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Antarctic Biological Science

Victoria Land Latitudinal Gradient Project: Benthic Marine Habitat Characterization

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A. PROJECT SUMMARY

The CSUMB Seafloor Mapping Lab (SFML) received funding from the National Science Foundation to participate in the multi-national and multidisciplinary Victoria Land Latitudinal Gradient Project (VLGP). This international collaboration involved polar scientists from Italy, New Zealand, Germany, Spain, and the U.S. The overall goal of the VLGP has been to take a latitudinal gradient approach to ecosystem studies in Victoria Land, Antarctica, with the following general goals:

- Determine climatic and environmental variability across a latitudinal gradient in Antarctica and interpret their connections to terrestrial and marine ecosystem structure and function.
- Integrate datasets from diverse disciplines (biology, glaciology, oceanography, geochemistry, geology, and atmospheric sciences) in interpreting environmental variability and ecosystem connections across the Victoria Land Coast as a global barometer of climate change.
- Foster research, logistic and data management collaborations among scientists from different disciplines and national programs.

Specific objectives for the January-February 2004 VLGP field season were to:

- Identify the environmental gradients linked to latitude and to relate community transitions along the Victoria Land Coast to climatic, geomorphologic and oceanographic features.
- Identify biochemical, physiological and other adaptive responses of representative organisms.
- Quantify biodiversity patterns and test the hypothesis of "progressive emergence" of marine assemblages with latitude.
- Use biotic changes associated with steep environmental gradients to predict potential effects of climate change.

The role of the SFML in the VLGP has been to use high-resolution acoustic remote sensing (multibeam and sidescan sonar), ROV video mapping, and spatial data modeling tools in the identification and characterization of benthic habitats, disturbance regimes, and species/habitat associations along the gradient from 0-200 m water depth. Accurate mapping and classification of habitat types within each study area are essential for valid community comparisons along the gradient. The mapping techniques used were the same as those employed by the SFML with Italian colleagues, Dr. Riccardo Cattaneo-Vietti and Dr. Mariachiara Chiantore, at Terra Nova Bay, Antarctica during the January 2002 field season. The VLGP 2004 study sites included locations in the areas of Cape Adare, Cape Hallett, Coulman Island, and Cape Russell. The SFML conducted mapping activities at all sites with the exception of Coulman Island, where heavy ice cover extended from shore out to the 400 m depth contour.

Products generated from the mapping activities for immediate use on the cruise for biotic sampling site selection included multibeam sonar bathymetry images in shaded relief and colored by depth zone. These maps reveal spatial patterns of intense ice scouring that varied with location, depth, and exposure. New spatial analysis tools were also developed during the cruise for auto-classification of ice scour disturbance intensity. ROV activities and virtually all of the video biotic mapping planned for the shallower sites (< 200m depth) were not carried out due to the many inadequacies of the new *R/V Skua* assigned to support that work.

B. FIELD WORK: FEBRUARY 1 - MARCH 6, 2004

SYSTEM INSTALLATION ABOARD R/V ITALICA

Rikk Kvitek, Pat Iampietro, Kate Thomas and Erica Summers, of the CSUMB Seafloor Mapping Lab, arrived at TNB from McMurdo on January 29, 2004 in advance of the arrival of the *R/V Italica* scheduled for January 31. February 1 - 3 was spent installing the following acoustic mapping systems aboard the *R/V Ice Bjorn*:

- Reson 8101 multibeam sonar with sidescan option on a fixed hull mount bolted to a horizontal "I" beam below the waterline of the vessel's bow.
- Isis Sonar data acquisition system
- Hypack Max for survey planning and navigation
- Trimble UHF radio and modem for receiving DGPS corrections from a mobile basestation to be placed at each survey location.
- TSS POS/MV for vessel motion correction and positioning
- SVPlus for sound velocity profiling

The mounting bracket for the ROV acoustic tracking system (ORE Track Point II) was also installed aboard the R/V Skua, the other small vessel provided for video mapping work. The multibeam sonar head and hydrophone installations required the very capable help with metal fabrication from the TNB and R/V *Italica* staff and crew.

Sea trials of the multibeam system were begun on February 3rd, but resulted in severe damage to one of the TSS POS/MV GPS antennas, and the 8101 multibeam cable, when the *Ice Bjorn* hit the *Italica* during launching operations. Repairs were made to the cable and antenna, and the system was operational again.

CAPE HALLETT

The *Italica* arrived at Cape Hallett on February 4th, but strong winds and poor visibility prevented the helicopter flights needed to set up the DGPS basestation and solar panels until February 9th. The base station was finally placed at 72.32152709 S latitude and 170.2610262 E longitude, and multibeam surveying was conducted in difficult ice conditions from aboard the *Ice Bjorn* from February 9-12th. On February 10th, a POS/MV GPS antenna was again damaged, this time beyond repair, when a piece of ice fell on to it from the crane while the *Ice Bjorn* was being lifted onto the *Italica*. A second set of Trimble GPS antennas brought by the SFML, but not designed for this purpose, were successfully substituted for the POS/MV antennas making the survey system operational again. The majority of the two VLGP Cape Hallett transect areas were surveyed with multibeam from 60 m to 200 m water depth along the outer coast east of the cape, and from 30 m to 200 m inside the inlet to the west of the cape (Figure 1).

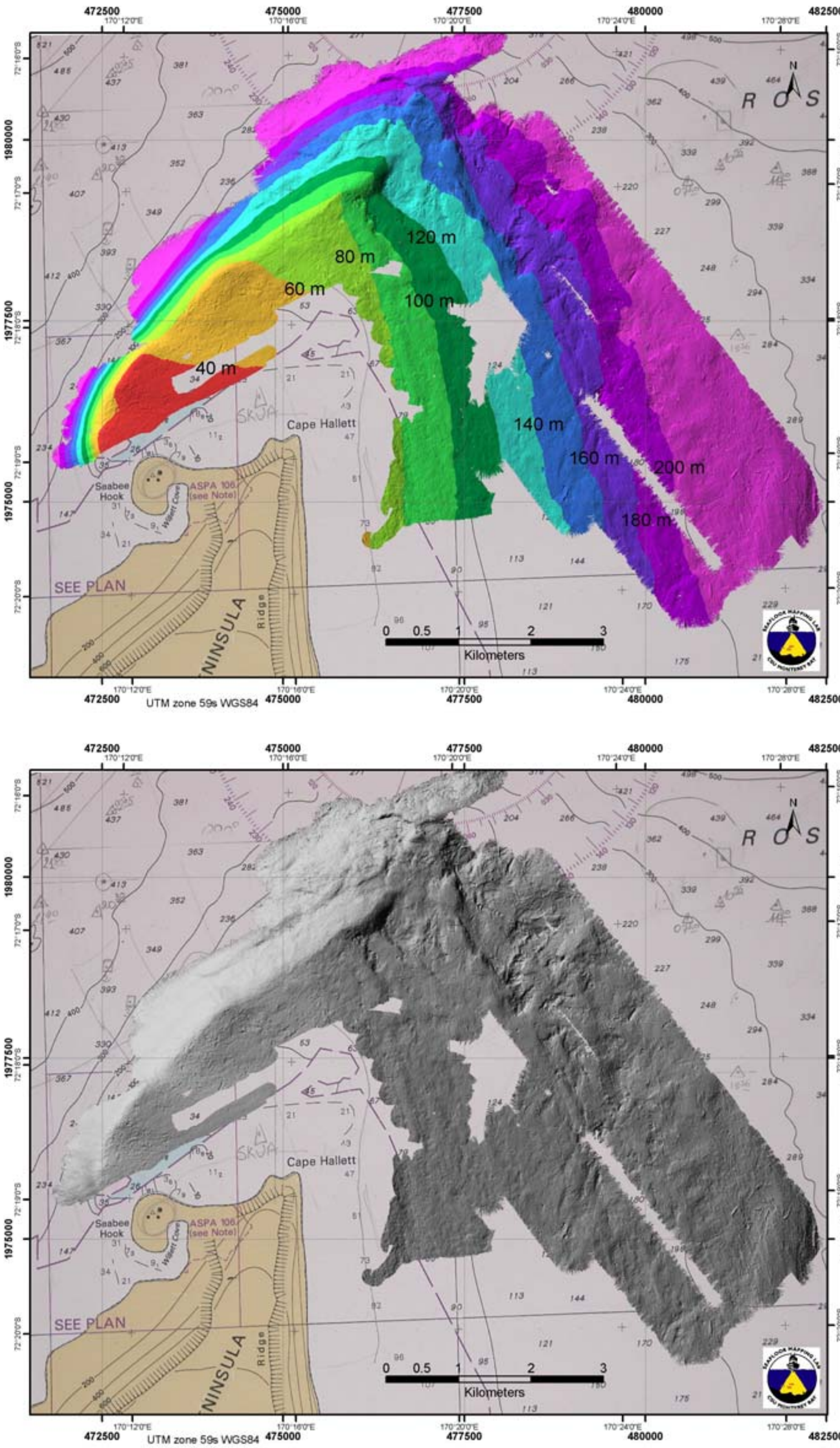


Figure 1. Cape Hallett: Imagery from multibeam sonar bathymetry colored by depth at 20 m intervals (top), and in gray scale shaded relief (bottom). Data gaps in coverage are due to heavy pack ice that prevented entry of survey vessel into the area.

CAPE ADARE

The *Italica* arrived at Cape Adare on the morning of February 14th after spending a day waiting for helicopters to transfer personnel at Cape McCormick. The DGPS base station and solar panels were place via helicopter at 71.35833497 S latitude and 170.3676463 E longitude in the base of a large bowl on the side of the cliff running along the eastern side of the cape. The *Ice Bjorn* was launched at 1830 on February 14th and ran multibeam sonar survey lines for 13 hours until 0730 on February 15th. This work covered a 4500 x 5500 m area spanning the Cape Adare transect line from 60 m to 200 m water depth (Fig. 2). Floating ice was not as much of a problem as at Cape Hallett, but still resulted in some gaps in the coverage, and prevented us from getting any shallower than 40 m or closer than 2 km from shore. Based on the multibeam results, which are the first depth soundings recorded for this area, the Italica was able to confidently approach the shore as far as the 100 m depth contour for benthic grab and dredge sampling. Prior to our work, the Italica would not venture shallower than the 200 m depth contour located > 6 km from shore.

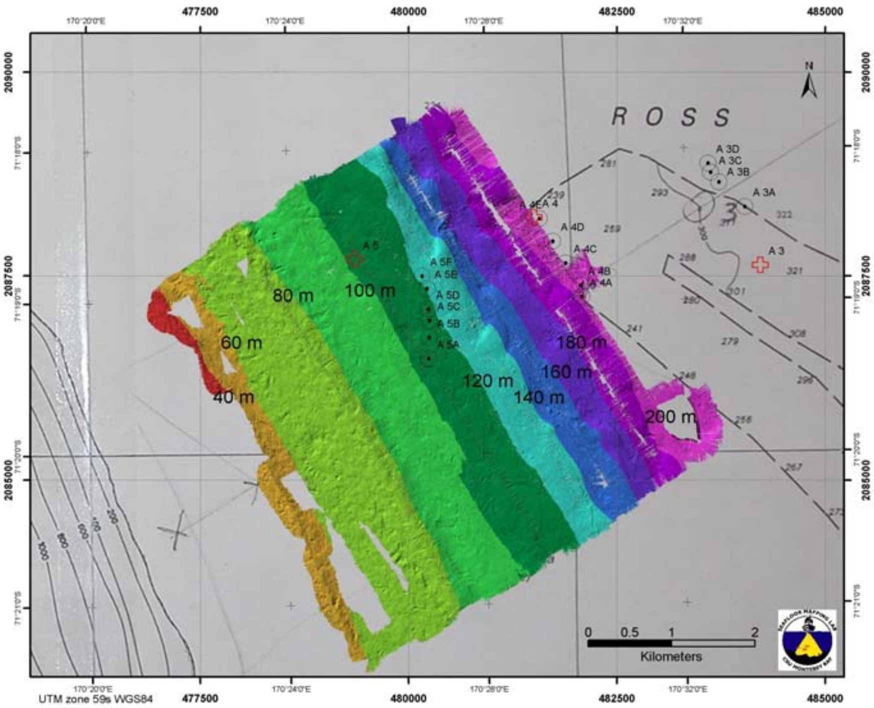


Figure 2. Cape Adare. Imagery from multibeam sonar bathymetry colored by 20 m depth contours. Other symbols (circles and crosses) show the locations of benthic grab and dredge samples respectively taken in the vicinity of the multibeam survey area.

TERRA NOVA BAY AND CAPE RUSSELL

The *Italica* arrived at Terra Nova Bay Station on the morning of February 20. After placing the DGPS basestation above Tethys Bay via helicopter, we attempted to survey the bay with multibeam on the *Ice Bjorn*. Unfortunately, cutting through the 5 cm of new ice with the *Ice Bjorn*'s hull made too much noise for effective acoustic mapping work and the survey had to be aborted. The following day, February 21st, we spent our final hours aboard the *Ice Bjorn* using multibeam to survey a 2000 x 6000 m area in front of a slight embayment just south of Adelie Cove (Fig. 3). Ice cover prevented access to a few regions within the survey area, but the coverage was generally good from the shore out to 200m. Unfortunately, the time available for use of the *Ice Bjorn* before it was to be pressed into service for closure of the TNB base, did not allow us to extend our 2004 survey coverage to the southern edge of our 2002 work that ended in Adelie Cove.

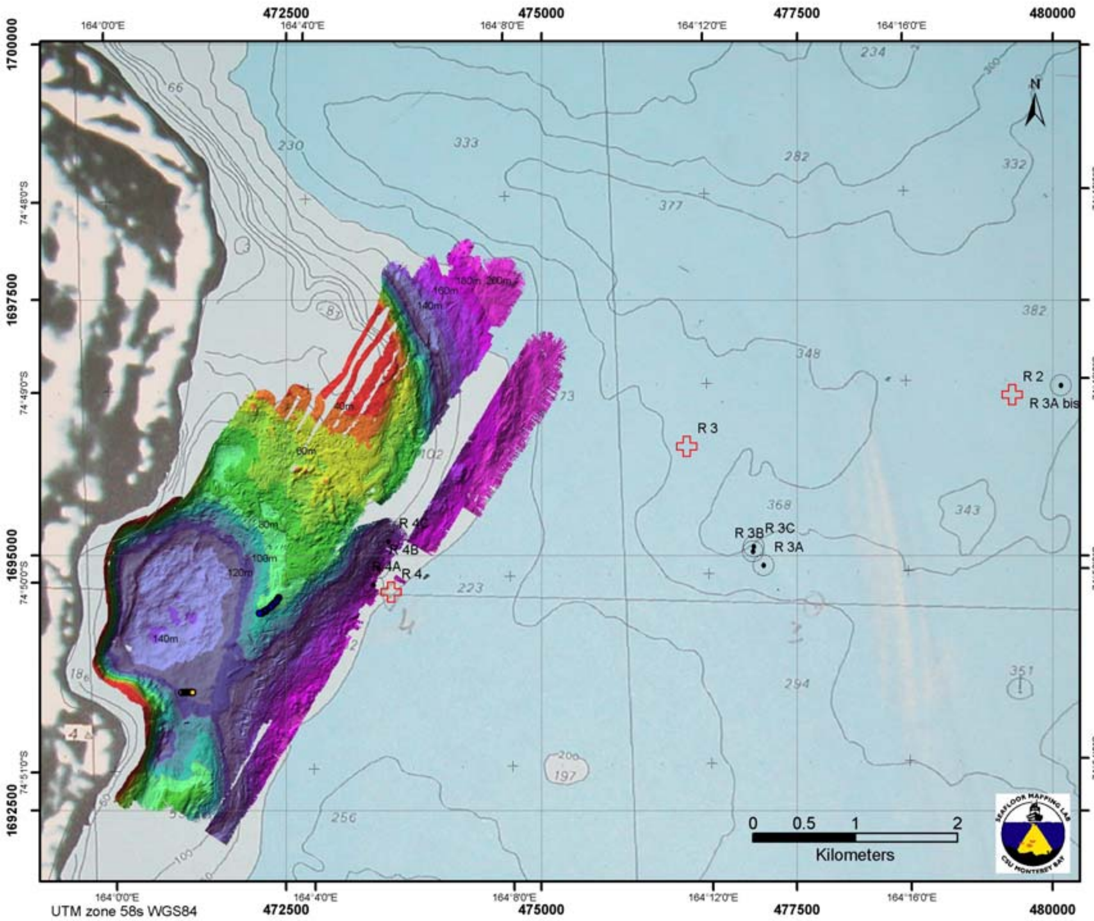


Figure 3. Cape Russell. Imagery from multibeam bathymetry colored in 10 m depth intervals. Benthic grab (circles with dots) and benthic dredge (crosses) locations are also shown. Small colored circles indicate the path of the Splashcam video surveys run by Simon Thrush and his team. .

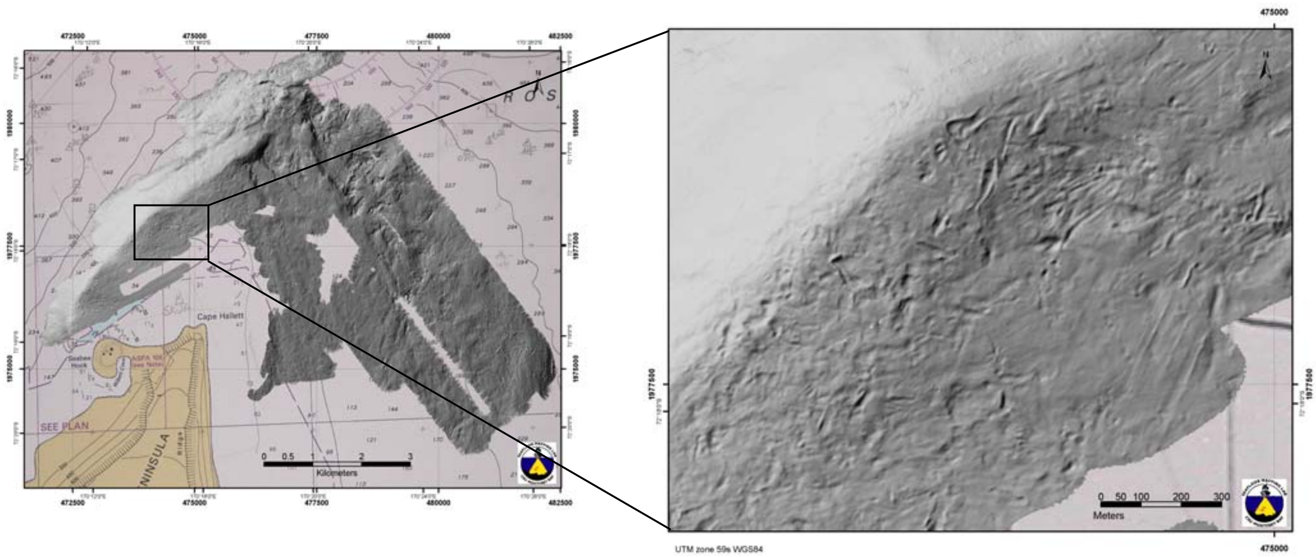
C. PRELIMINARY ACOUSTIC DATA PROCESSING

The multibeam data were processed on board the Italica using CARIS HIPS and ArcGIS to produce the following preliminary products:

- Digital Elevation Models (DEM) at 3 m resolution
- Shaded relief images in geotif format, in which ice scours, basins and other geomorphologies are clearly visible
- Color raster maps contoured at various depth intervals
- XYZ data at various grid intervals
- Bathymetric contour lines
- Map files of the above showing the positions of various benthic sampling locations.
- Sidescan sonar data from the 8101 in the shallower depths (30-50 m) were suitable for analysis, and mosaicked for these depth zones at Cape Hallett.
- ArcMap GIS project files and all related data files

D. PRELIMINARY DATA ANALYSIS

The multibeam imagery revealed extensive ice scouring at all locations. A wide variety of ice disturbance features were clearly visible, from shallow scrapes < 1m deep to broad gouges 100m wide with > 8m of vertical relief from trough to berm. Distinct spatial patterns were also evident in the scouring, with different sizes and percent bottom disturbed correlated with depth and exposure. Auto classification of ice scour disturbance was developed using Topographic Position Index (TPI) analysis to identify troughs and berms, and percent bottom disturbed. (Figs. 4 and 5).



	Area (m2)	% Area
Trough	175056	12.72%
Berm	223400	16.23%
Total Scour	398456	28.95%
Total Survey	1376328	

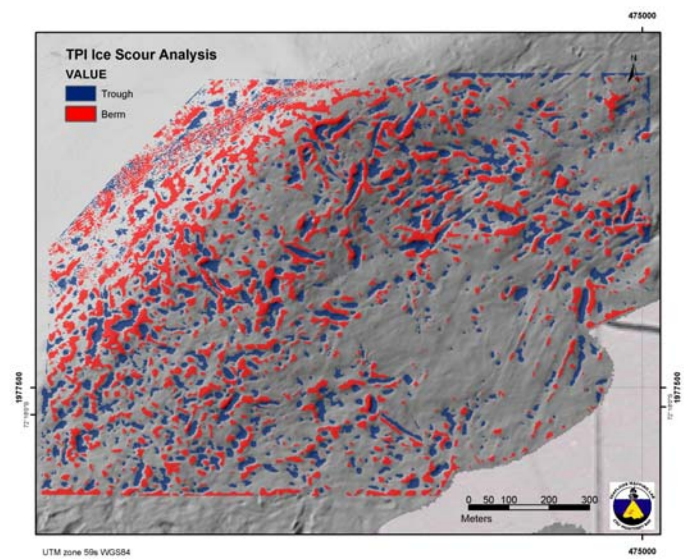


Figure 4. Cape Hallett ice scour disturbance analysis. Ice scour troughs and berms clearly visible in shaded relief multibeam imagery of Cape Hallett (top right). Topographic Position Index (TPI) analysis (lower right) was applied to a 2 m DEM grid of the same area and "tuned" to detect troughs (blue) and berms (red). These results were used to calculate the percent bottom disturbed shown in the table above and the size class distribution of trough and berm disturbance patches shown in figure 5.

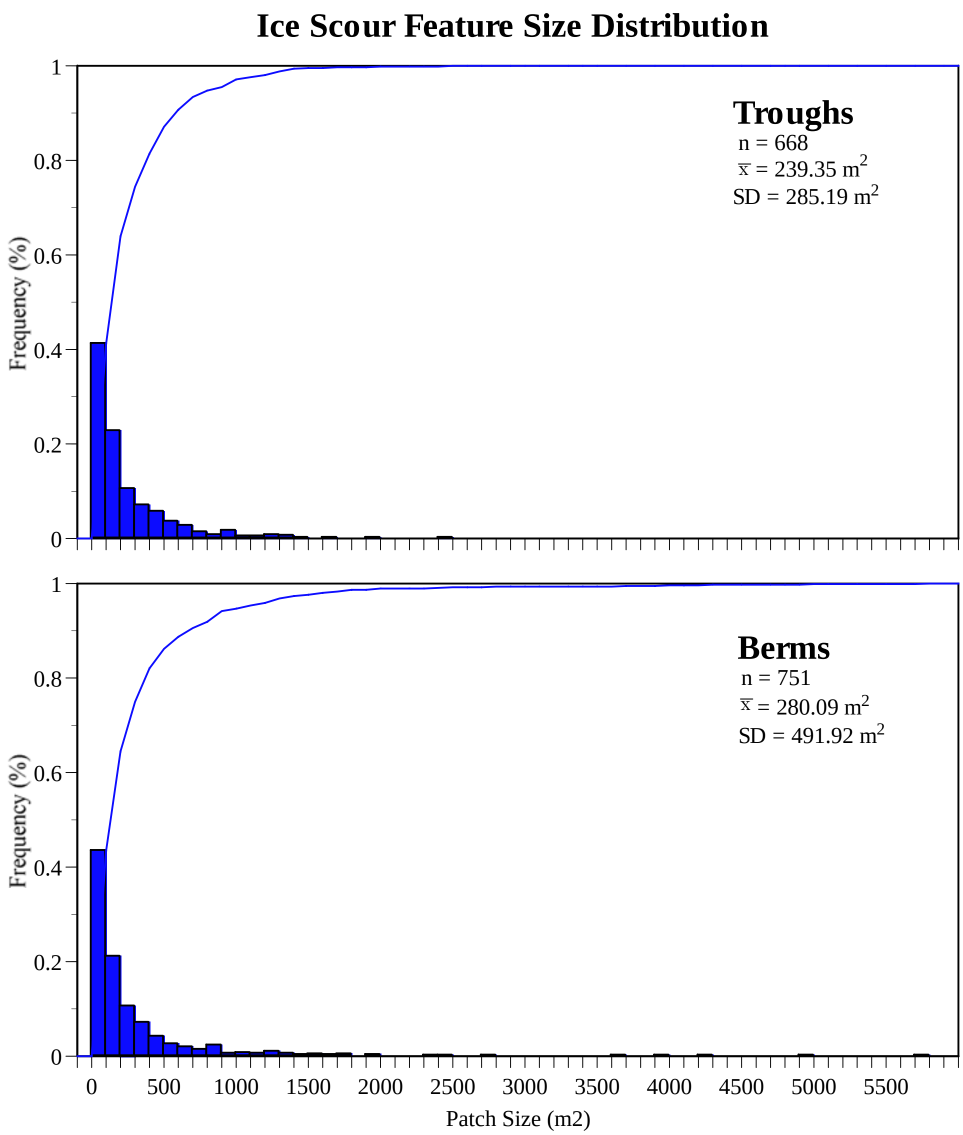


Figure 5. Size class distributions of trough and berm disturbance patches detected with TPI in the 40-50m depth zone at Cape Hallett shown in figure 4. (Blue lines represent cumulative frequencies.)

E. FINAL PRODUCTS: LIMITATIONS AND FUTURE DIRECTIONS

Final products to be produced by the SFML for this project will be more limited than originally planned due to a variety of environmental and logistical constraints. More than half of the sea days were not suitable for survey work due to ice or weather conditions. More importantly, the vast majority of the biological data collection that was to have been conducted by the various members of the VLGP collaborative within the areas and depth zones surveyed by SFML did not happen. This unfortunate outcome was due almost entirely to the inadequacy of the *Italica*'s second small vessel, the R/V *Skua*, provided for this purpose. The *Skua*, which is a new vessel just completed in time for this expedition, could rarely be used because its excessive weight made it impossible to safely launch the boat in anything but the calmest conditions. Moreover, its poor trim, speed, and handling abilities prevented the *Skua* from operating without another vessel in close support. Consequently, the extensive diving, ROV and video sledge surveys that had been planned to map the biotic communities within the habitats mapped by the SFML simply did not happen. These surveys were to have covered the 200m and shallower zone that the *Italica* generally would not enter, and when it did, was not able to serve as an effective platform for the precise deployment of video survey sledges or drop cameras.

Thus, rather than focusing on species-habitat relationships along the latitudinal gradient, the SFML will be developing the analysis tools to quantify the spatial variation in the character and intensity of ice scour disturbance with depth and exposure at the different sites surveyed. Our preliminary multibeam results reveal a subtidal landscape dominated by a mosaic of disturbance patches stratified by depth and in various stages of recovery. Habitats at depths of 200-300m and unprotected by topographic highs are exposed to the massive impact of tabular icebergs 100s to 1000s of meter in horizontal dimensions that come from the 300m thick Ross Ice Shelf. The scours made by these giants are unmistakable due to the depth range in which they occur, and by the characteristically broad and extremely flat “road-like” appearance of the features. In the 40-150 m depth range, the scours are carved by more pointed ice keels, and tend to be narrower, ending in a terminal pit. Additionally, there are often one or two prevailing trends in the orientations of the scours. This bi-directionality can result in “boomerang” marks as ice keels ground in one direction and exit in another. Shallower than 40 m, the scours tend to be smaller in both horizontal and vertical dimensions. Our work will now be centered on quantification of various parameters associated with the different populations of ice scours observed: shape, aerial extent, relief, orientation, size distribution, and percent bottom disturbed.

Any serious attempt to characterize differences in communities found along the Victoria Land gradient, must take this habitat complexity into consideration. Precisely positioned video surveys are perhaps the only tool capable of efficiently and accurately capturing the biotic variability undoubtedly associated with that of the landscape. Benthic grabs and dredges cannot be controlled precisely enough to know whether they have sampled inside or outside of a recent or old ice scour. The potential for bias due to sampling error is therefore very high when using these types of devices, especially given the generally small number of replicates taken.

The potential for describing the spatial structure and controlling factors of the Victoria Land continental shelf benthos, however, remains great. Indeed, it may well be the impact of ice that distinguish this shallower system from the deeper benthos recently described by Barry et al. (2003) for 270 – 1200m in the SW Ross Sea. On the shelf, ice scour disturbance and upper ocean factors, rather than static habitat characteristics and lateral advection of organic material along the seabed in deeper zones, will likely play a significant role in regulating the spatial distribution of Ross Sea benthos. With the right vessels, video sledges, and acoustic mapping system, this story could be unraveled and told in wonderfully accurate detail. On this cruise, we have demonstrated the ability to accurately map and analyze the impact of ice scour on habitat patchiness and relief over broad areas and at the biologically relevant scale of meters. The biotic mapping capabilities brought by Simon Thrush, and ecological expertise of our international colleagues were ideally suited to achieving the other half of this shallow water effort, but they could not be brought to bear due to the inadequacy of the vessel assigned to that duty under the conditions in which we found ourselves.