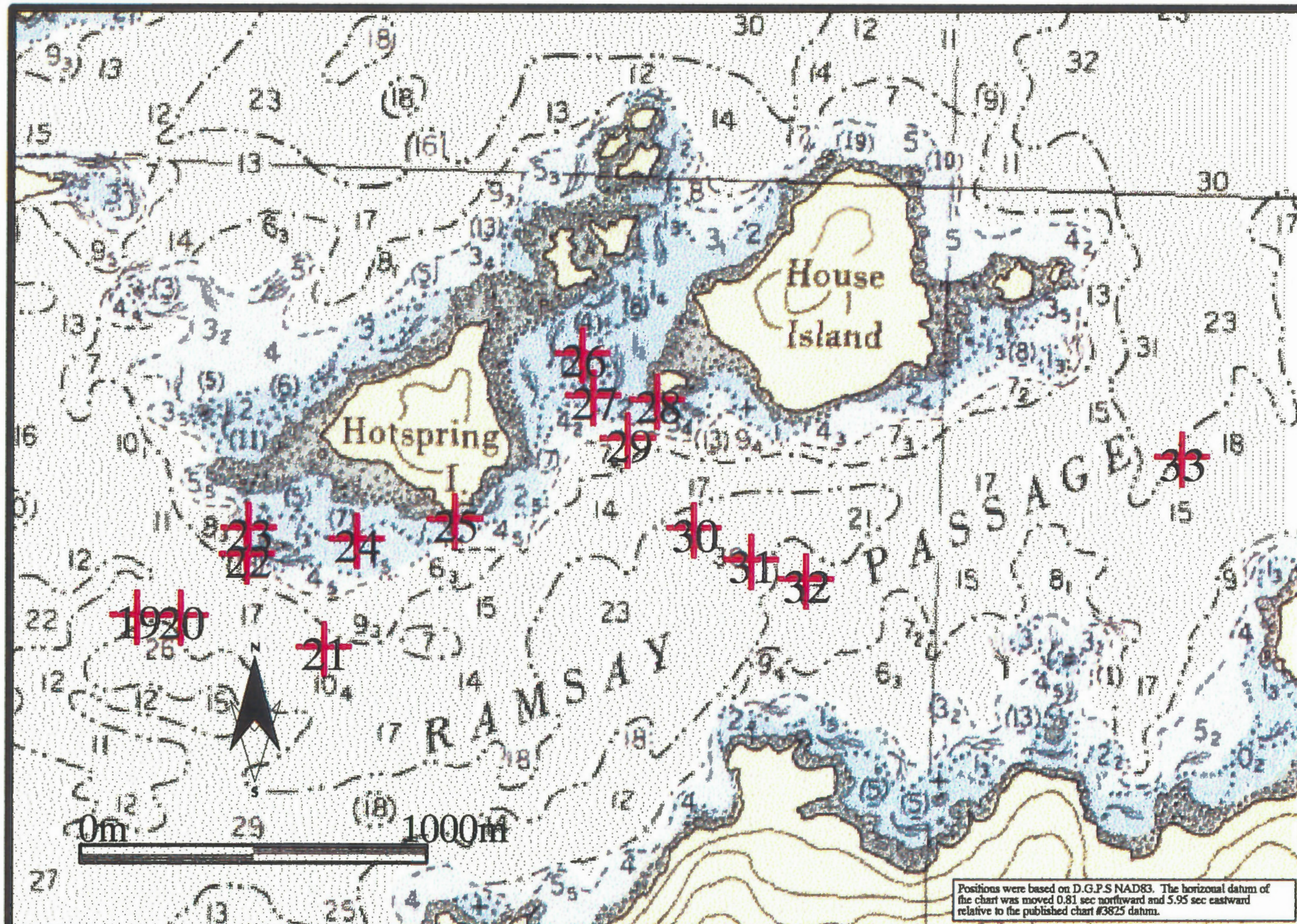
Canadian Heritage
Parks Canada

Natural Resources
Canada

Digitally compiled
by J. Harding

F 27

Sample Locations
Hotspring Island
-GWAI97



Canadian Heritage Parks Canada

Natural Resources Canada

Prepared By: Jennifer Harding

Fig 28

Fig 29

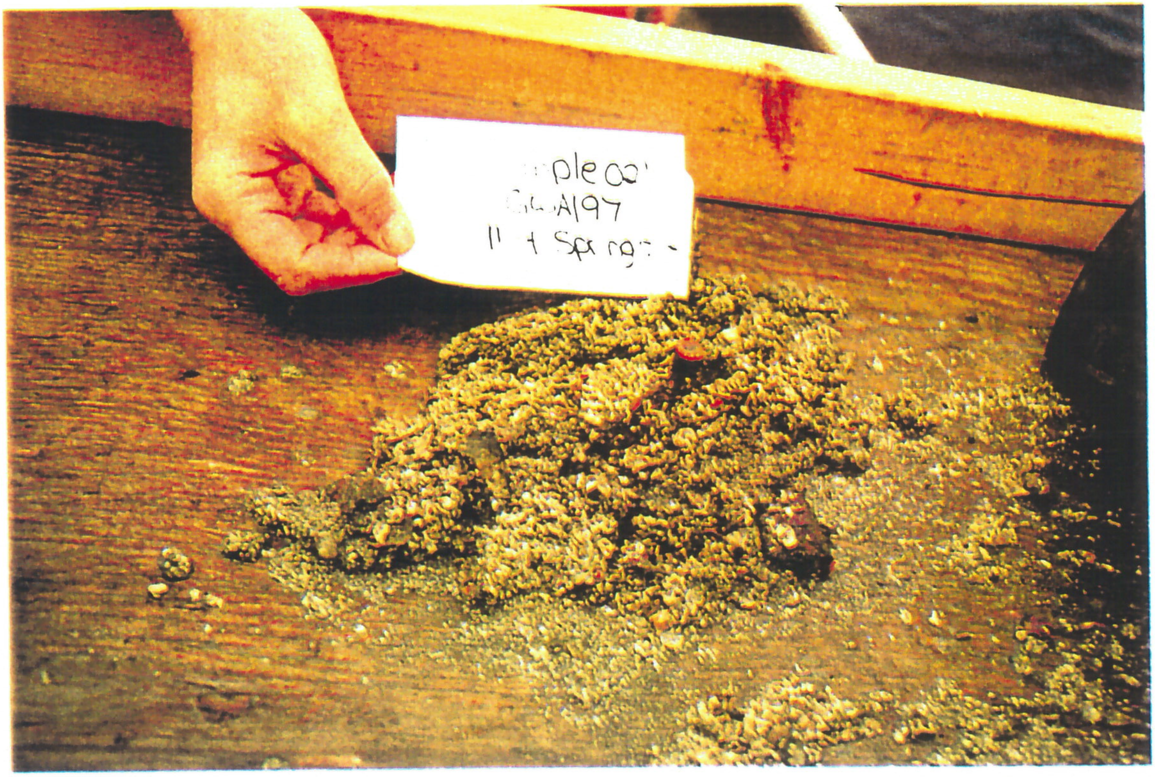


Fig 30

Fig 31

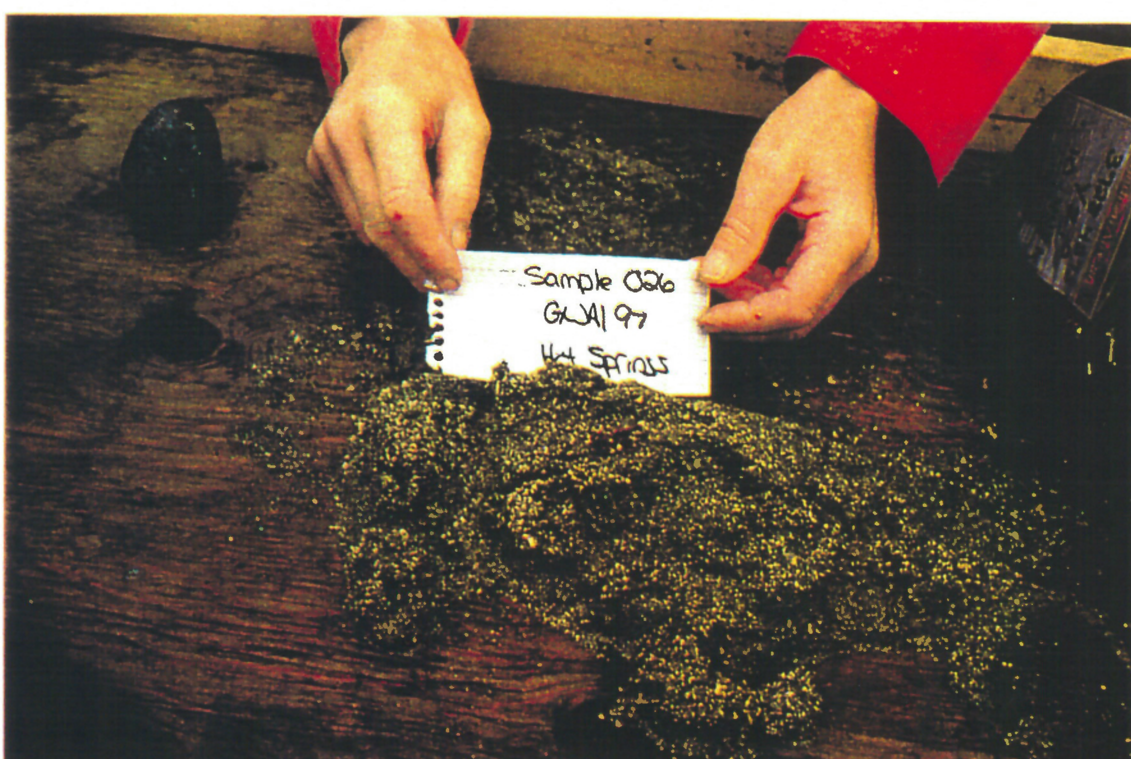


Fig 32

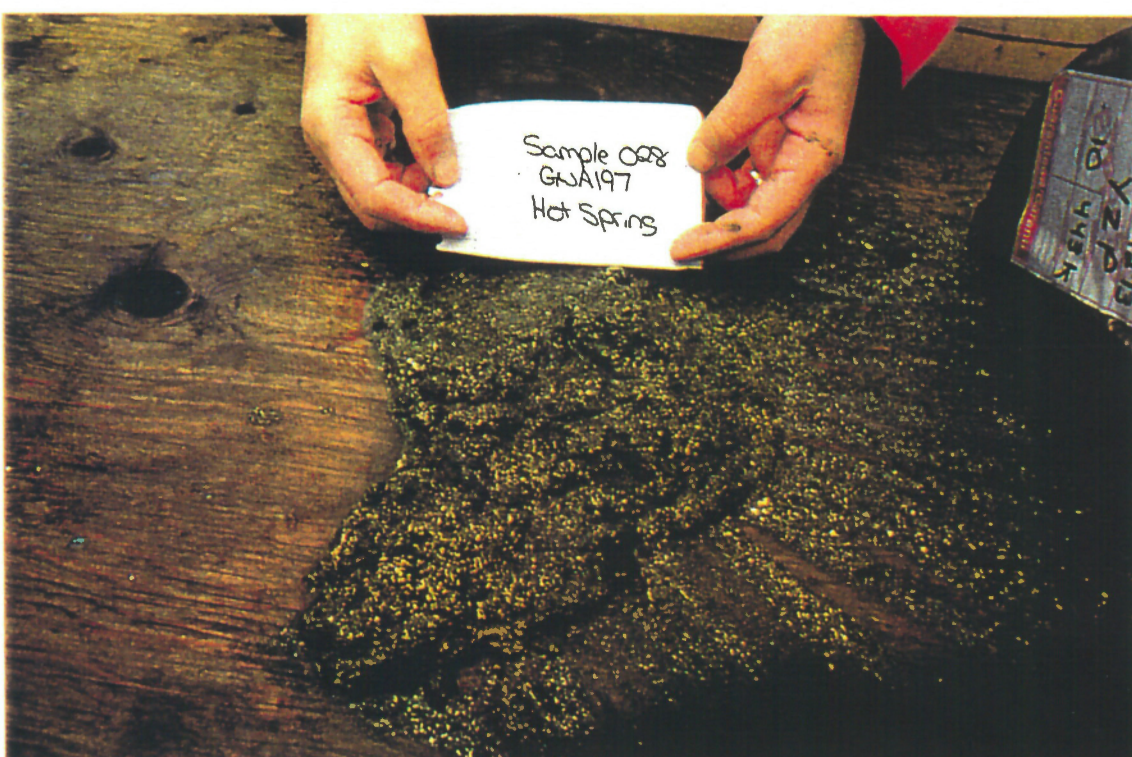


Fig 33


Grainsize 029
GWA197
Hot Springs


Sample 030
GWA197
Hot Springs

Fig 34


Sample 031
GWA197
Hot Springs


Sample
032
GWA197
Hot Springs

Fig 35

Fig 36

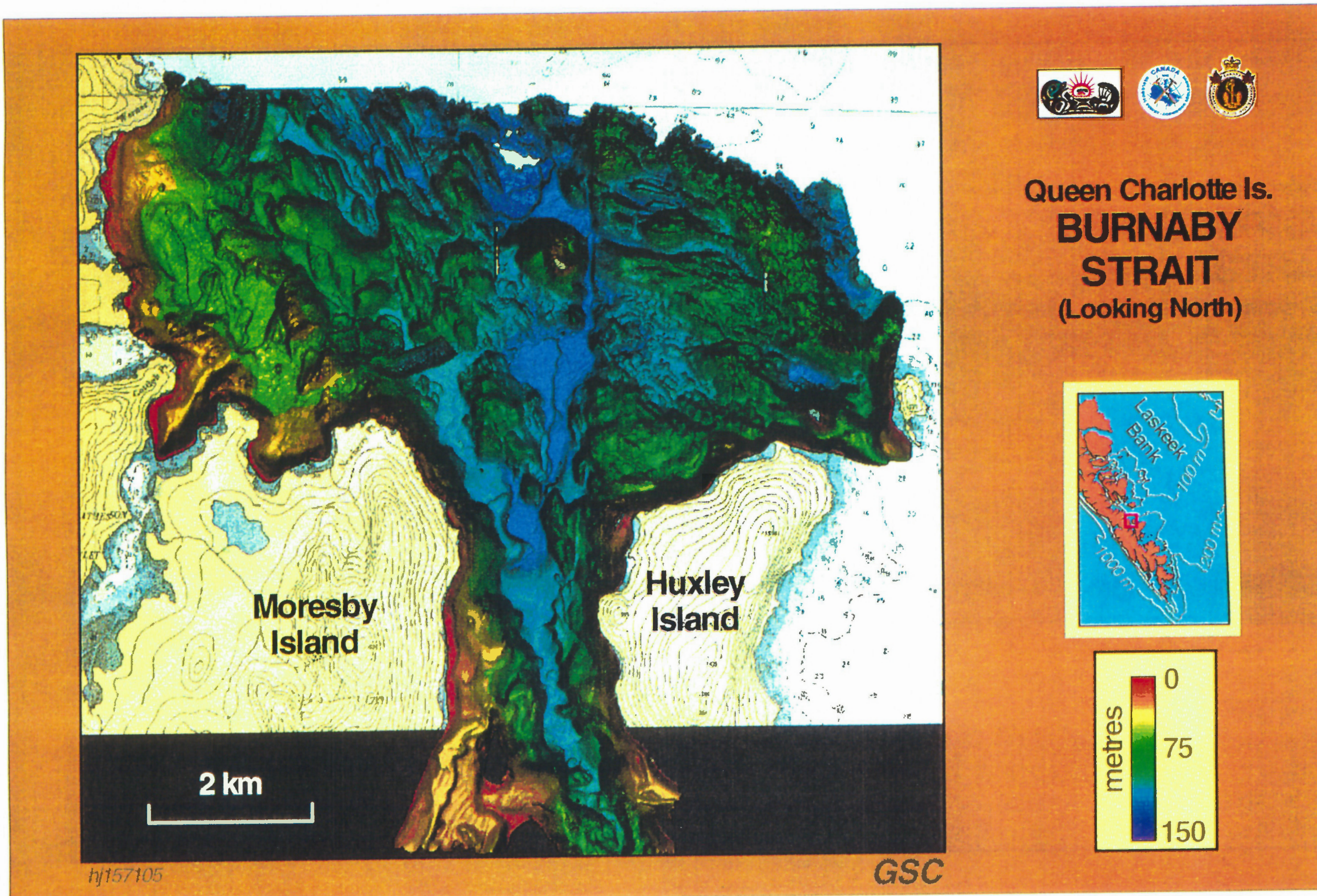

Queen Charlotte Is.
BURNABY
STRAIT
(Looking North)
Moresby
Island
Huxley
Island
2 km
Laskeek
Bank
100 m
200 m
1000 m
metres
0
75
150
hj157105
GSC

Fig 37

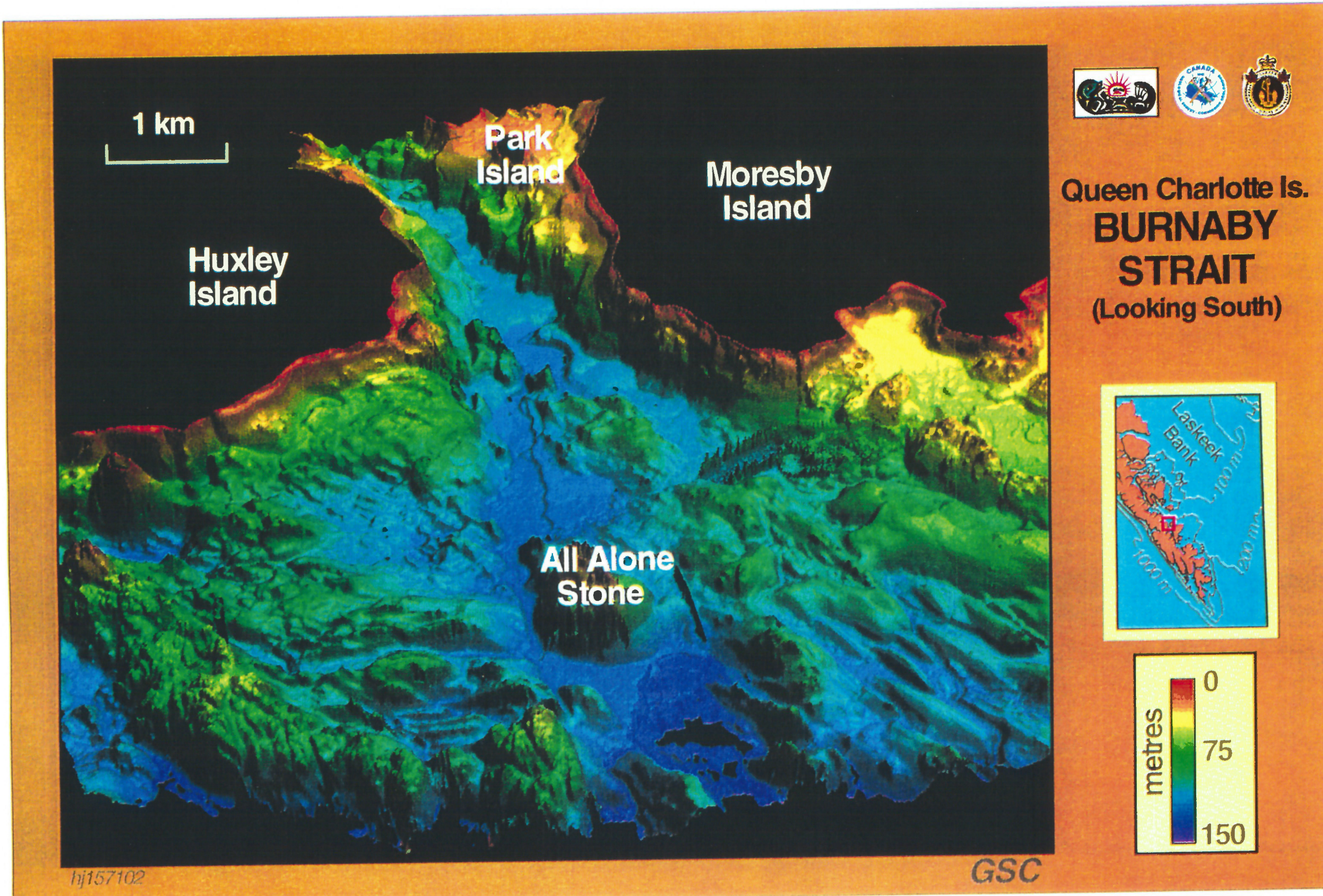
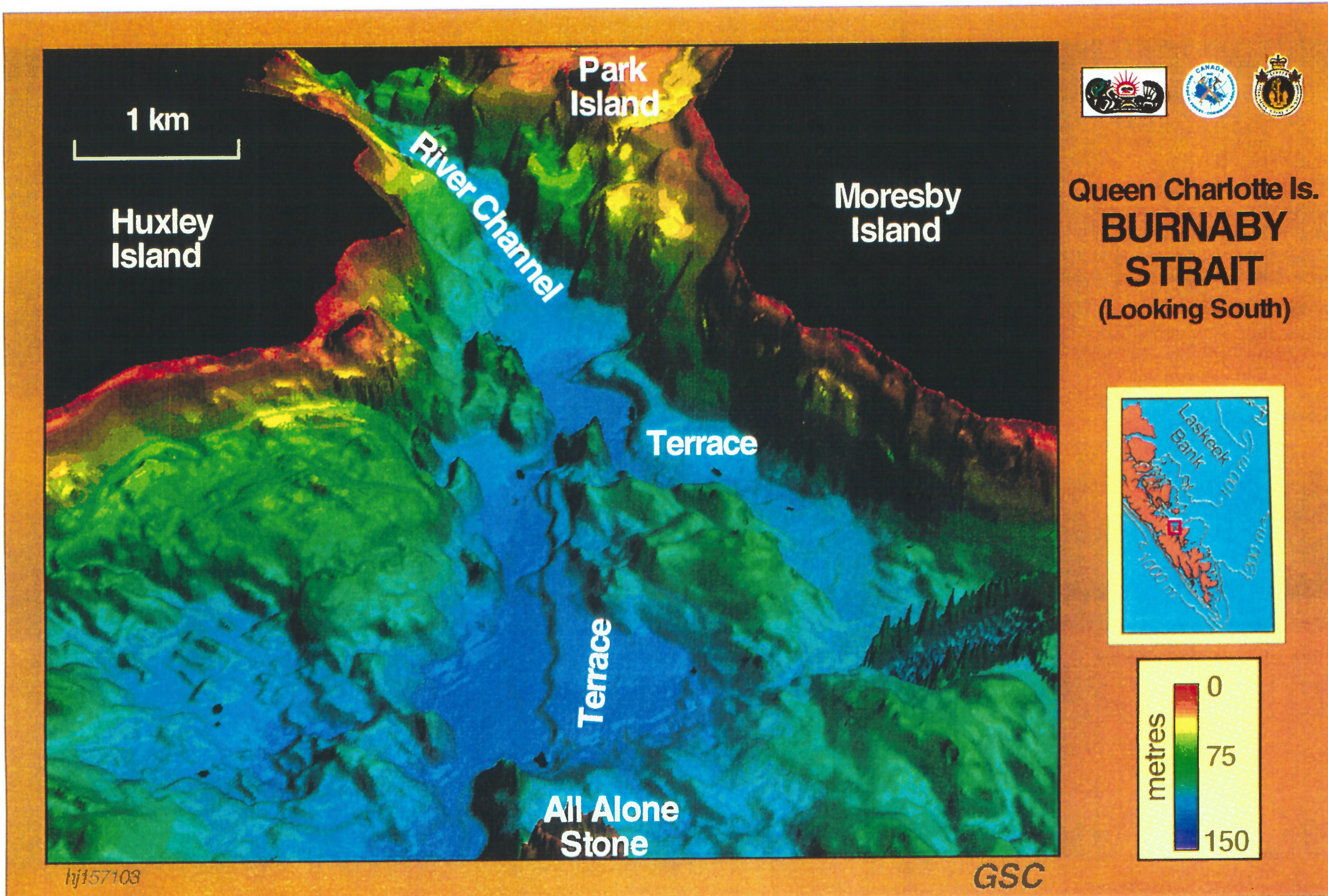
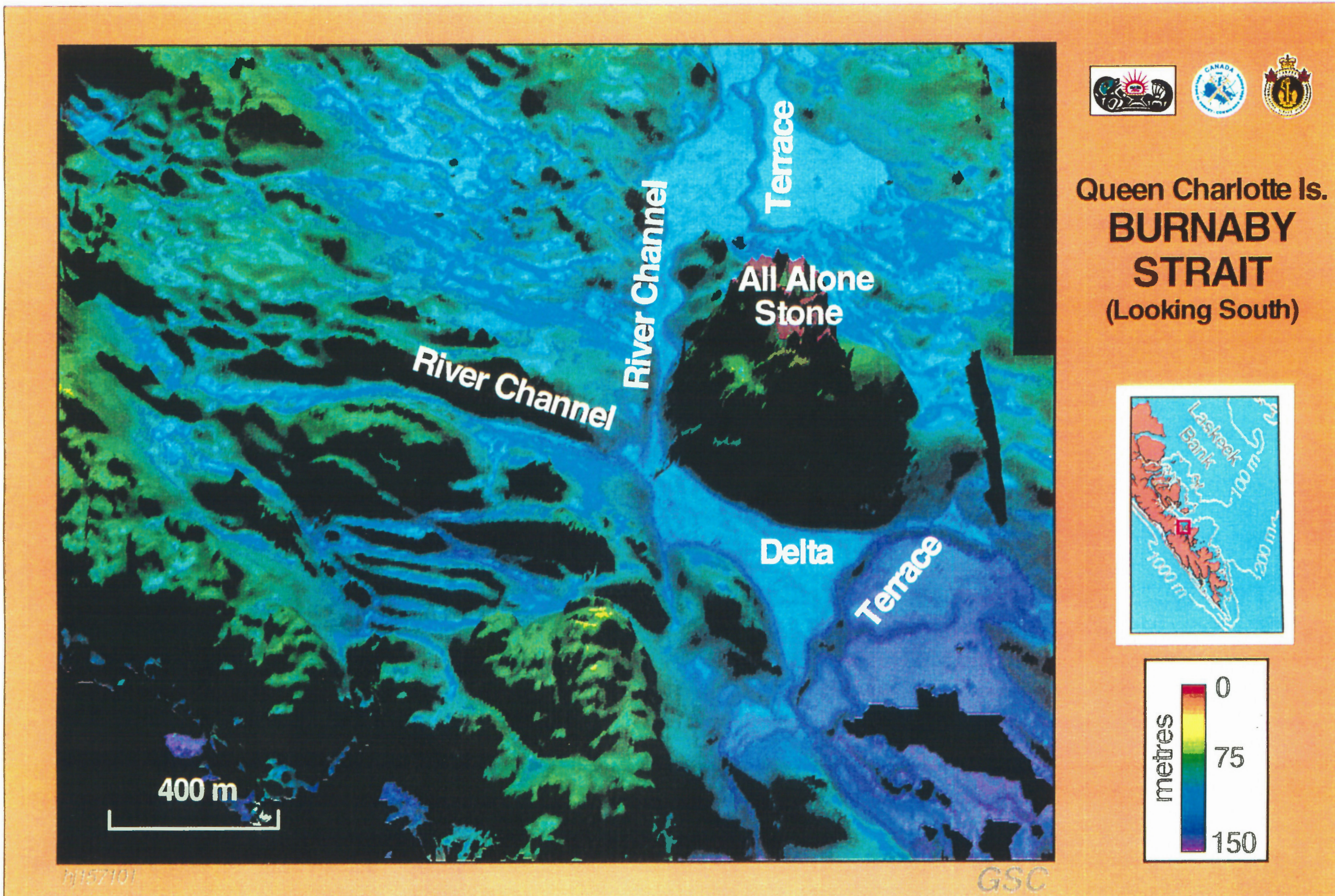

1 km
Park Island
Moresby Island
Huxley Island
All Alone Stone
Queen Charlotte Is.
BURNABY STRAIT
(Looking South)
Laskeek Bank
100 m
200 m
1000 m
metres
0
75
150
hj157102
GSC

Fig 38


1 km
Huxley Island
Park Island
River Channel
Moresby Island
Terrace
Terrace
All Alone Stone
hj157103
GSC
Queen Charlotte Is.
BURNABY STRAIT
(Looking South)
Laskeek Bank
100 m
200 m
1000 m
metres
0
75
150

39


Queen Charlotte Is.
BURNABY
STRAIT
(Looking South)
River Channel
River Channel
Terrace
All Alone
Stone
Delta
Terrace
400 m
Laskeek
Bank
100 m
200 m
1000 m
metres
0
75
150
GSC

40

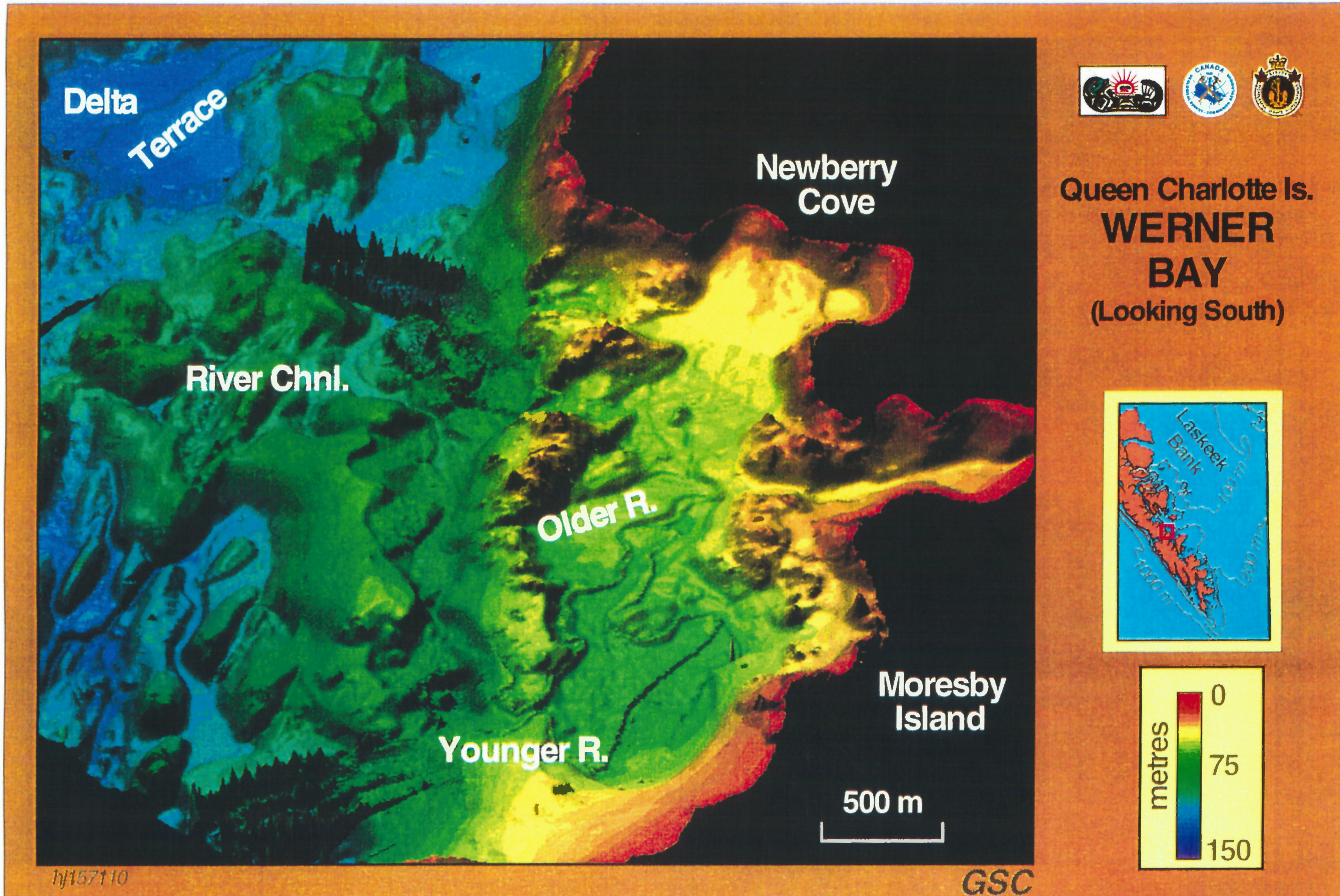
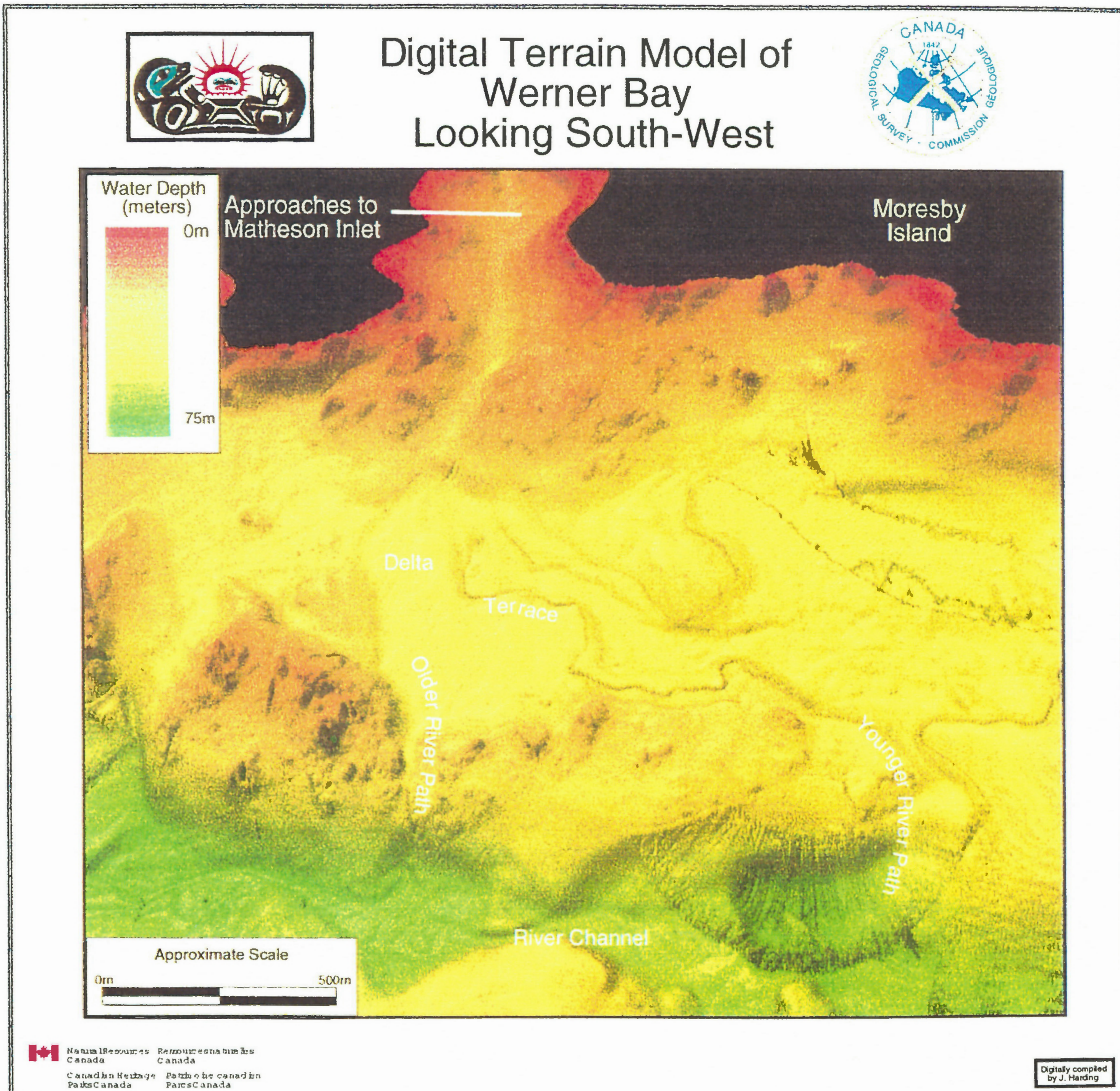
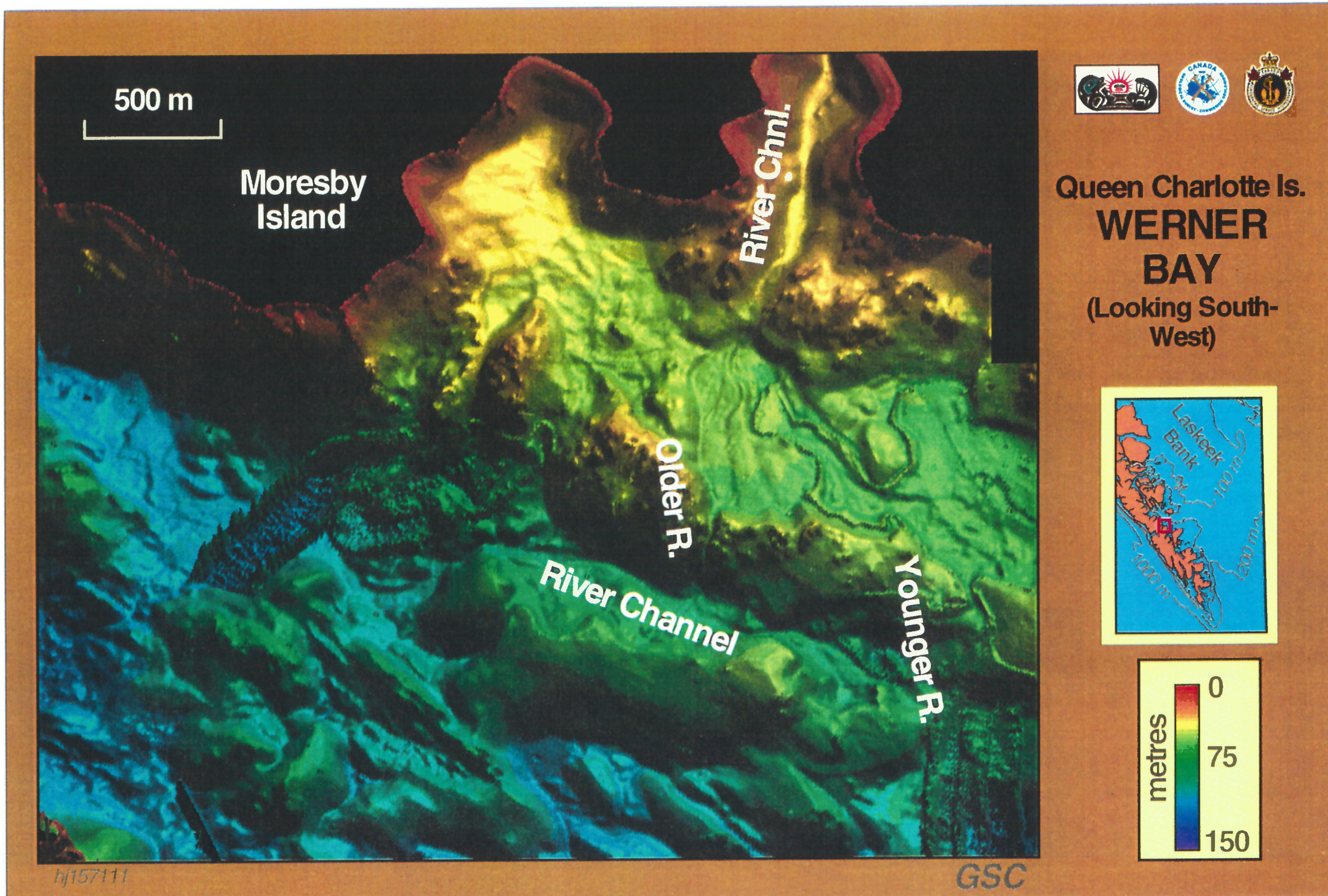

Delta
Terrace
River Chnl.
Newberry
Cove
Older R.
Younger R.
Moresby
Island
500 m
Queen Charlotte Is.
WERNER
BAY
(Looking South)
Laskeek
Bank
metres
0
75
150
hf157110
GSC

Fig 41

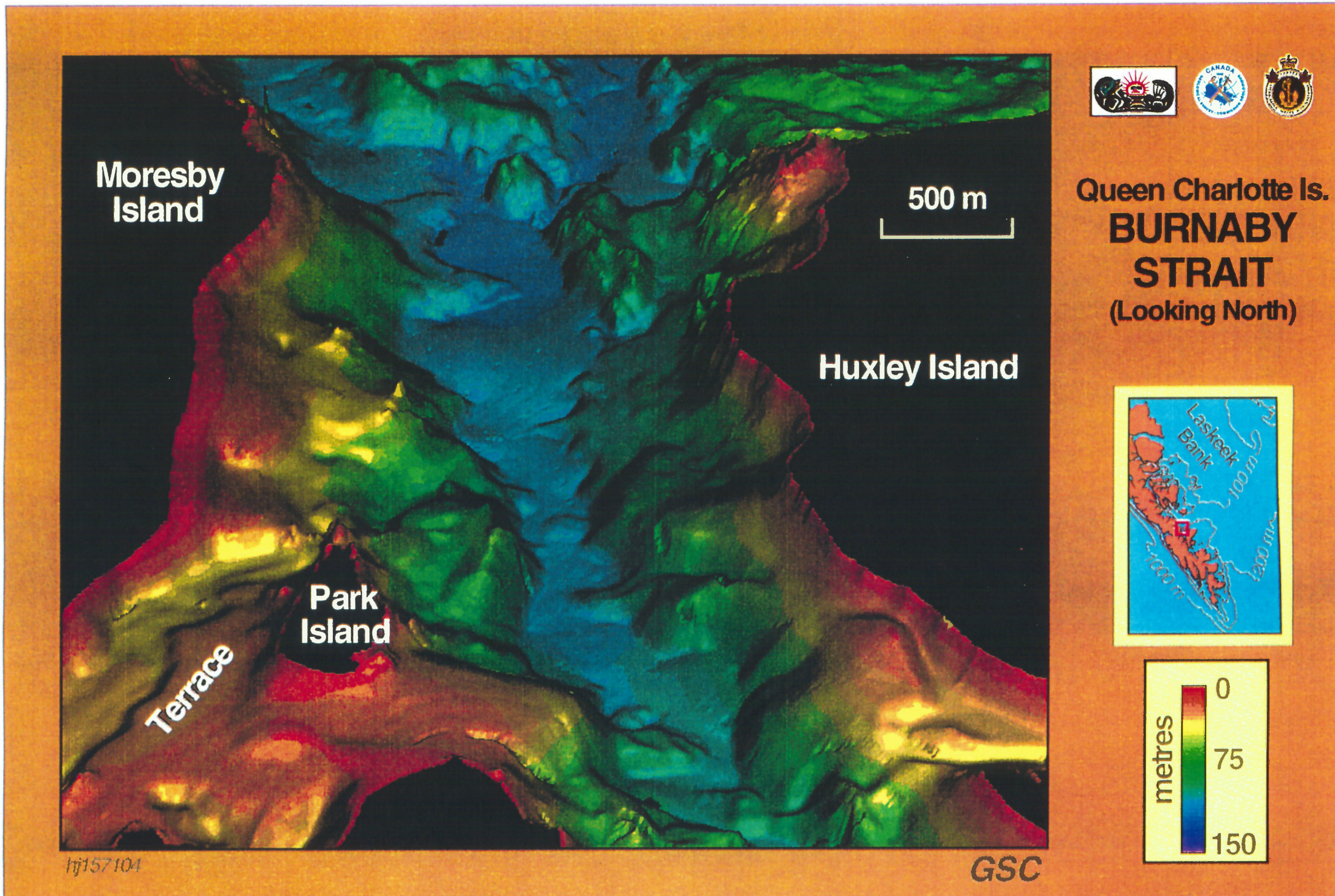


Digital Terrain Model of
Werner Bay
Looking South-West
CANADA
GEOLOGICAL SURVEY · COMMISSION GEOLOGIQUE
Water Depth
(meters)
0m
75m
Approaches to
Matheson Inlet
Moresby
Island
Delta
Terrace
Older River Path
Younger River Path
River Channel
Approximate Scale
0m
500m
Digitally compiled
by J. Harding

Fig 42


500 m
Moresby Island
River Chnl.
Older R.
River Channel
Younger R.
Queen Charlotte Is.
WERNER BAY
(Looking South-West)
Laskeek Bank
100 m
200 m
1000 m
metres
0
75
150
hj157111
GSC

'9 43


Queen Charlotte Is.
BURNABY
STRAIT
(Looking North)
Moresby Island
Huxley Island
Park Island
Terrace
500 m
Laskeek Bank
100 m
200 m
1000 m
metres
0
75
150
hj157104
GSC

44

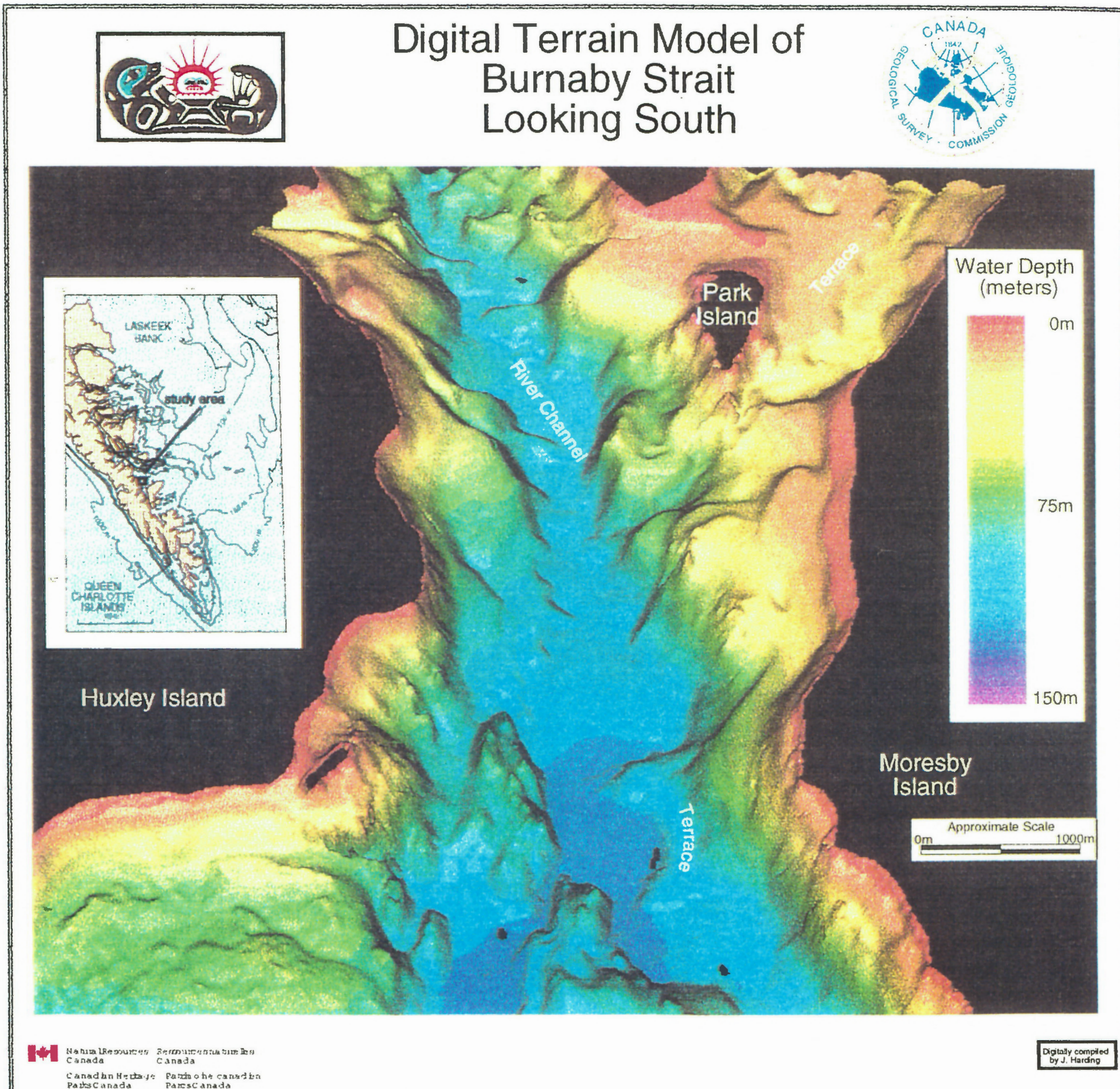
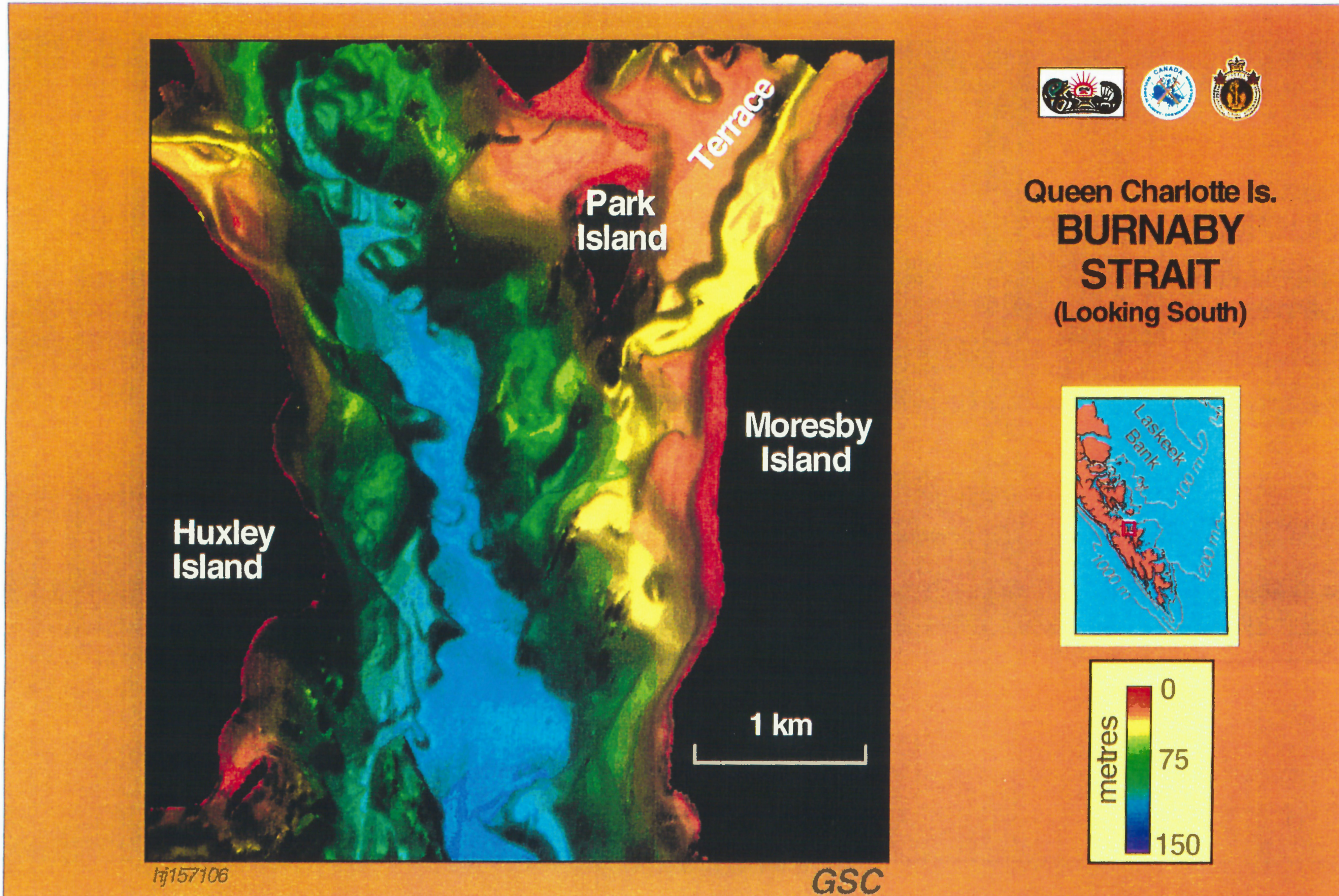
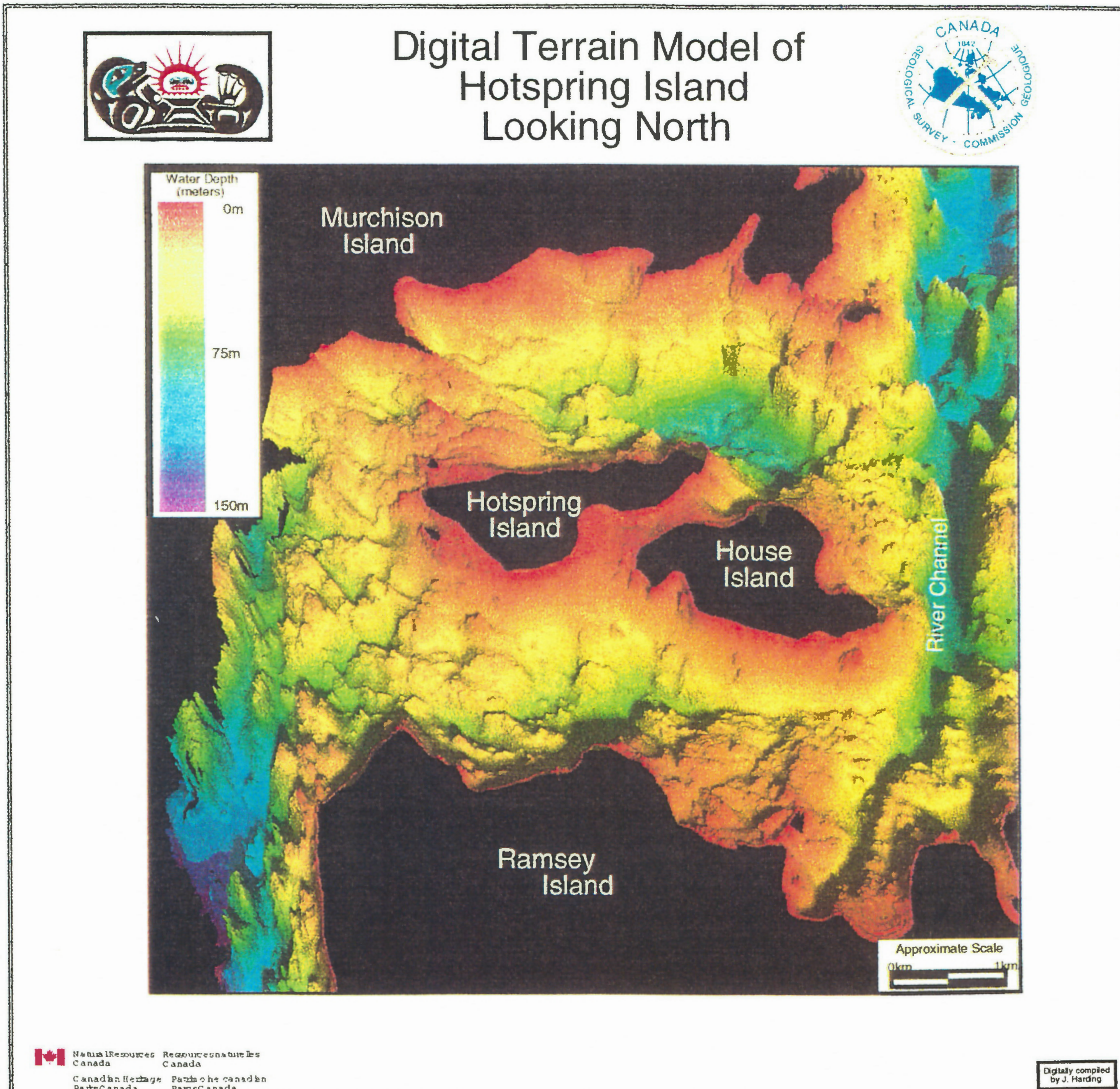

Digital Terrain Model of
Burnaby Strait
Looking South
CANADA
GEOLOGICAL SURVEY
COMMISSION GEOLOGIQUE
LASKEEK BANK
study area
QUEEN CHARLOTTE ISLANDS
Park Island
Terrace
River Channel
Water Depth (meters)
0m
75m
150m
Huxley Island
Moresby Island
Approximate Scale
0m
1000m
Terrace
Natural Resources Canada
Canadian Heritage Parks Canada
Digitally compiled by J. Harding

Fig 45


Queen Charlotte Is.
BURNABY
STRAIT
(Looking South)
Terrace
Park Island
Moresby Island
Huxley Island
1 km
Laskeek Bank
100 m
200 m
1000 m
metres
0
75
150
hj157106
GSC

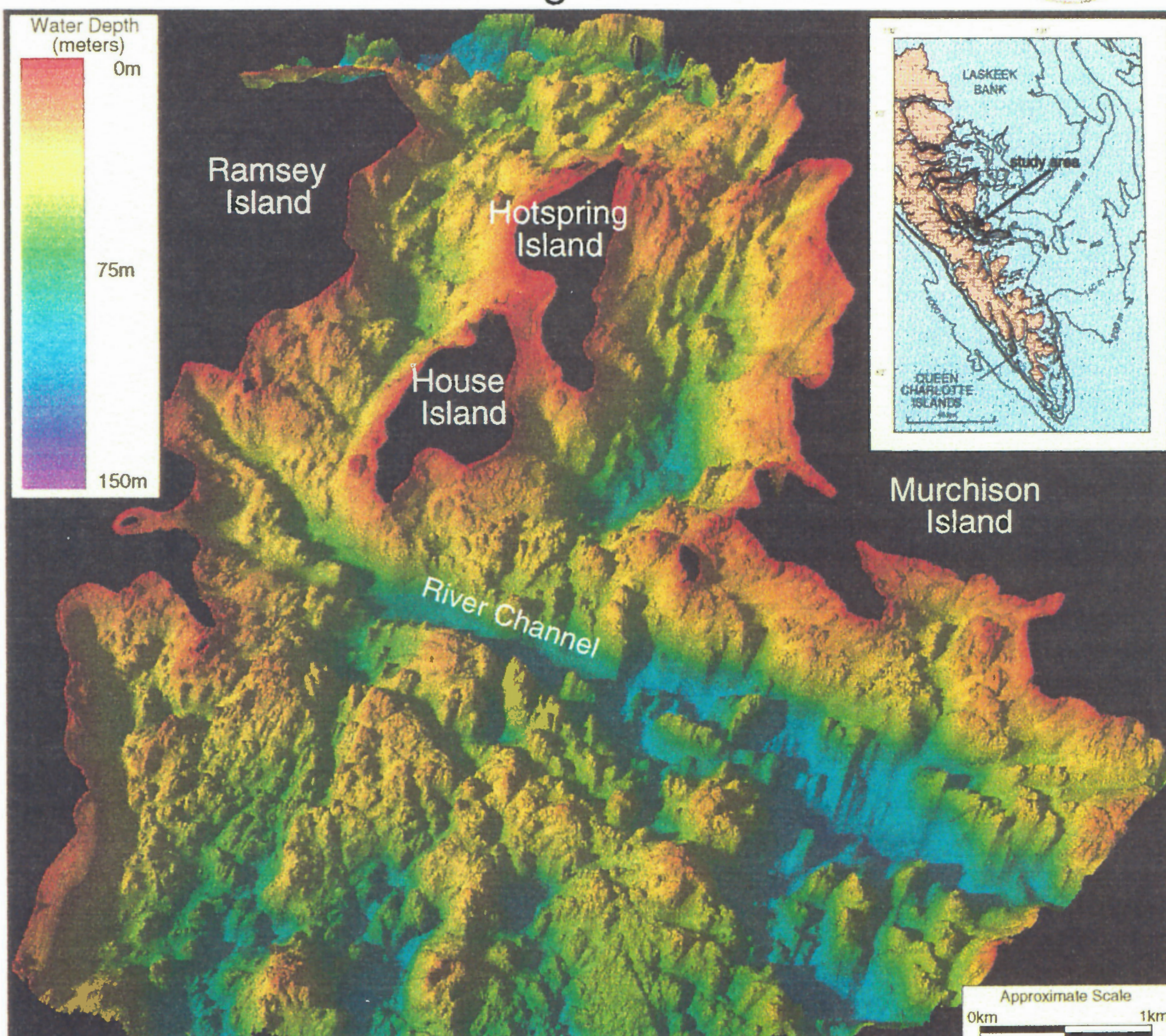
4/6



Digital Terrain Model of
Hotspring Island
Looking North
CANADA
GEOLOGICAL SURVEY - COMMISSION GEOLOGIQUE
1842
Water Depth
(meters)
0m
75m
150m
Murchison
Island
Hotspring
Island
House
Island
River Channel
Ramsey
Island
Approximate Scale
0km
1km
Natural Resources Canada
Ressources naturelles Canada
Canadian Heritage Parks Canada
Patrimoine canadien Parcs Canada
Digitally compiled
by J. Harding

Fig 47

Digital Terrain Model Around Hotspring Island Looking South-West

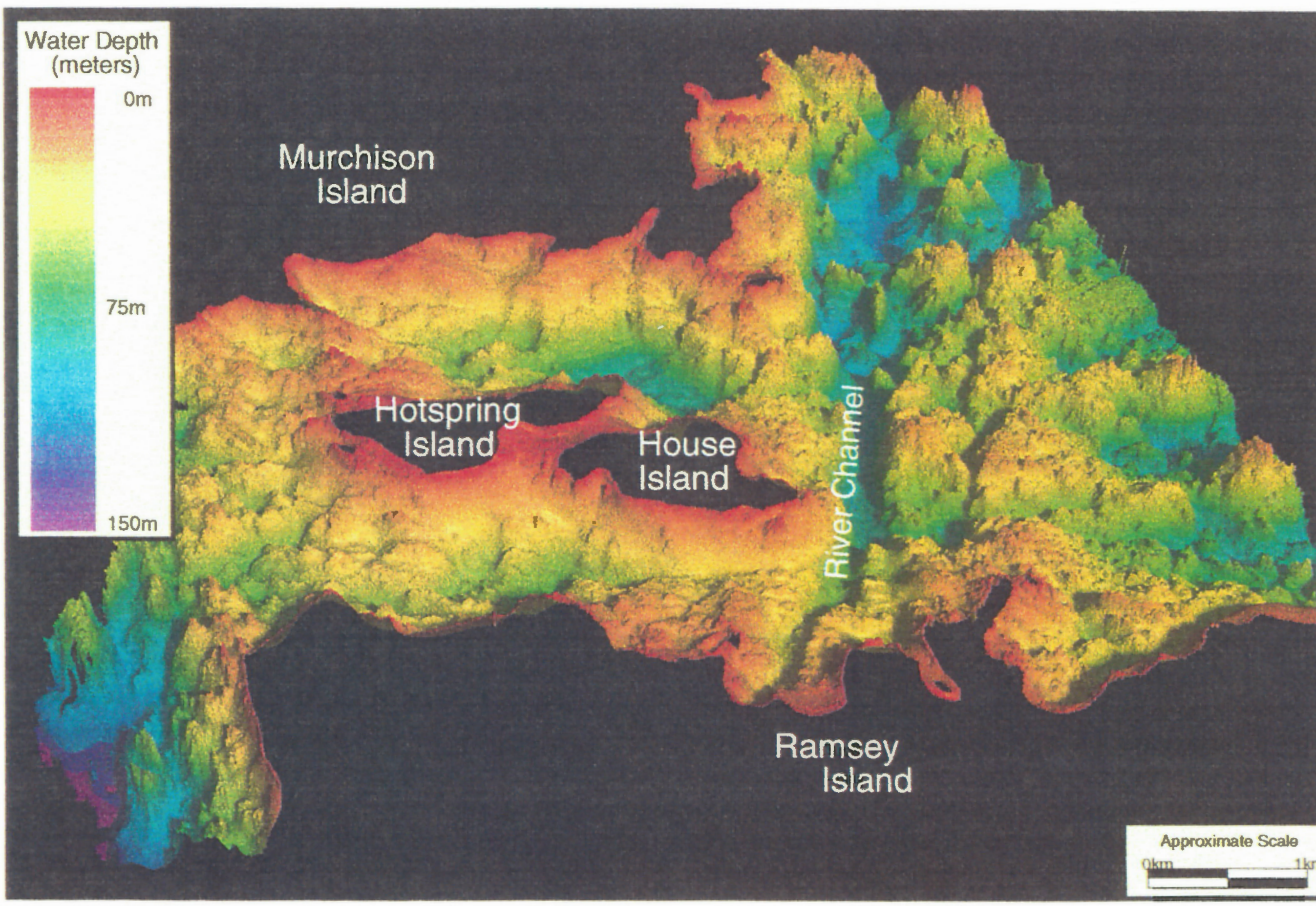


Natural Resources Canada / Ressources naturelles Canada
Canadian Heritage Parks Canada / Patrimoine canadien Parcs Canada

Digitally compiled by J. Harding

Fig 48

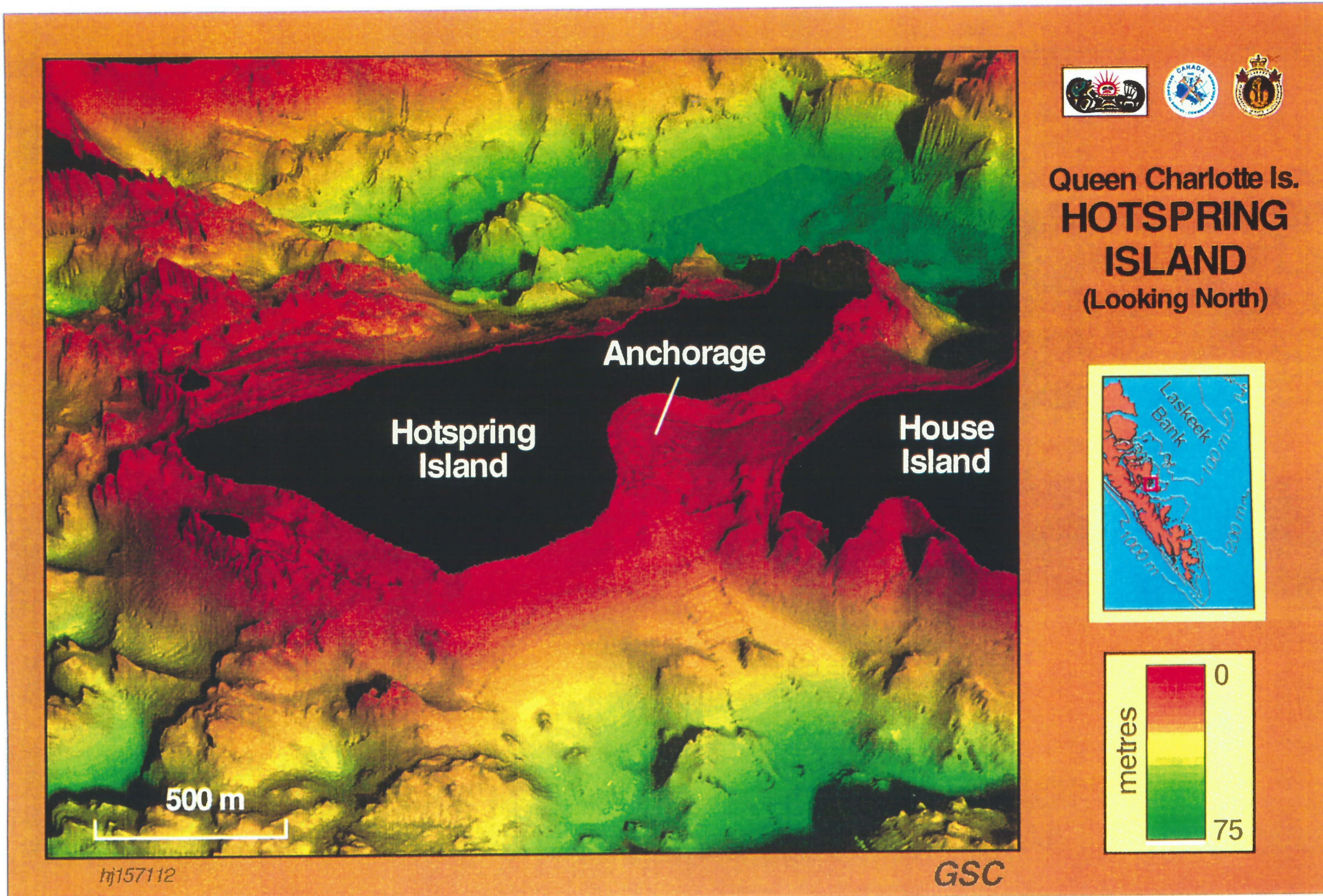
Digital Terrain Model of Hotspring Island Looking North



Natural Resources Canada   Ressources naturelles Canada
Canadian Heritage Parks Canada   Patrimoine canadien Parcs Canada

Digitally compiled by J. Harding

Fig 49


Queen Charlotte Is.
HOTSPRING
ISLAND
(Looking North)
Hotspring Island
Anchorage
House Island
500 m
Laskeek Bank
100 m
200 m
1000 m
metres
0
75
hj157112
GSC

50

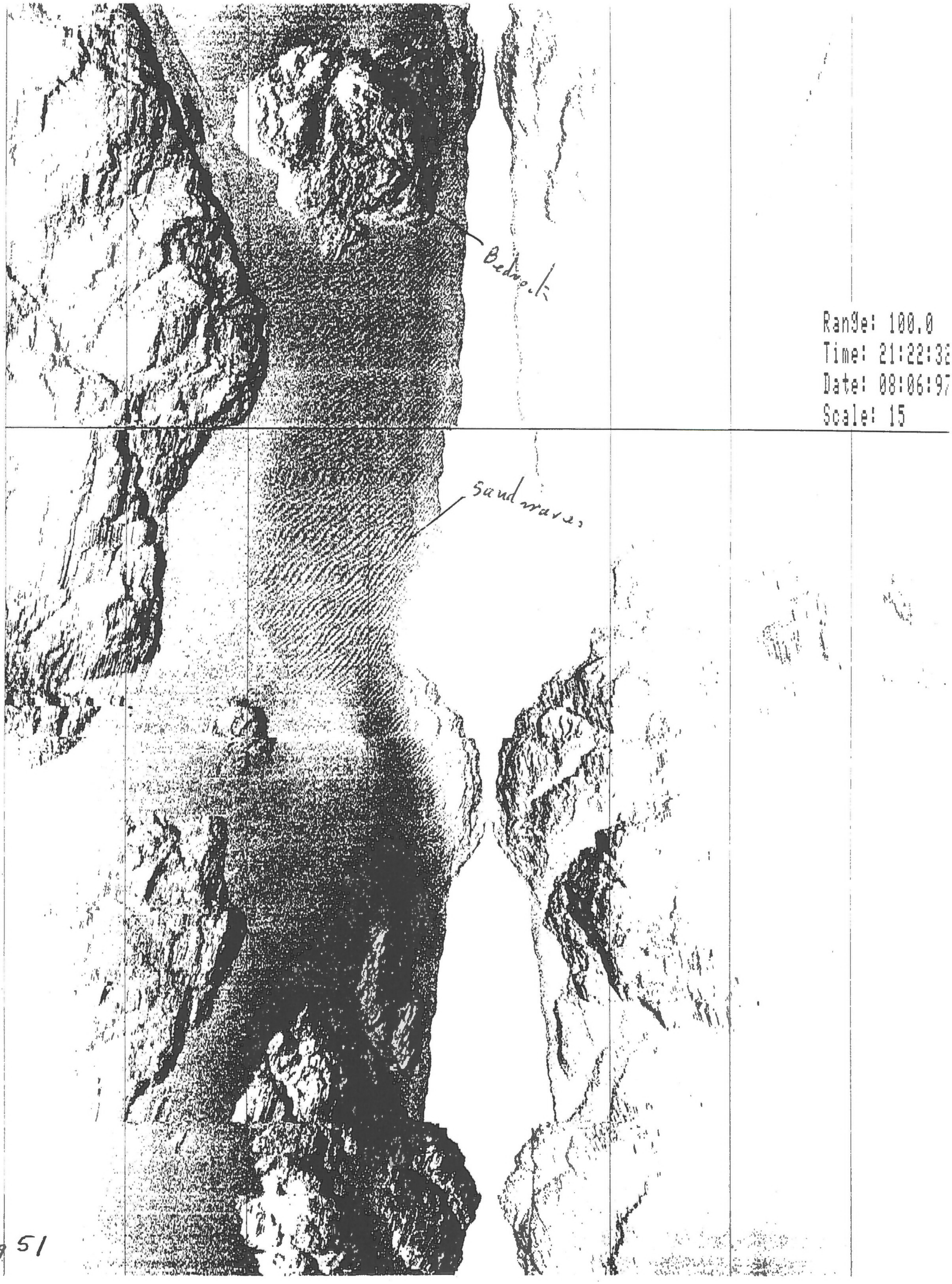

Bedrock
Sand waves
Range: 100.0
Time: 21:22:3
Date: 08:06:97
Scale: 15

Fig 51

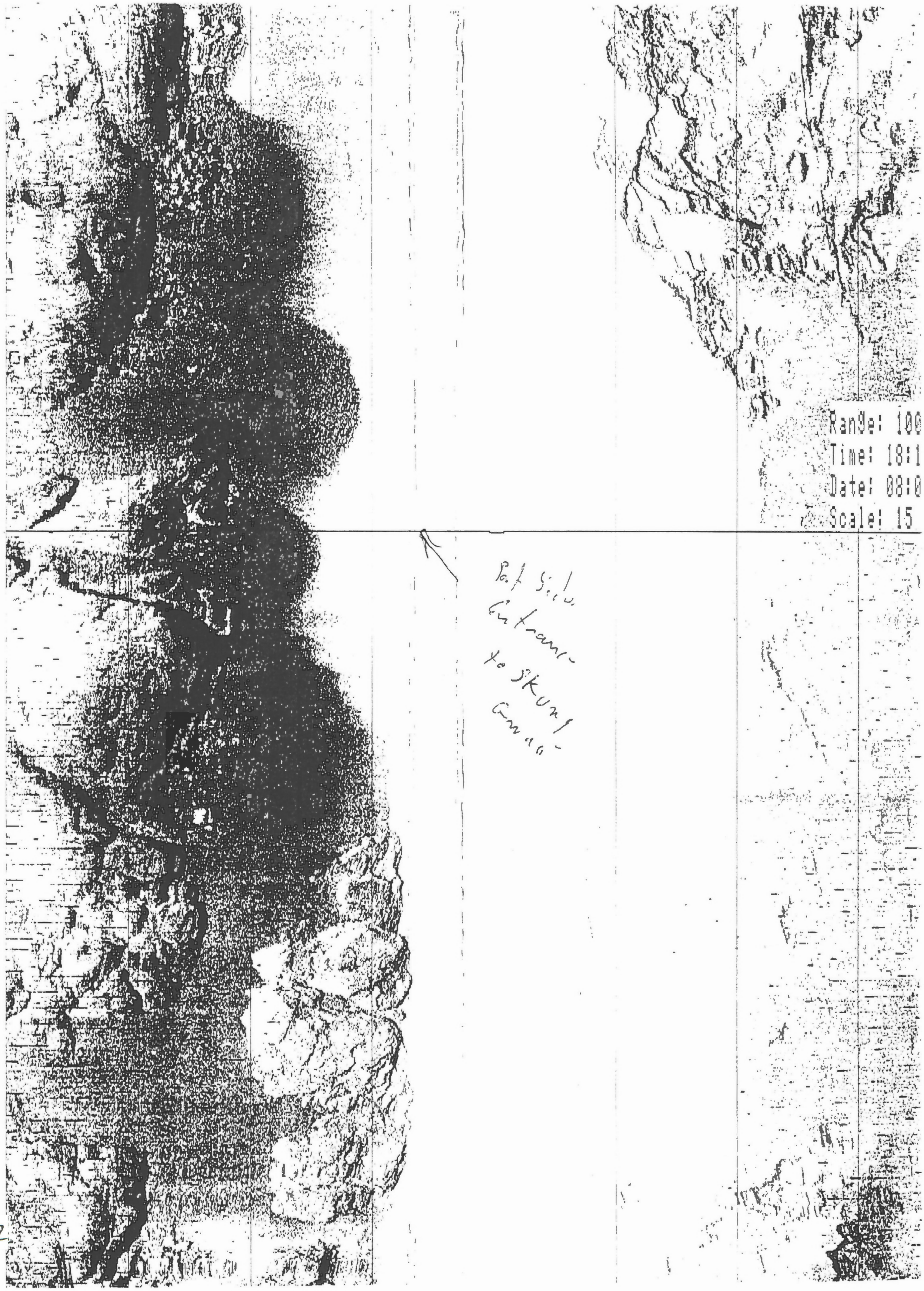

Range: 100
Time: 18:1
Date: 08:0
Scale: 15
Port Side
Entrance
to Skunk
Cave

Fig 52

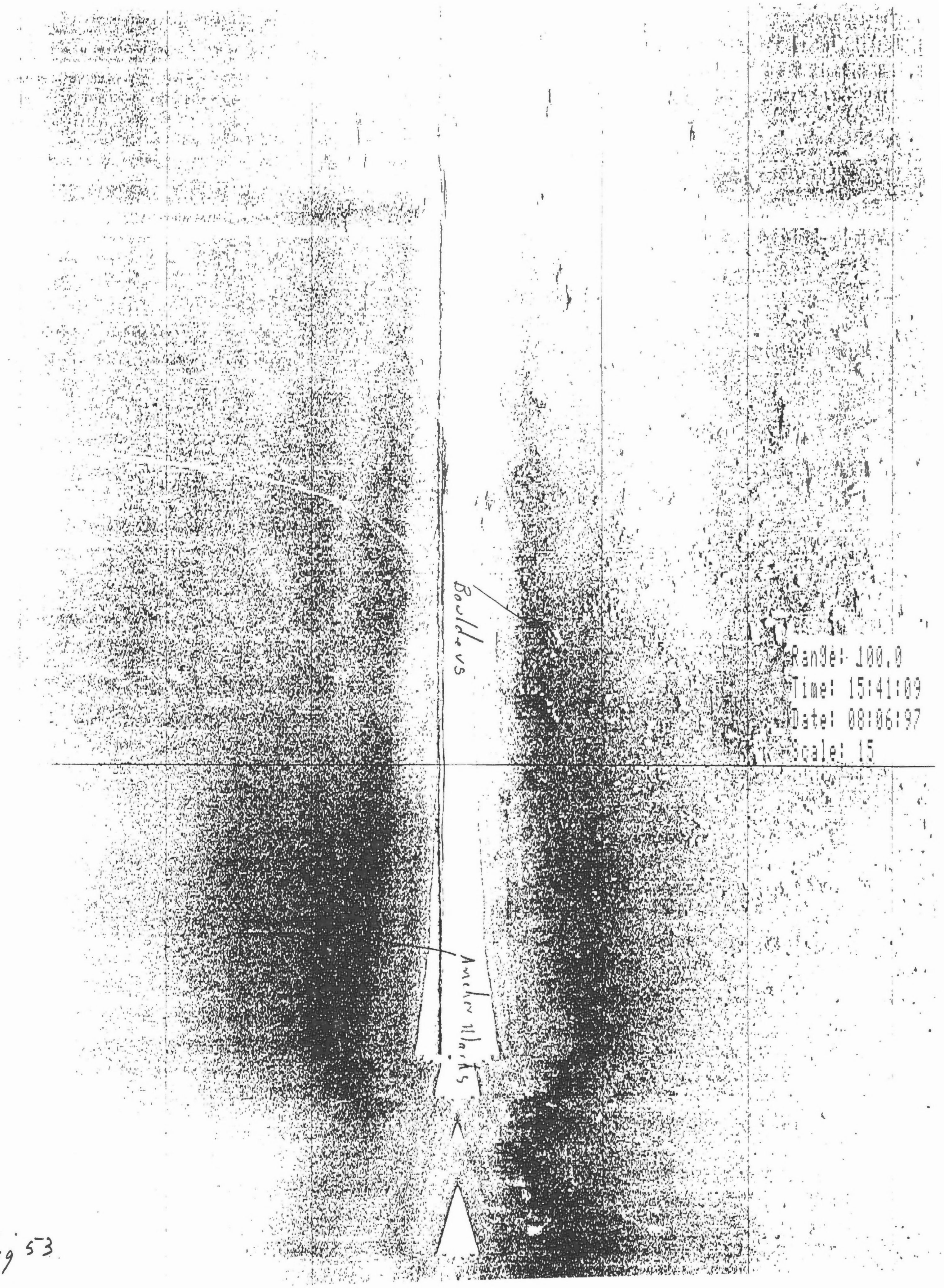

Boulders
Anchor Marks
Range: 100.0
Time: 15:41:09
Date: 08:06:97
Scale: 15

Fig 53

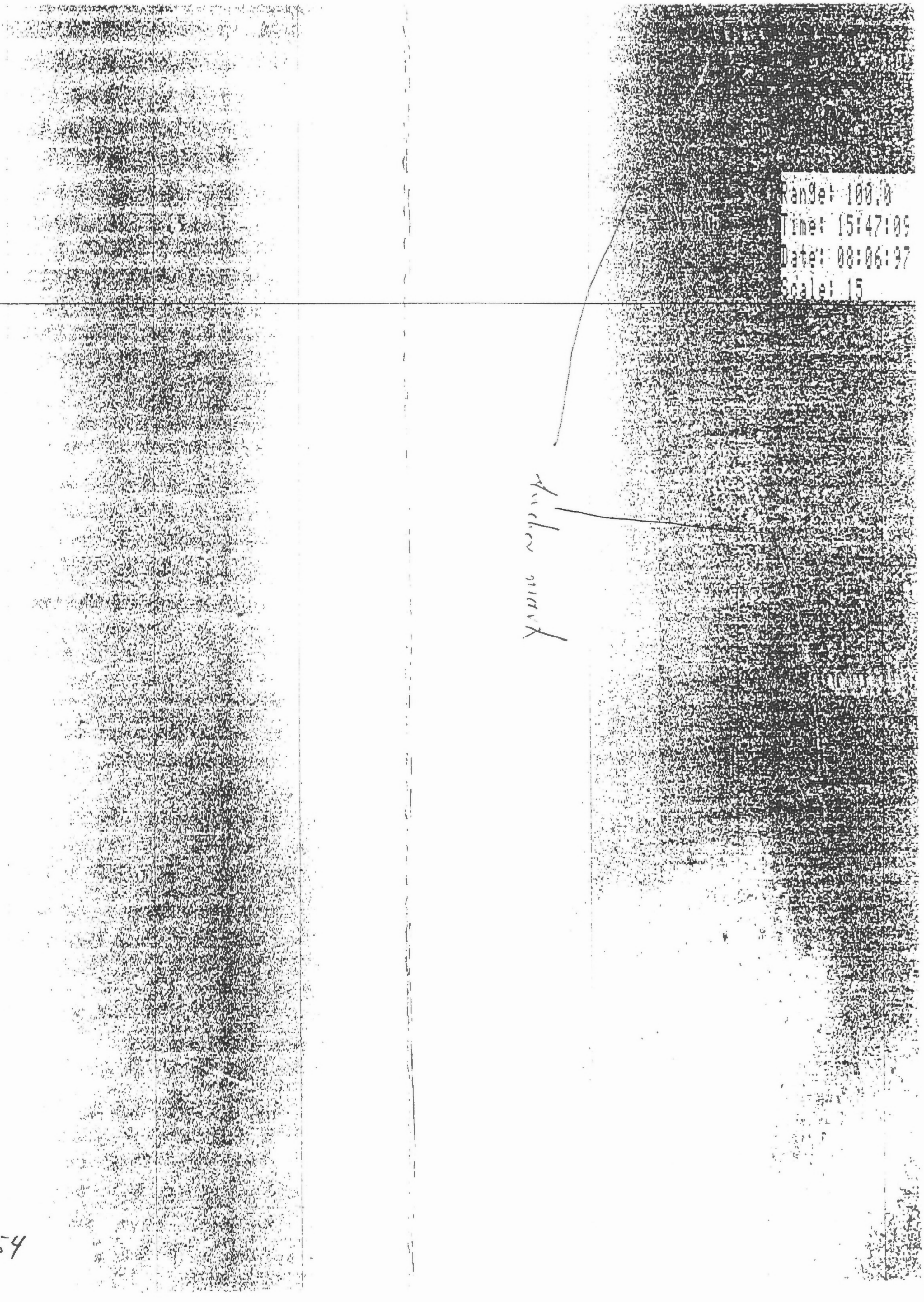
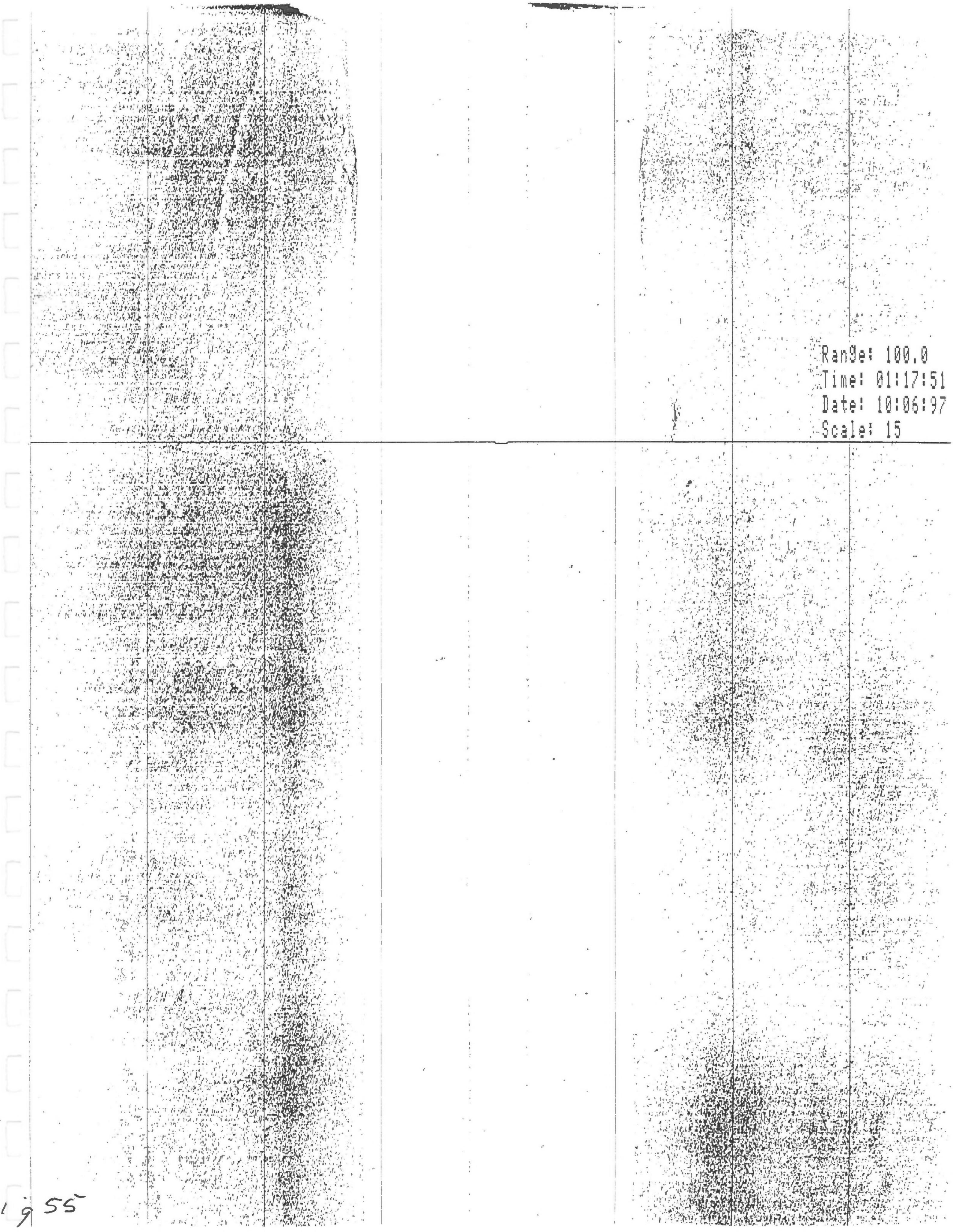


Fig 54



1 9 55

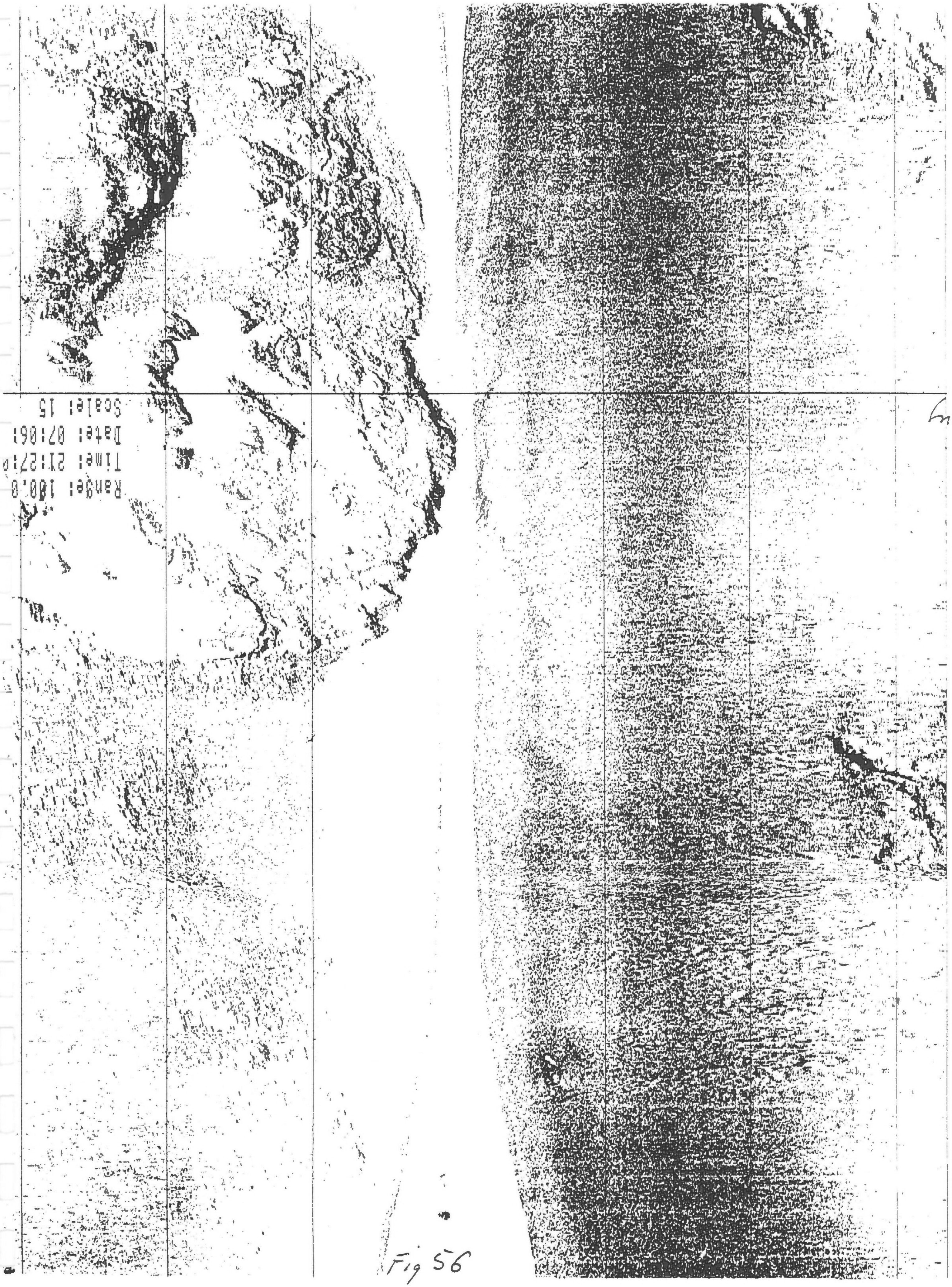


Fig 56

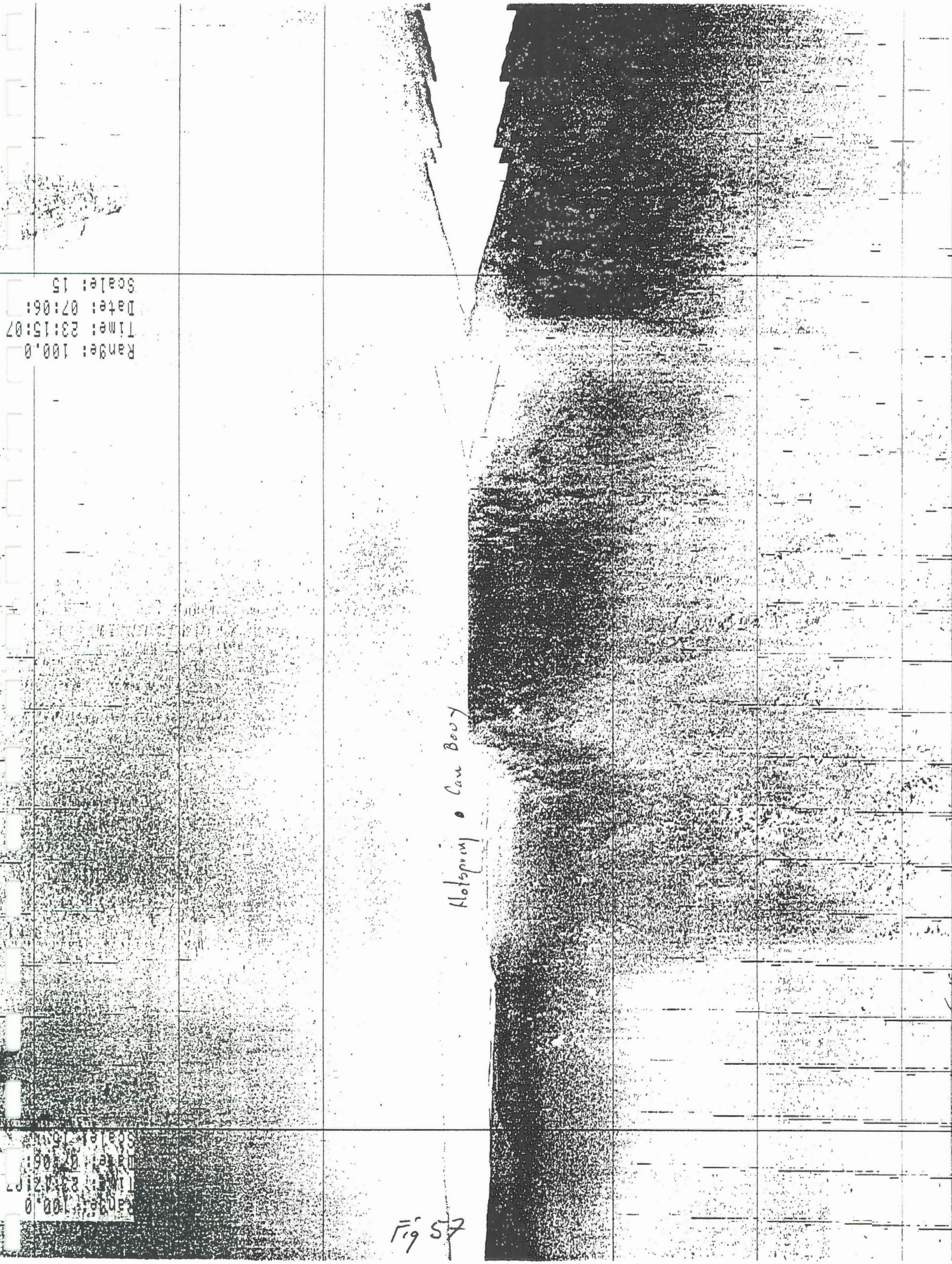

Range: 100.0
Time: 23:15:07
Date: 07:06:
Scale: 15
Hotspring • Can Bouy

Fig 57

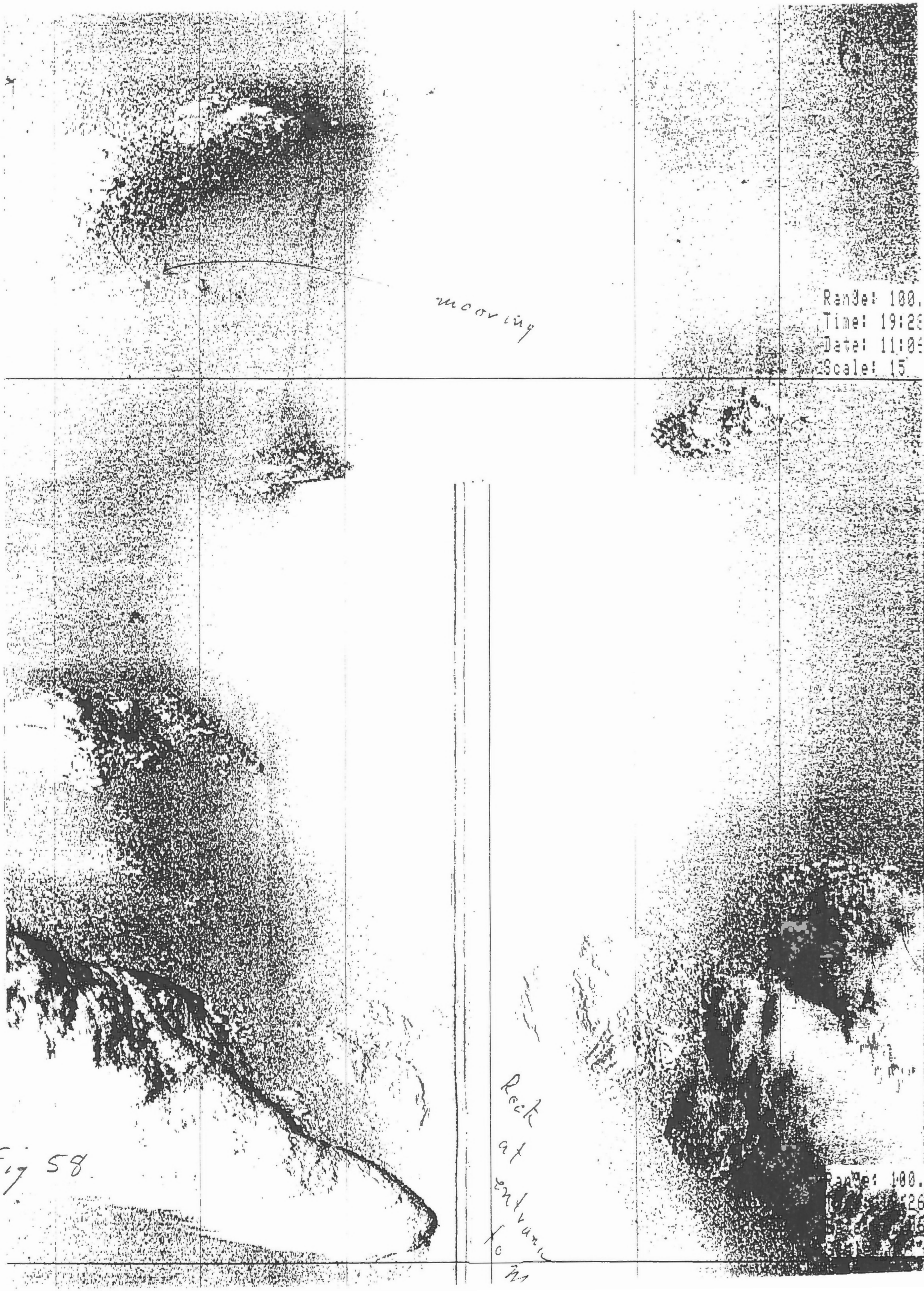

mooring
Range: 100.
Time: 19:28
Date: 11:0
Scale: 15
Rock at entrance to
Range: 100.0

Fig 58

Fig 59

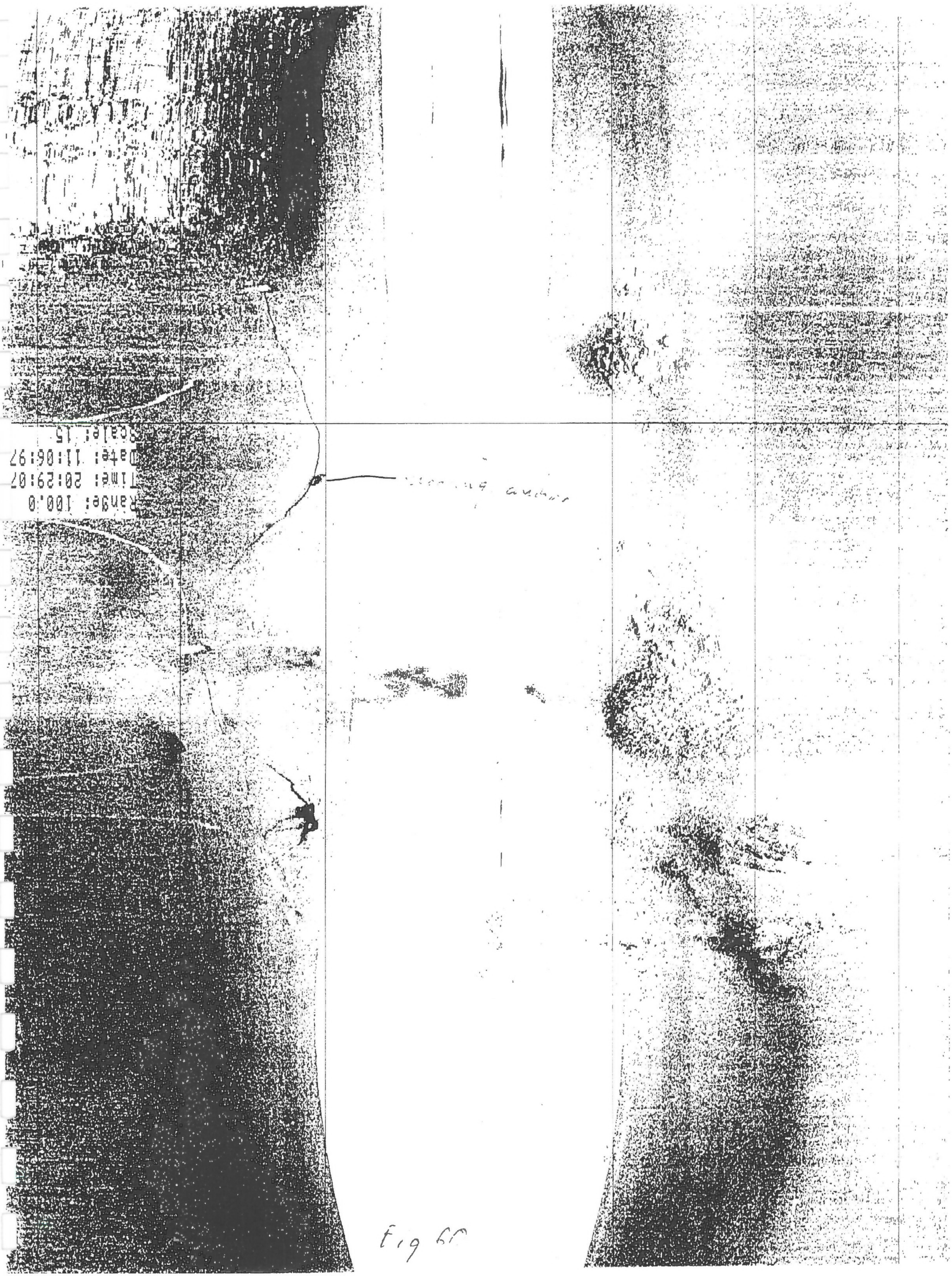


fig 6c