Ocean Observatory Mapping Requirements

- Regional Context
- Cable Route Survey
- Site Selection

Ocean Observatory Mapping Requirements

- Regional Context
  - large areal coverage with best resolution possible - bathymetry and backscatter
  - typical trade-offs between resolution and coverage

Ocean Observatory Mapping Requirements

- Cable Route Survey
  - very high resolution over relatively narrow swath
  - 100% bathymetry - 800 m swath
  - sidescan (backscatter) - 1200 m swath overlapping bathymetry
  - subbottom, coring and CPT if cable to be buried (2.5 m subbottom)
  - detect obstacles to 1 m lateral dimension

Ocean Observatory Mapping Requirements

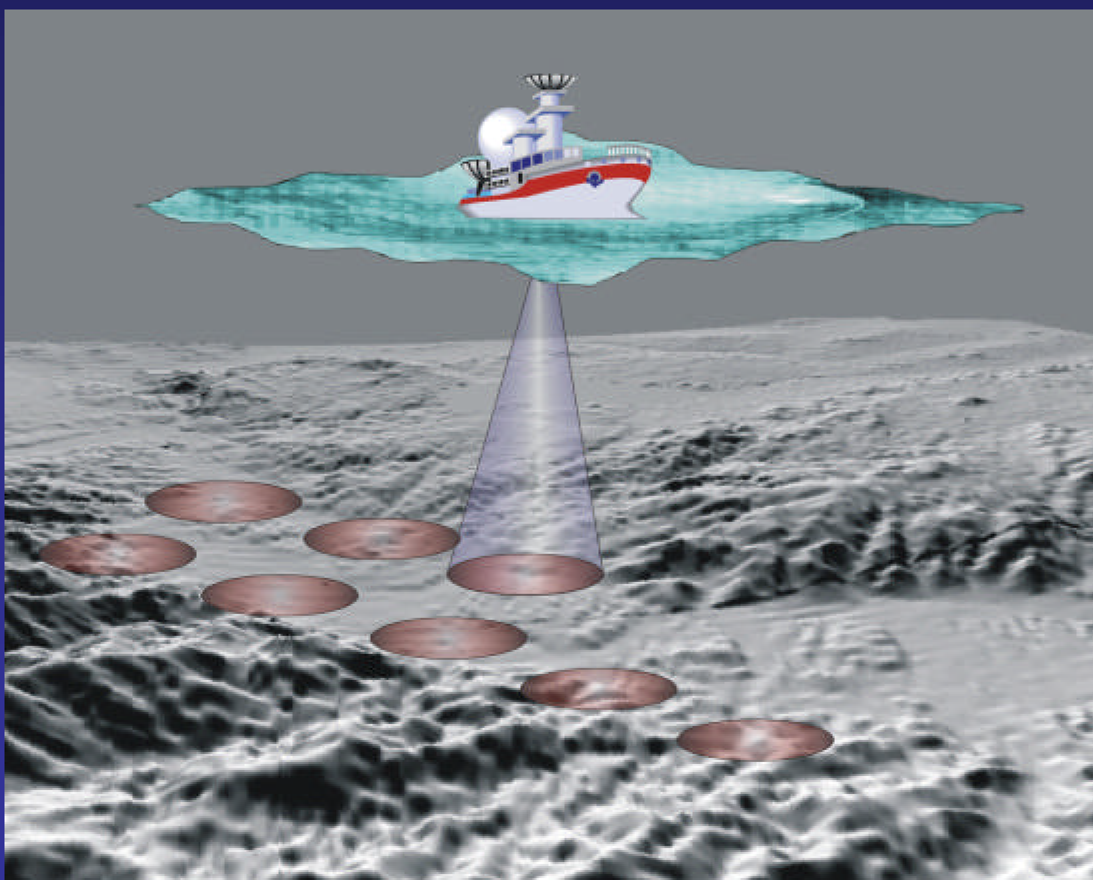
- Cable Route Survey
  - detect hazards
    - surface faulting, tectonic deformation, turbidity flows, unstable slopes,potential liquefaction, gas charged sediment, rocky outcrops, hard bottom (if ploughed), steep slopes, pinnacles, boulders, seismic activity,high currents, trawl marks, anchor marks, proximity to cables, pipelines,etc., manmade debris or hazardous materials, signs of oil or oil exploration

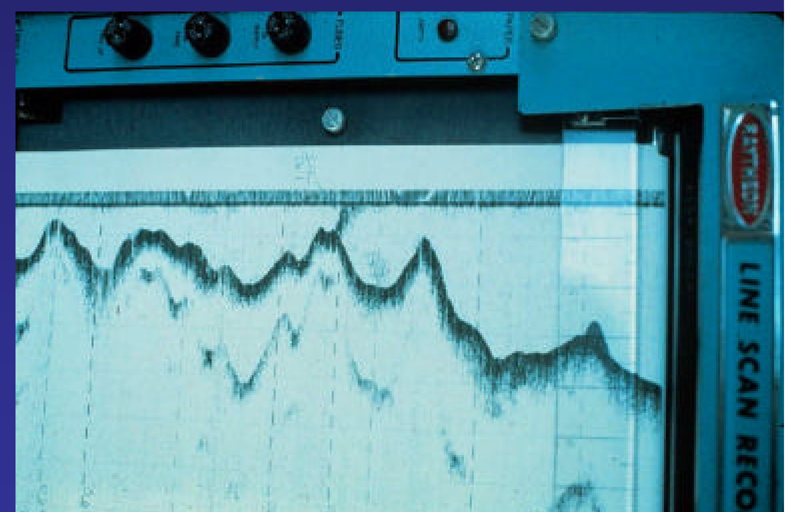
Ocean Observatory Mapping Requirements

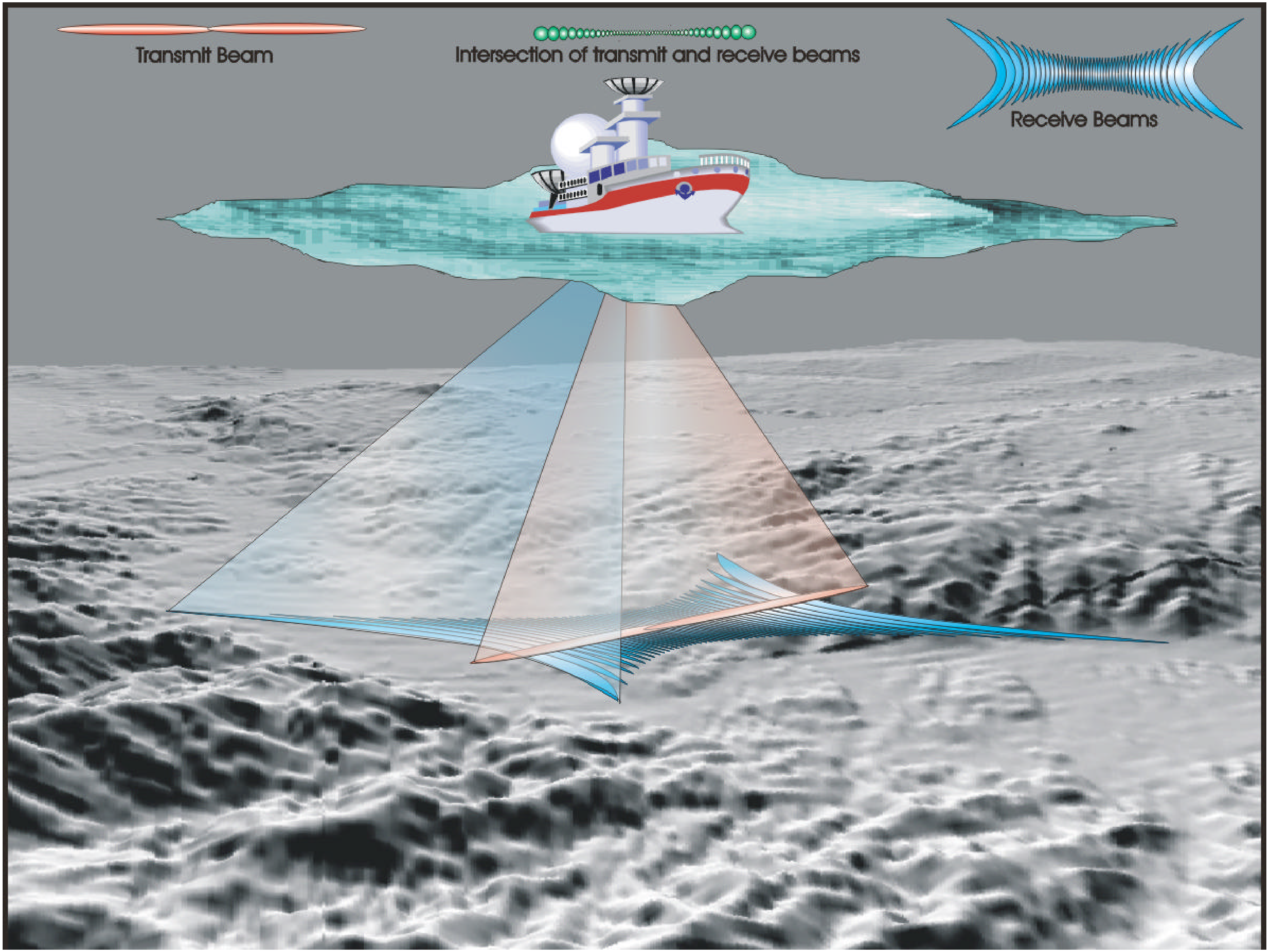
- Cable Route Survey
  - real-time processing for near real-time decision making

- Site Selection
  - Halfway between the two ??

Single Beam Echo Sounder







Transmit Beam
Intersection of transmit and receive beams
Receive Beams

Resolution of Multibeam Sonar

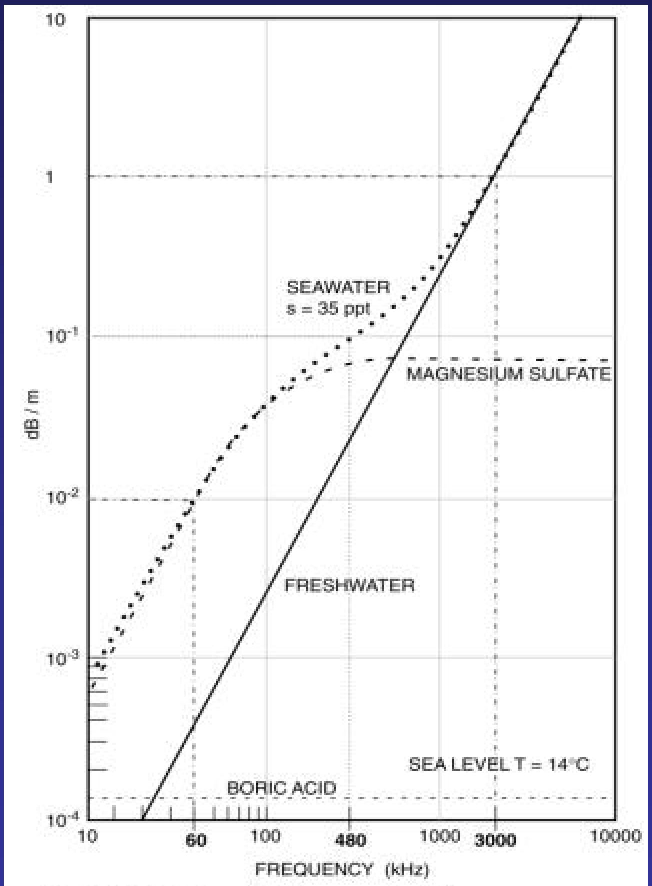
Vertical Resolution:

f (PULSE LENGTH (bandwidth), digitizing rate, bottom detection algorithm) -- ~ **1 - .1 % of water depth**

Horizontal Resolution:

f (BEAM WIDTH (array size), geometry, bottom detection and beam forming algorithms) -- ~ **5 - 1% of water depth**

Range *is limited by attenuation which increases with operating frequency*



[Clay & Medwin, *Acoustical Oceanography*, 1977]

The operating frequency of an acoustic system is governed by the range requirement

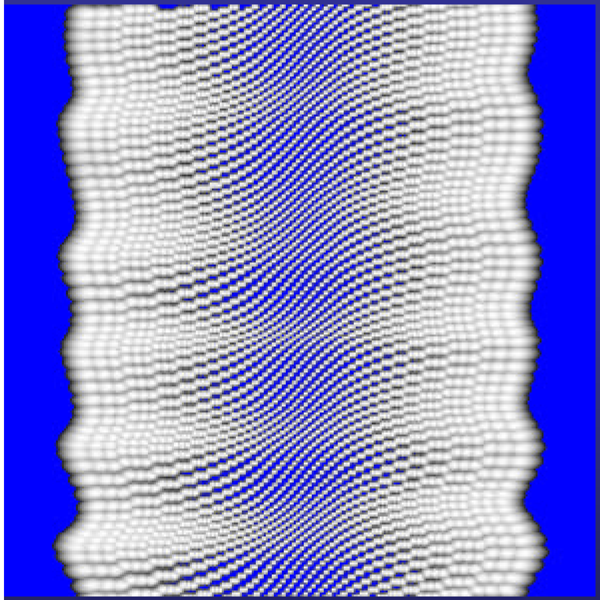
Trade-offs between operating frequency, range, array size, resolution

FREQUENCY	12 kHz	30 kHz	100 kHz	300 kHz	455 kHz
Typical Attenuation	1 dB/km	5 dB/km	30 dB/km	65 dB/km	100 dB/km
Typical Range	11000 m	5000 m	1000 m	200 m	100 m
Sonar Beamwidth	Transducer Dimensions				
0.5 degrees	18 m	7.2 m	2.2 m	0.6 m	0.5 m
1 degree	9 m	3.6 m	1.1 m	0.3 m	0.2 m
2 degrees	4.5 m	1.8 m	0.6 m	0.2 m	0.1 m
5 degrees	1.8 m	0.7 m	0.2 m	0.1 m	.05 m
10 degrees	0.9 m	0.36 m	0.1 m	0..03 m	0.02 m

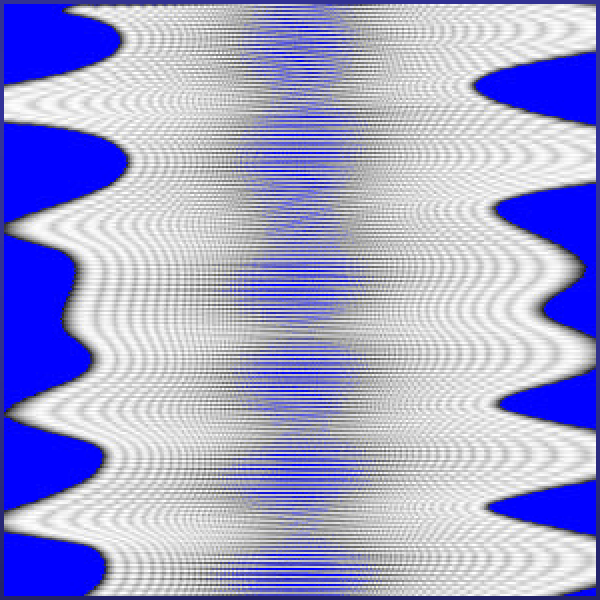
Traditional multibeams constrained to work in FAR-FIELD which limits size of array and thus lateral resolution

Multibeam sonar footprints

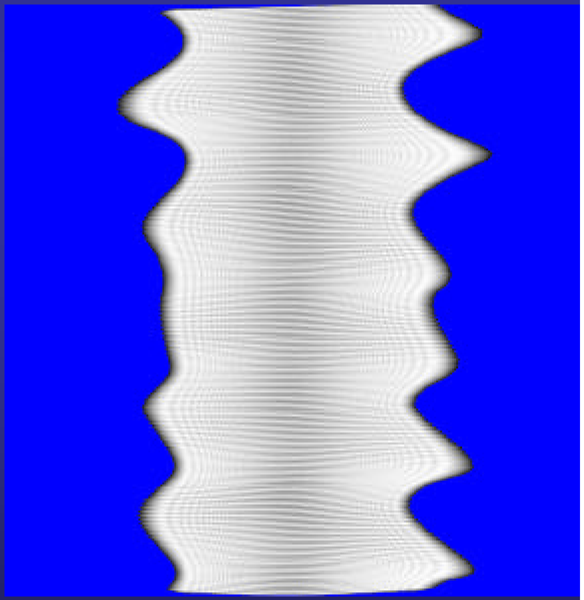
200 m swath



Elac 1180 – 180 kHz

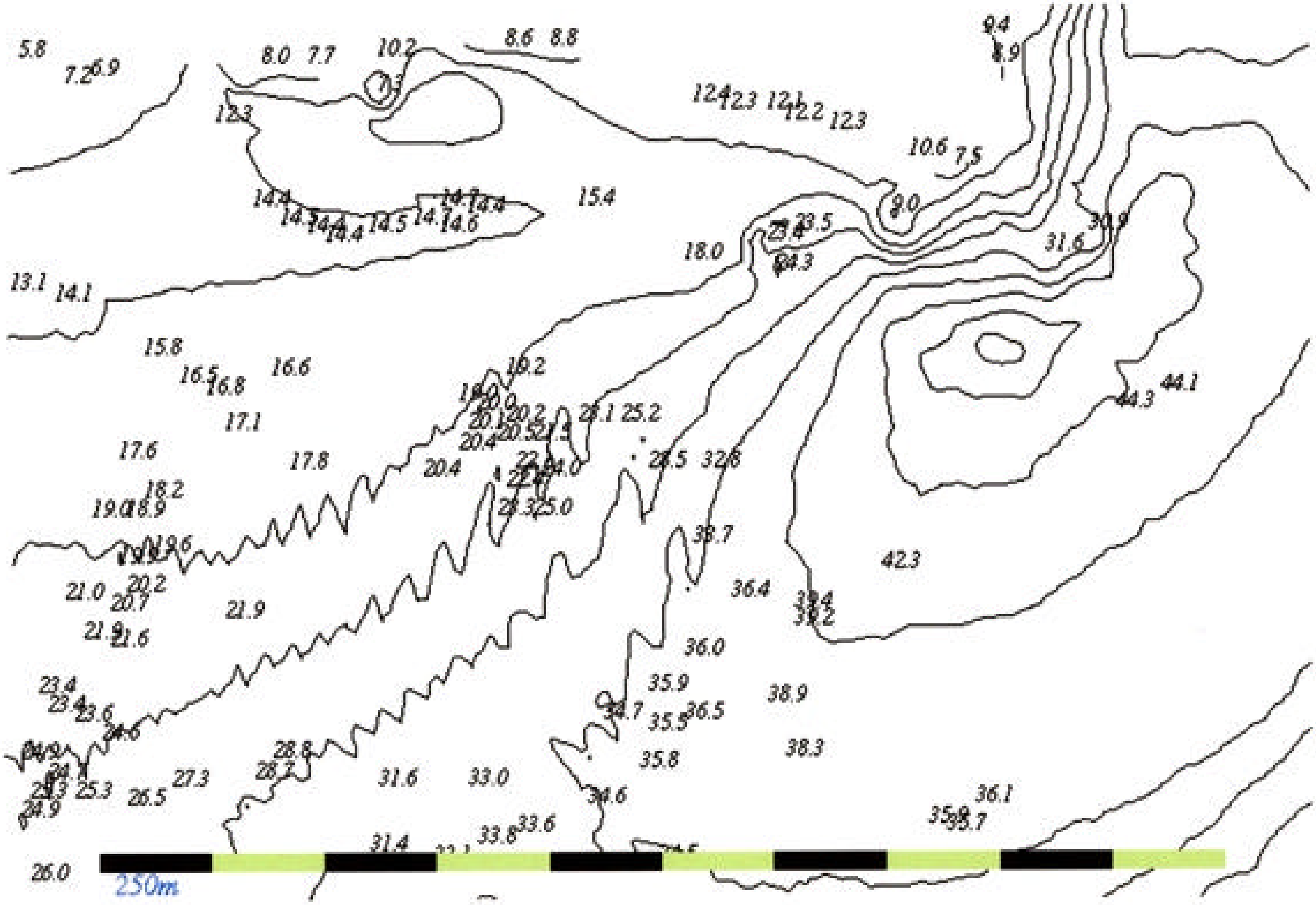


Reson 8101 – 240 kHz



Simrad EM 3000 – 300 kHz

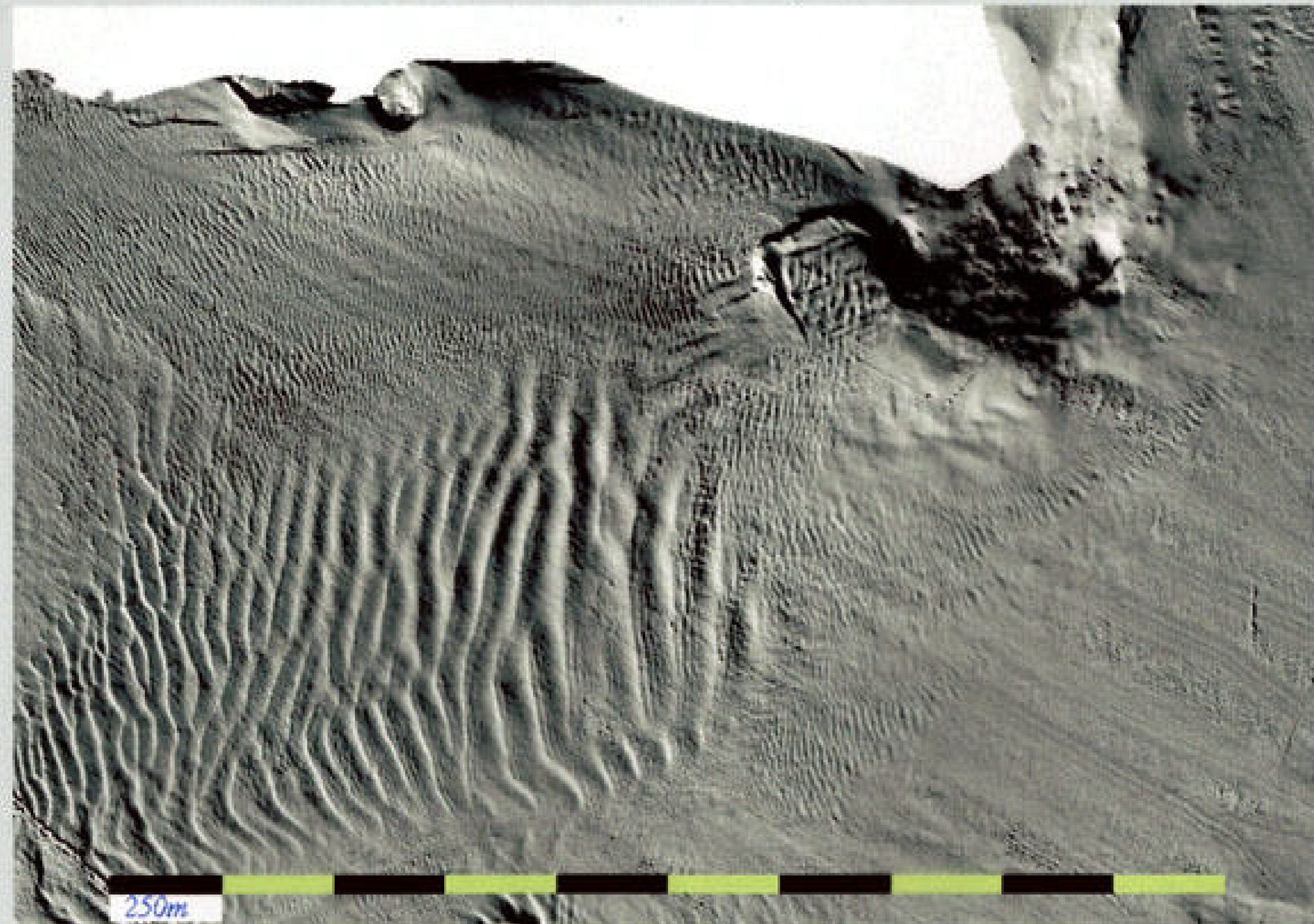
C&C Tech., San Francisco Bay: EM1000 8 knots



Processed using **OMG/UNB SwathEd**

Data courtesy of: USGS(WR) Jim Gardner

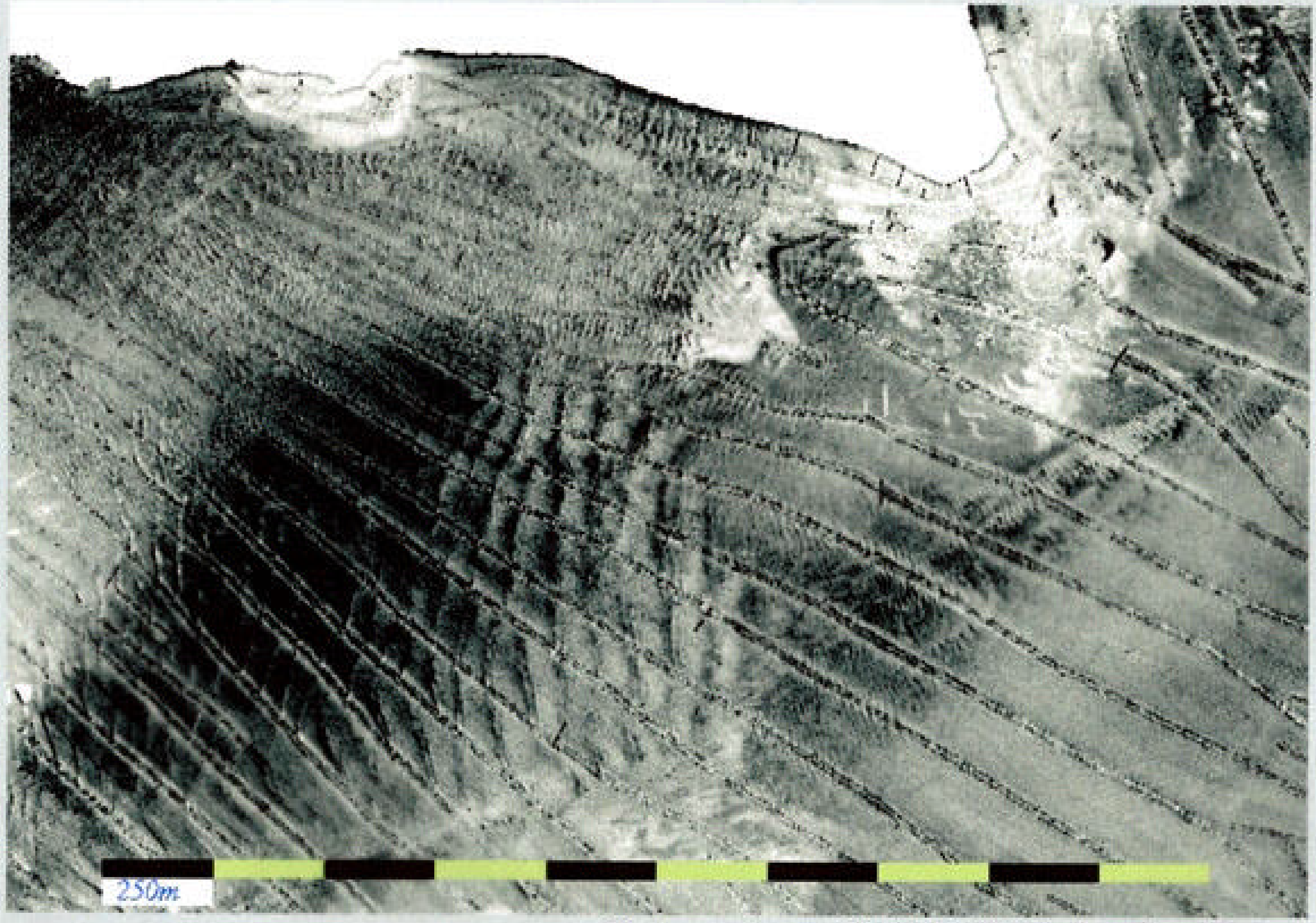
C&C Tech., San Francisco Bay: EM1000 8 knots



Processed using **OMG/UNB SwathEd**

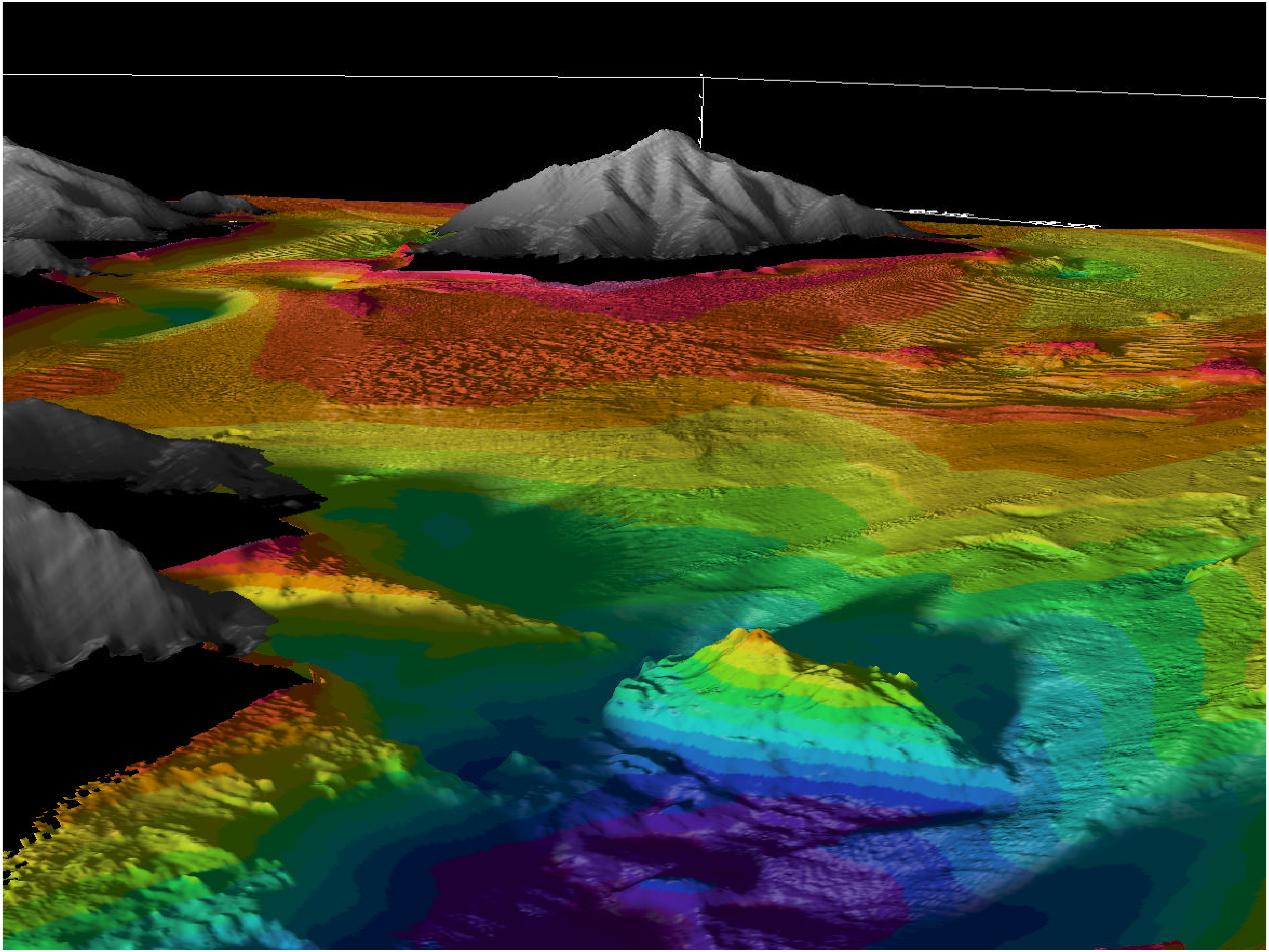
Data courtesy of: USGS(WR) Jim Gardner

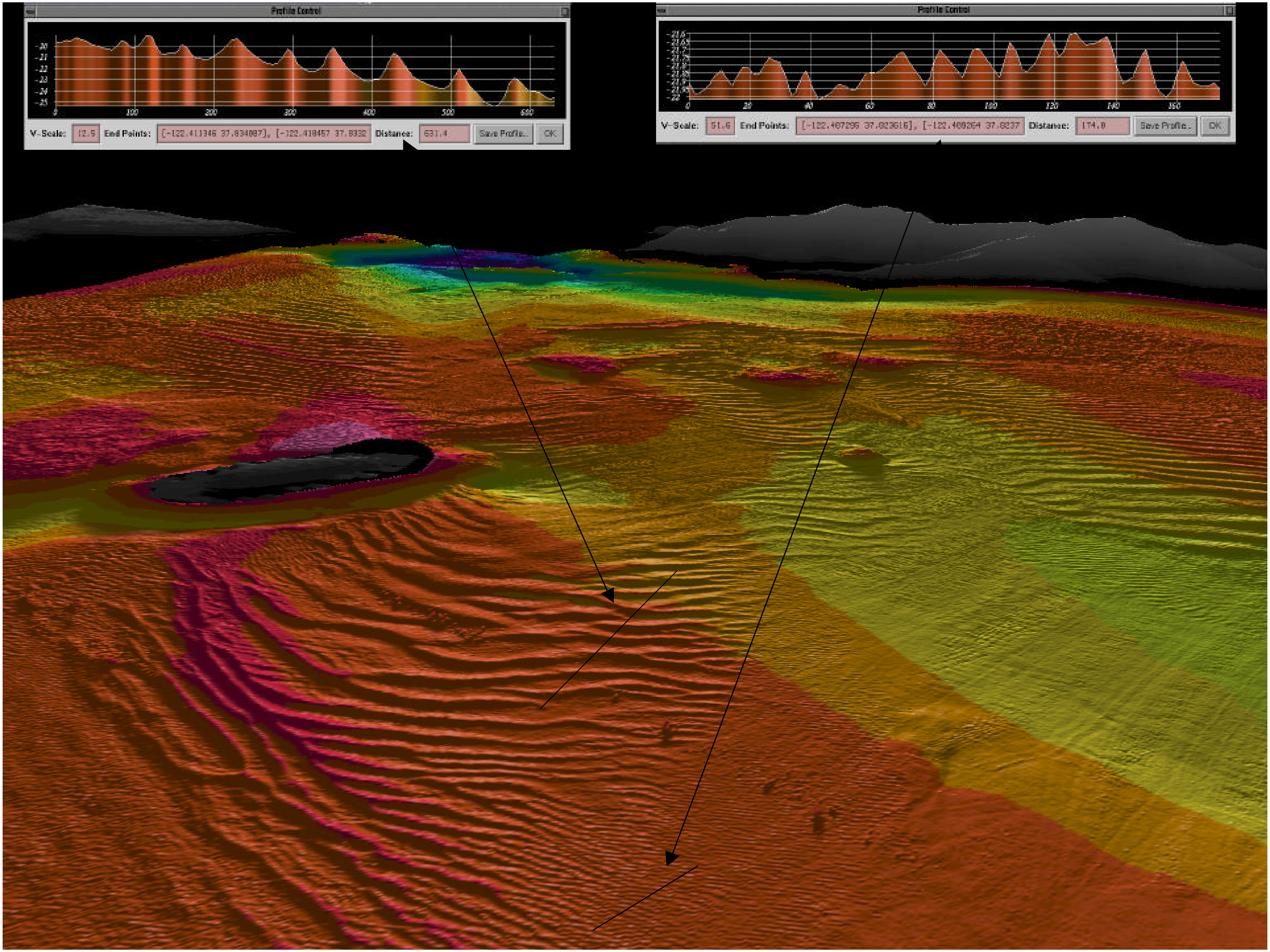
C&C Tech., San Francisco Bay: EM1000 8 knots

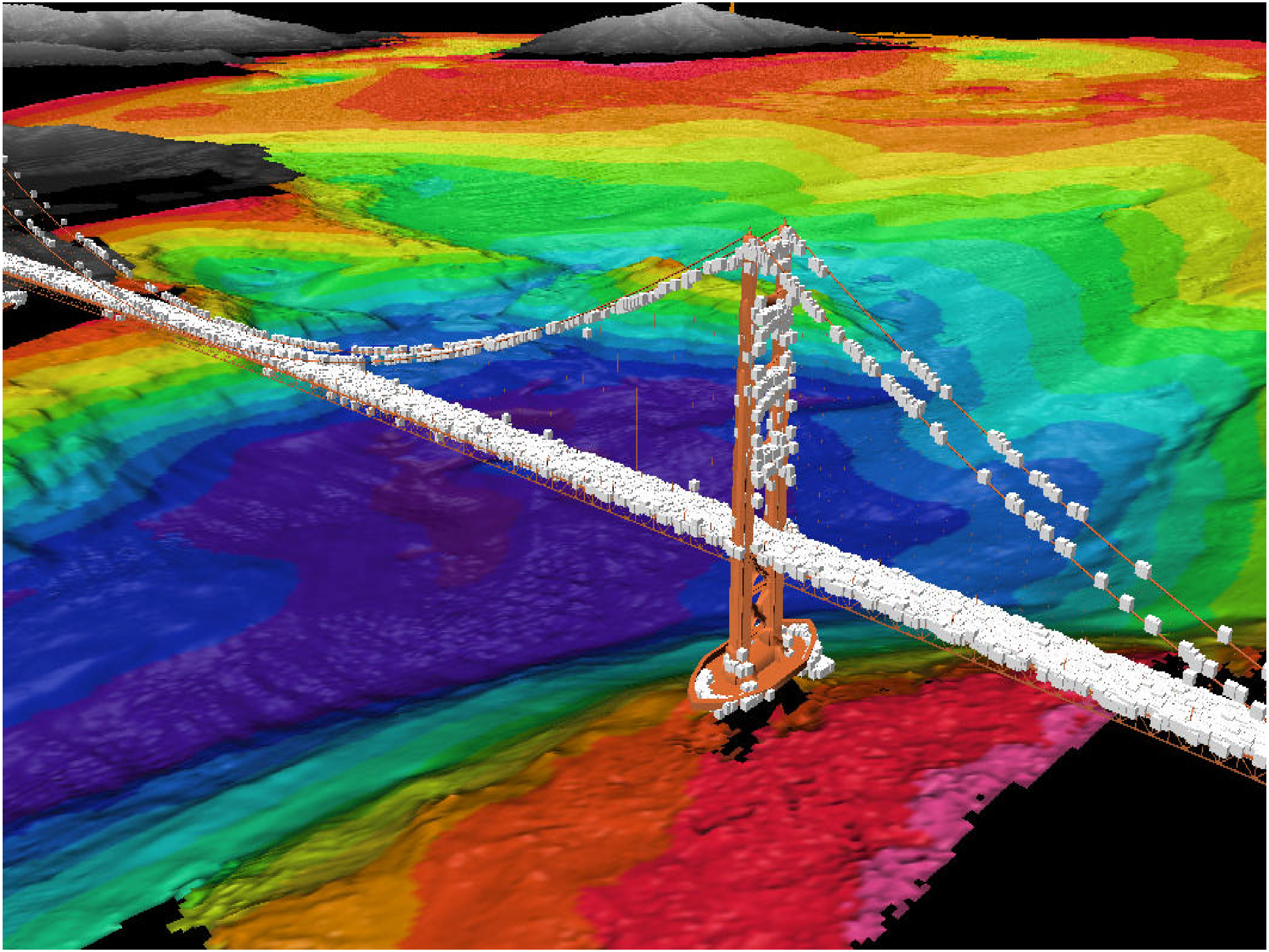


Processed using **OMG/UNB SwathEd**

Data courtesy of: USGS(WR) Jim Gardner




Profile Control
-20
-21
-22
-23
-24
-25
0
100
200
300
400
500
600
V-Scale: 12.5
End Points: [-122.411346 37.834087], [-122.418457 37.8332
Distance: 631.4
Save Profile..
OK
Profile Control
0
20
40
60
80
100
120
140
160
V-Scale: 51.6
End Points: [-122.407296 37.823616], [-122.408264 37.8237
Distance: 174.0
Save Profile..
OK



Advances in Offshore Positioning

System	Accuracy
1960's - Sextant	~ 1 n.m. (if good)
1970's - Transit Satellite	~ 100 m intermittantly
Early 1990's - GPS	~ 100 m continuously
Late 1990's - DGPS	~ 10 m continuous
Early 00's - RTK	~ 5 cm x,y,z, continuous

Advances in Motion Sensors

1970's - Damped pendulum

1990 - Vertical gyro

1993 - Loose inertial/GPS integration

early 00's - Tightly integrated inertial/GPS

Attitude - .01 deg (RTK)
Heading - .02 deg (RTK or DGPS)
Velocity - .01 m/sec (RTK)
Position - .02 - .10 m (RTK)
200 Hz update rate

Advances in Computing Power

- Time to transfer 1 gigabyte of data:
  - 28.8 kbaud modem — 75 hours
  - ISDN — 17 hours
  - ADSL — 30 minutes
  - 10 BaseT — 13 minutes
  - 100 BaseT — 80 seconds
  - 1000 BaseT — 8 seconds

Benefits of Increased Data Density:

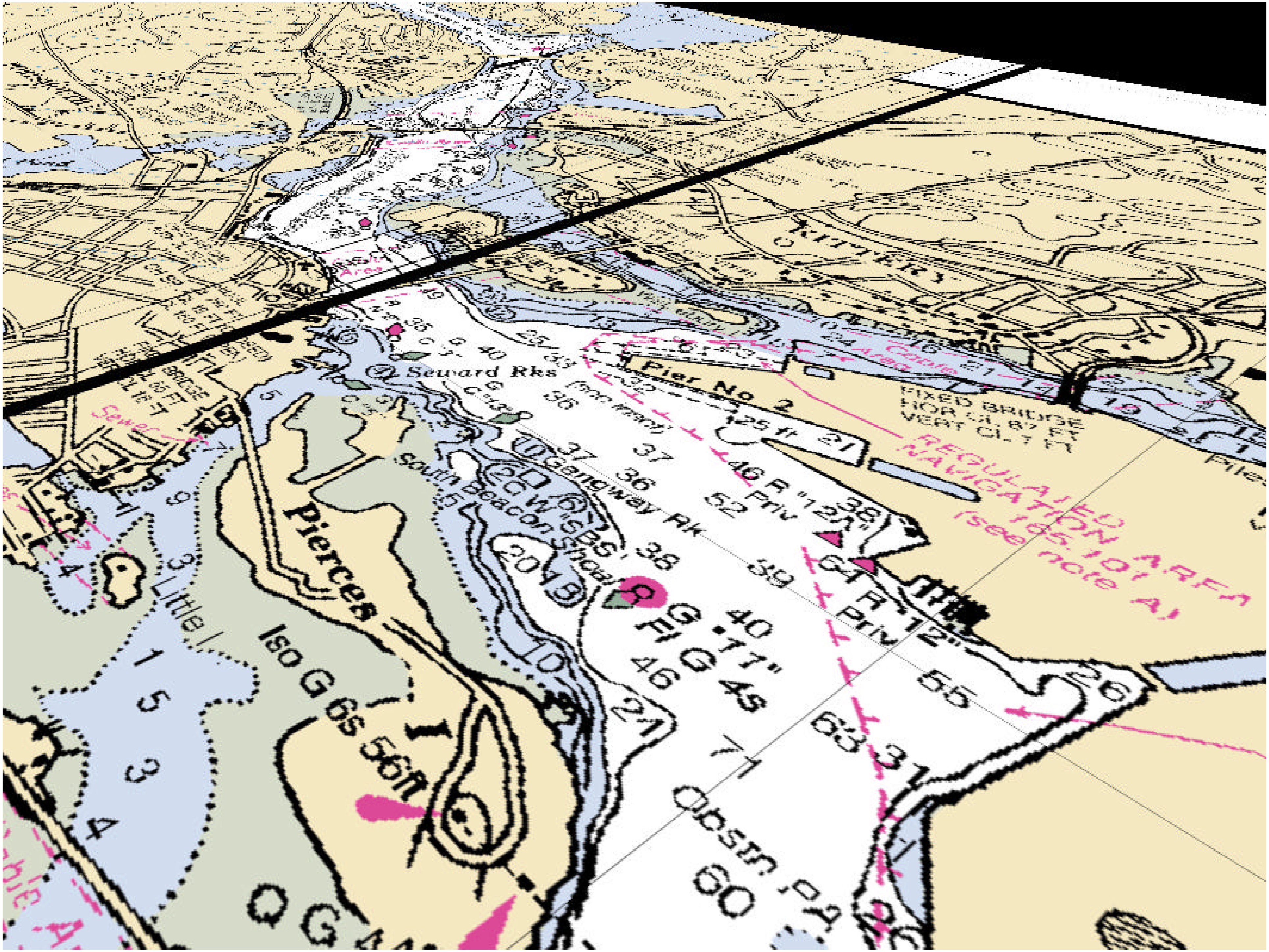
- **Redundancy provides increased accuracy**

- **Data density allows us to visualize and quantitatively explore the data in new ways**

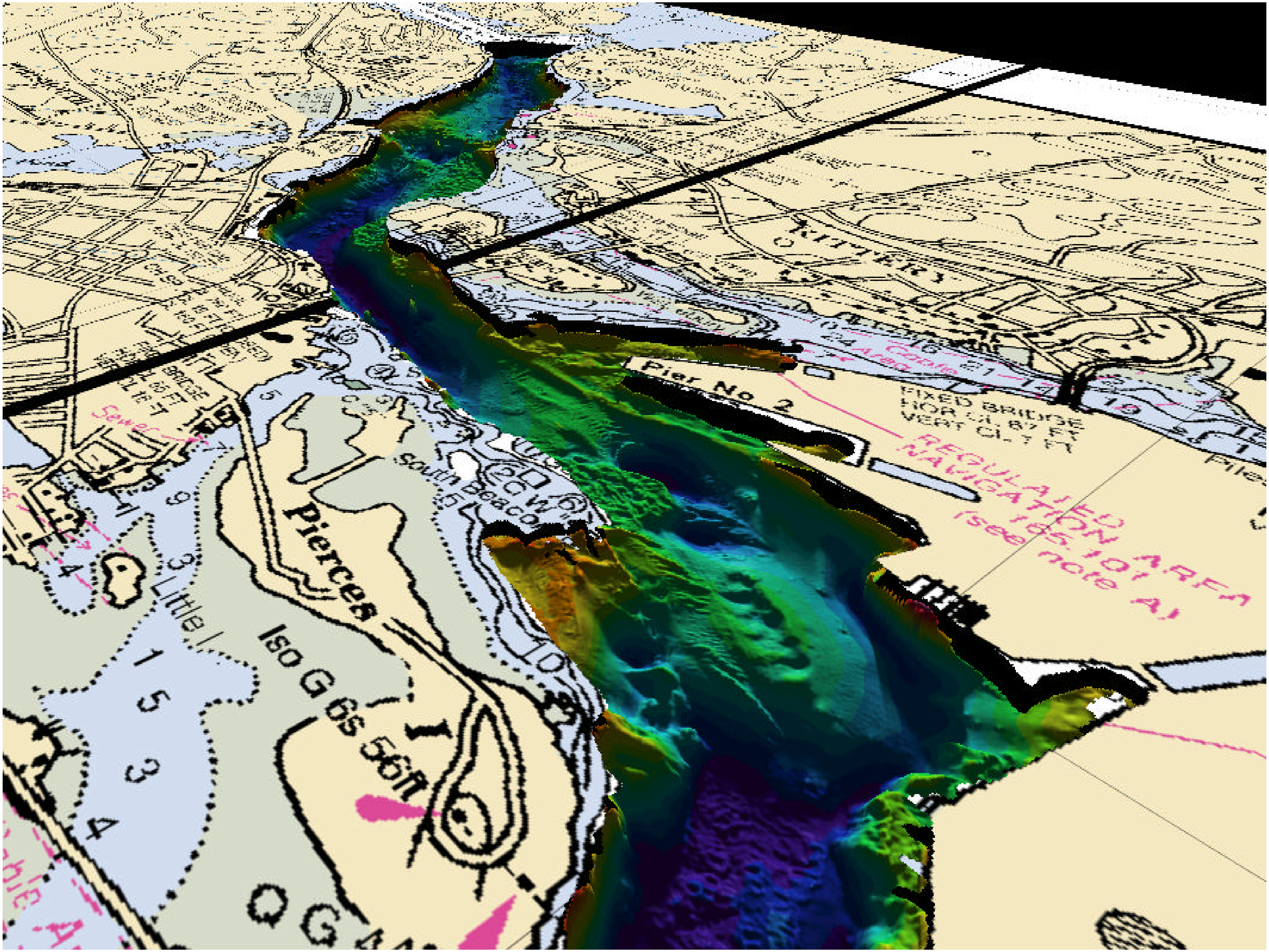
PORTSMOUTH HARBOR COMMON DATA SET

Reson 8101
Klein 5000
Orthophotos
IKONOS
Navitronics Sweep
QTC
Submetrix
Simrad EM3000
Sediment cores
Video Mosaics
Geoacoustics
Reson 8125
Triton Elics 200kHz
Odom Echoscan
Atlas Fansweep 20
Knudsen
Elac 1180
EdgeTech MPX
SHOALS LIDAR
Terrestrial LIDAR
Simrad EM2000
Seistek boomer
EdgeTech Chirp

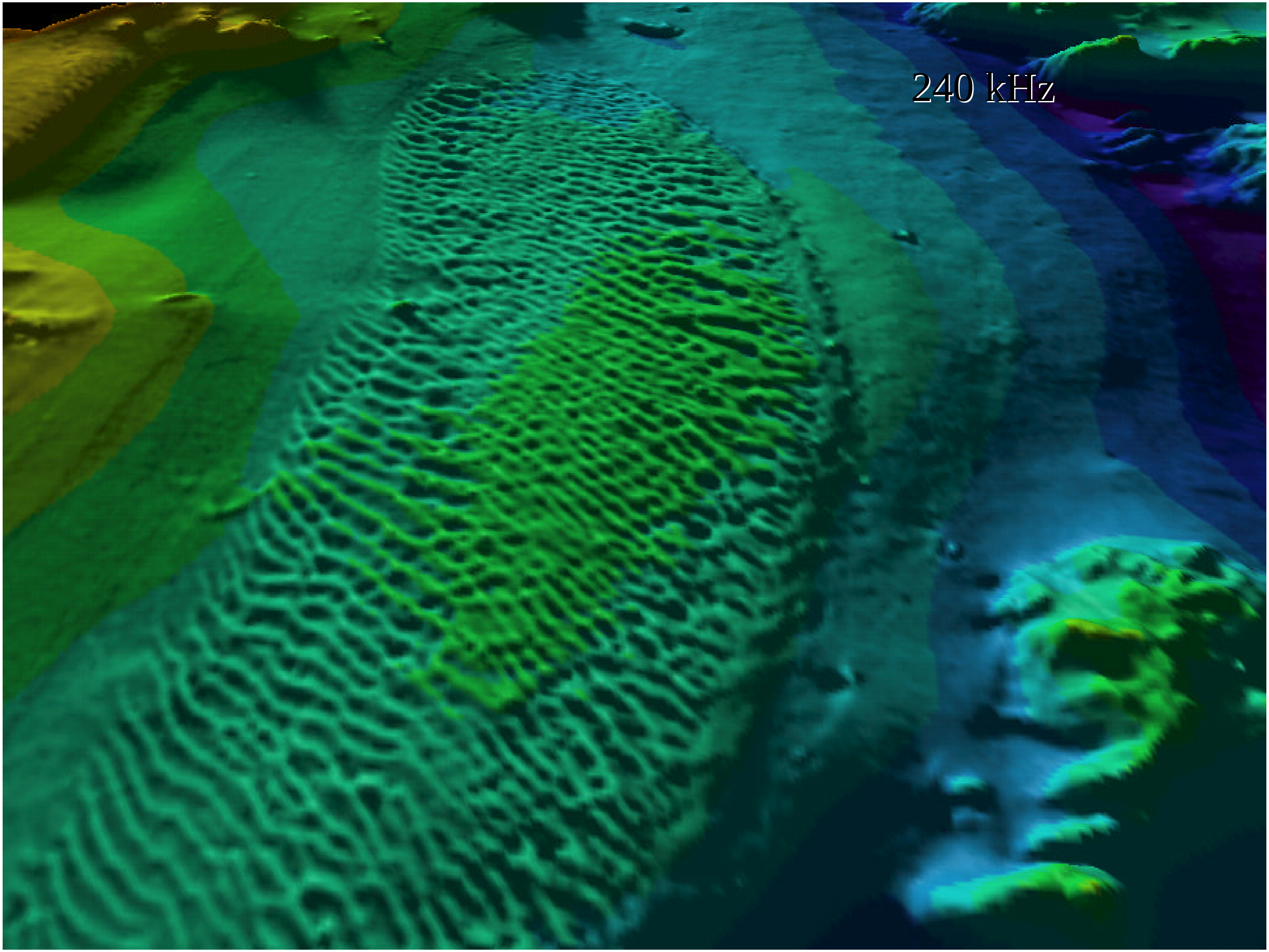
www.ccom.unh.edu/shallowsurvey.htm

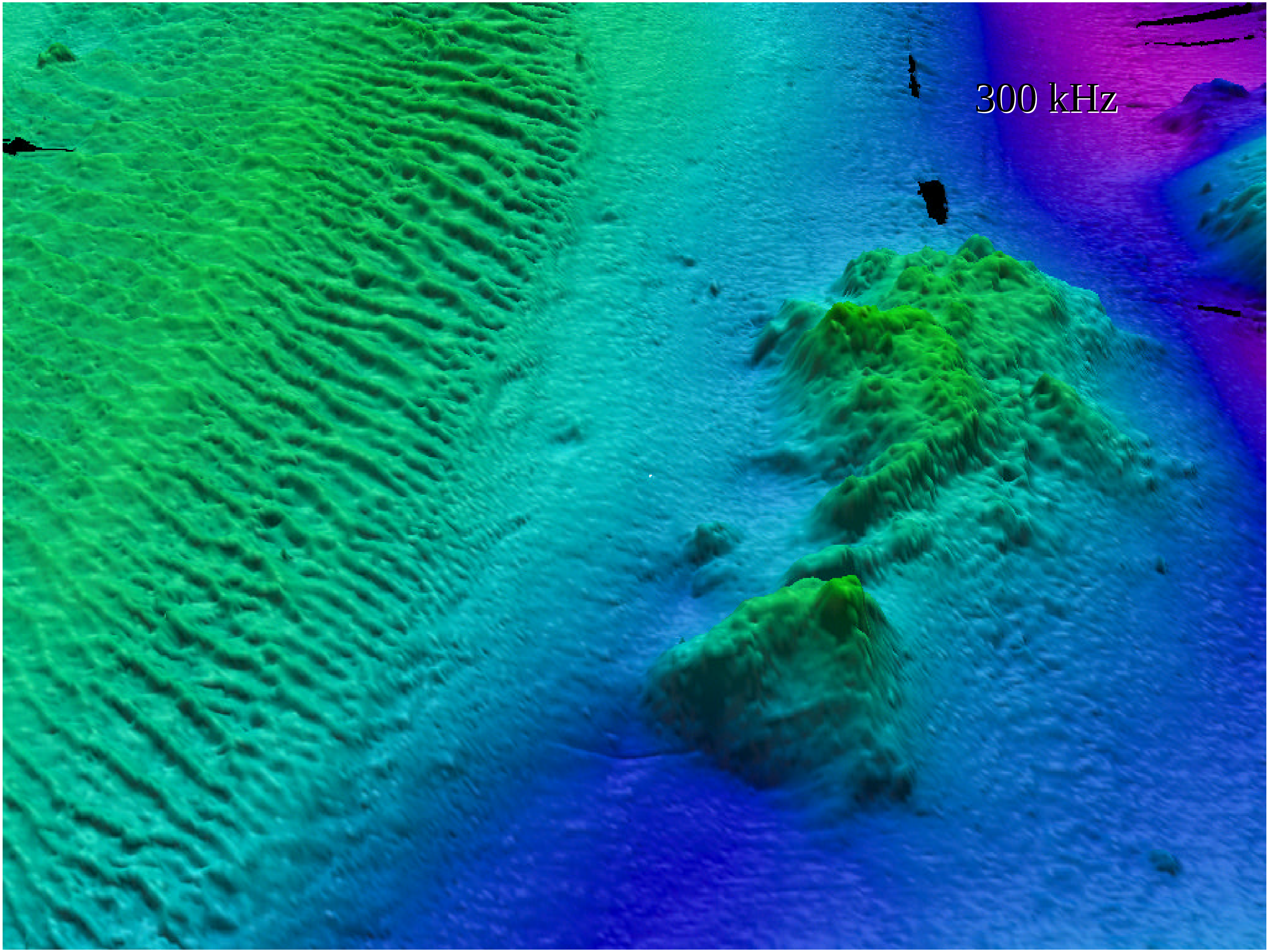


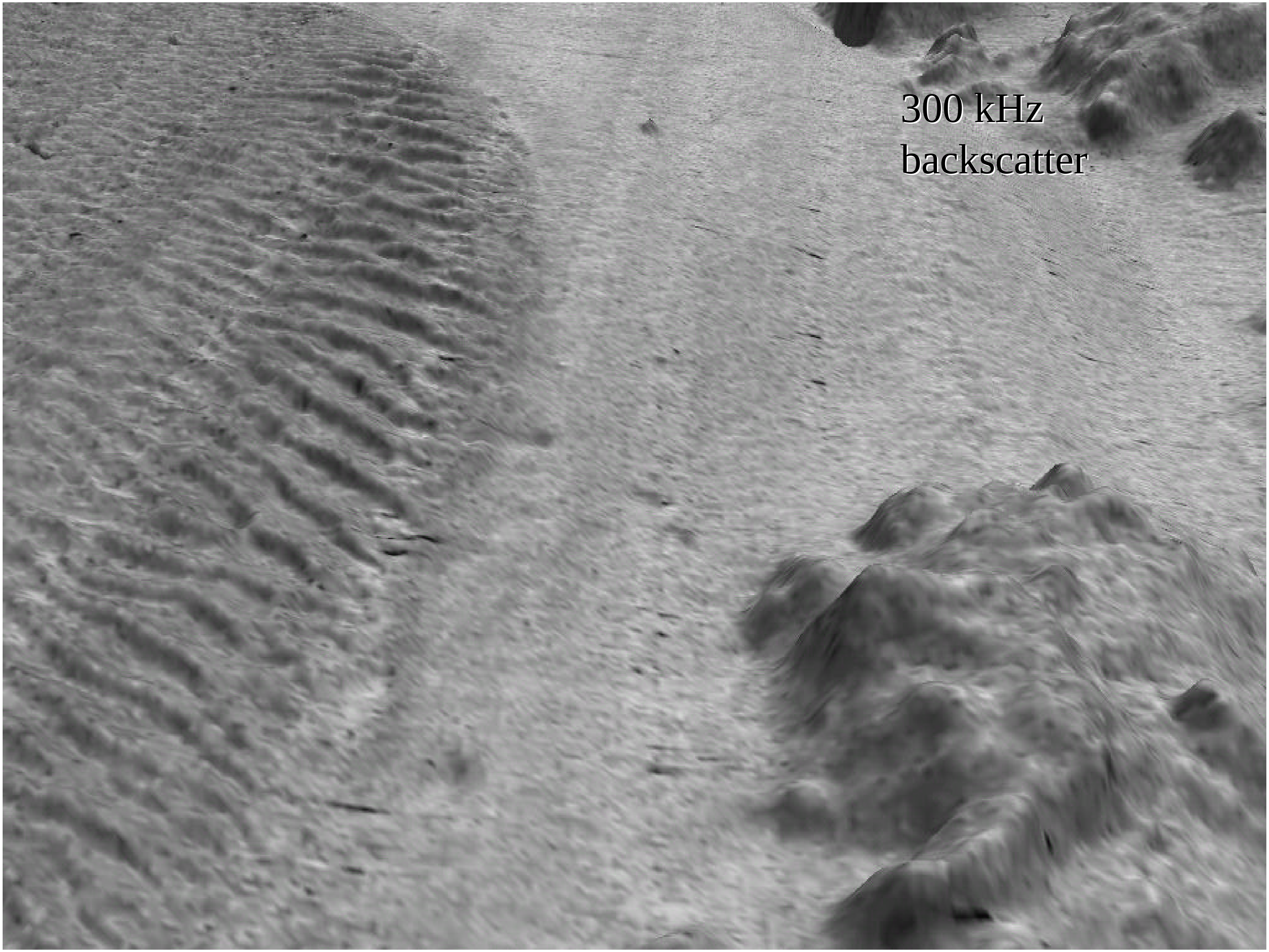
Seward Rks
Pier No. 2
FIXED BRIDGE
KITTERY
Gangway Rk
South Beacon Shoal
Pierces
Little I.
Iso G 6s 56ft
G "11"
Fl G 4s
R "12A" Priv
R "12" Priv
REGULATED AREA
Obstn

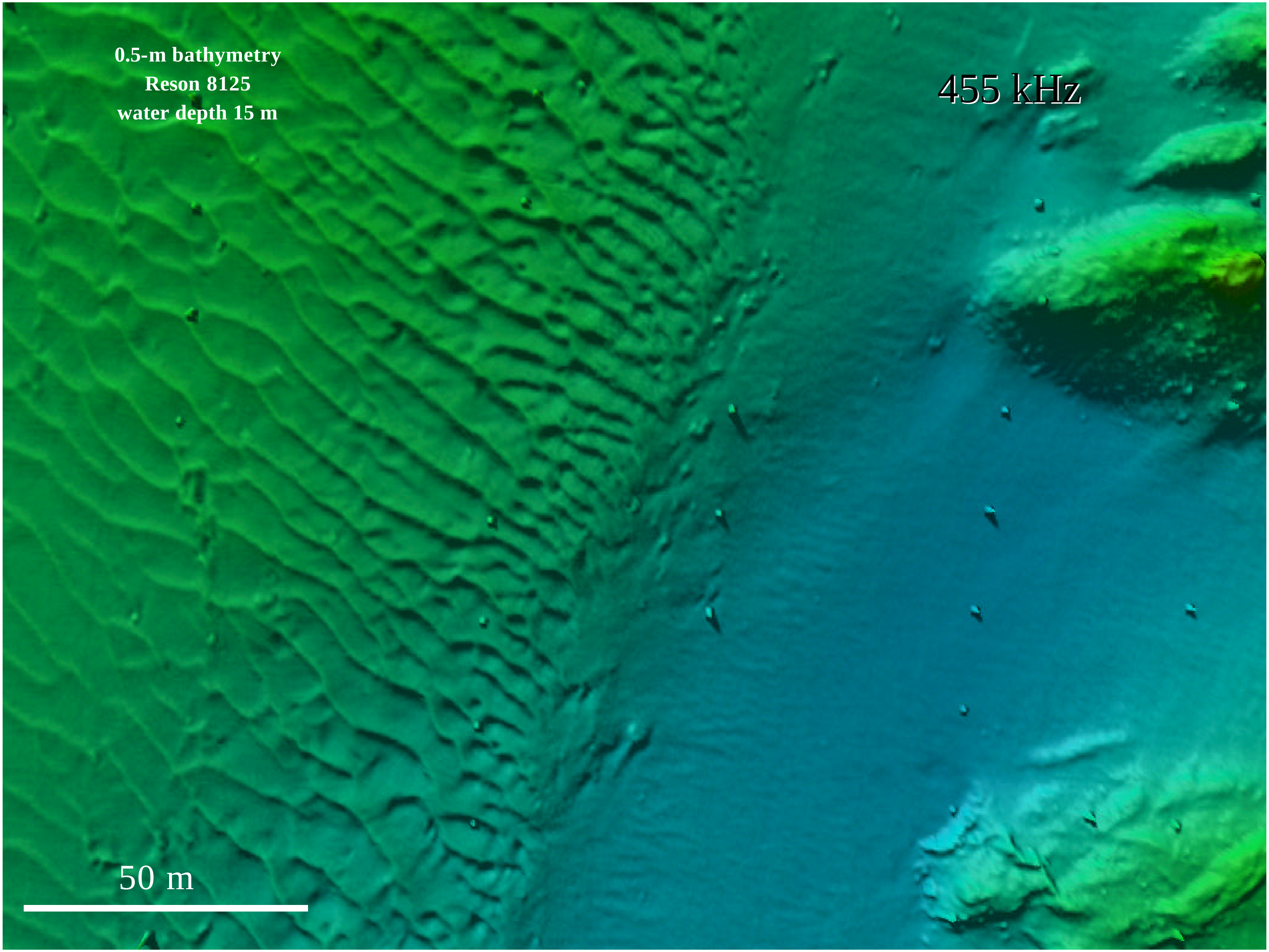


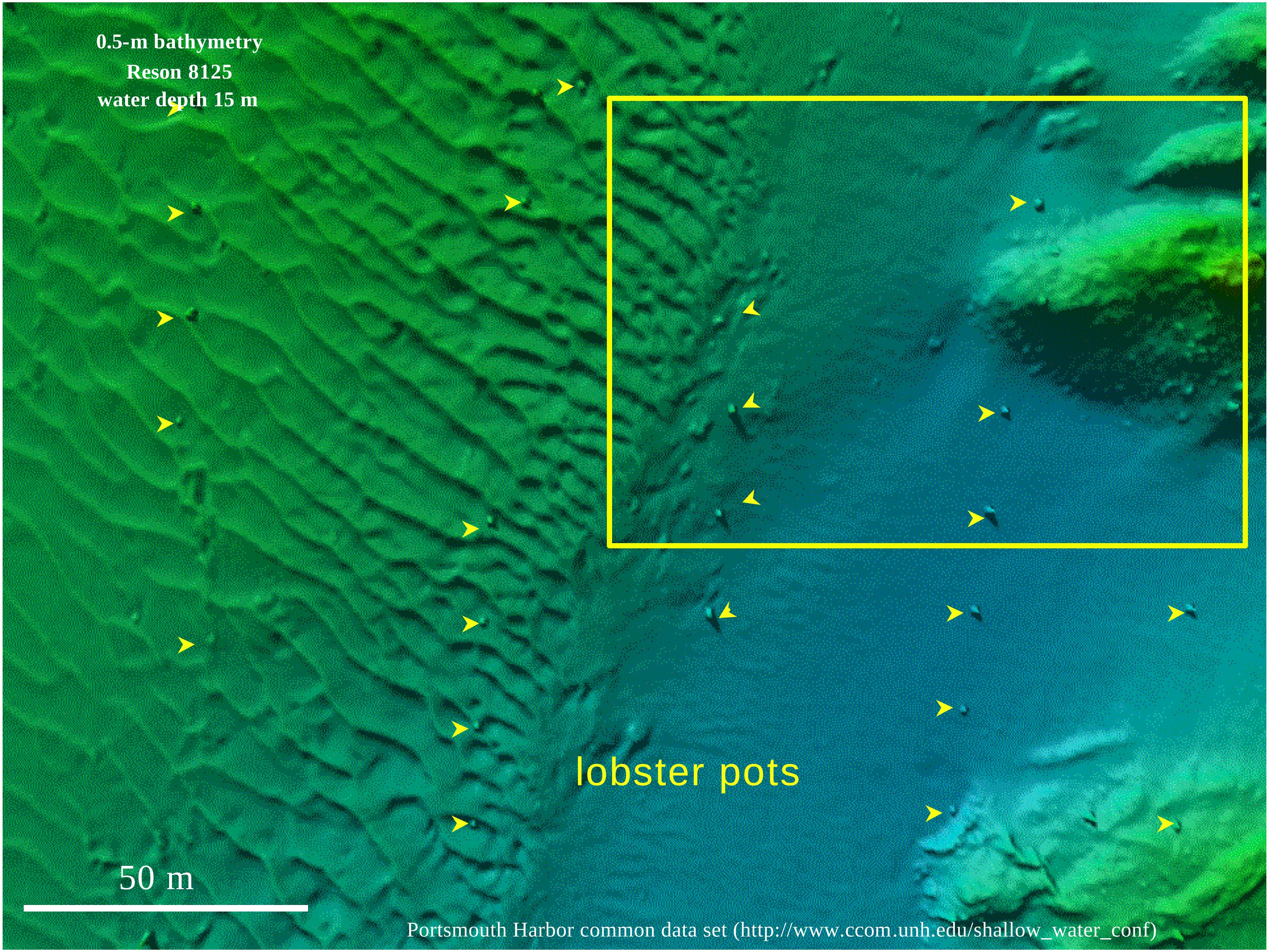
KITTERY
Pier No 2
FIXED BRIDGE
REGULATED AREA
NAVIGATION
(see note A)
South Beach
Pierces
Little I.
Iso G 6s 56ft
Sewer

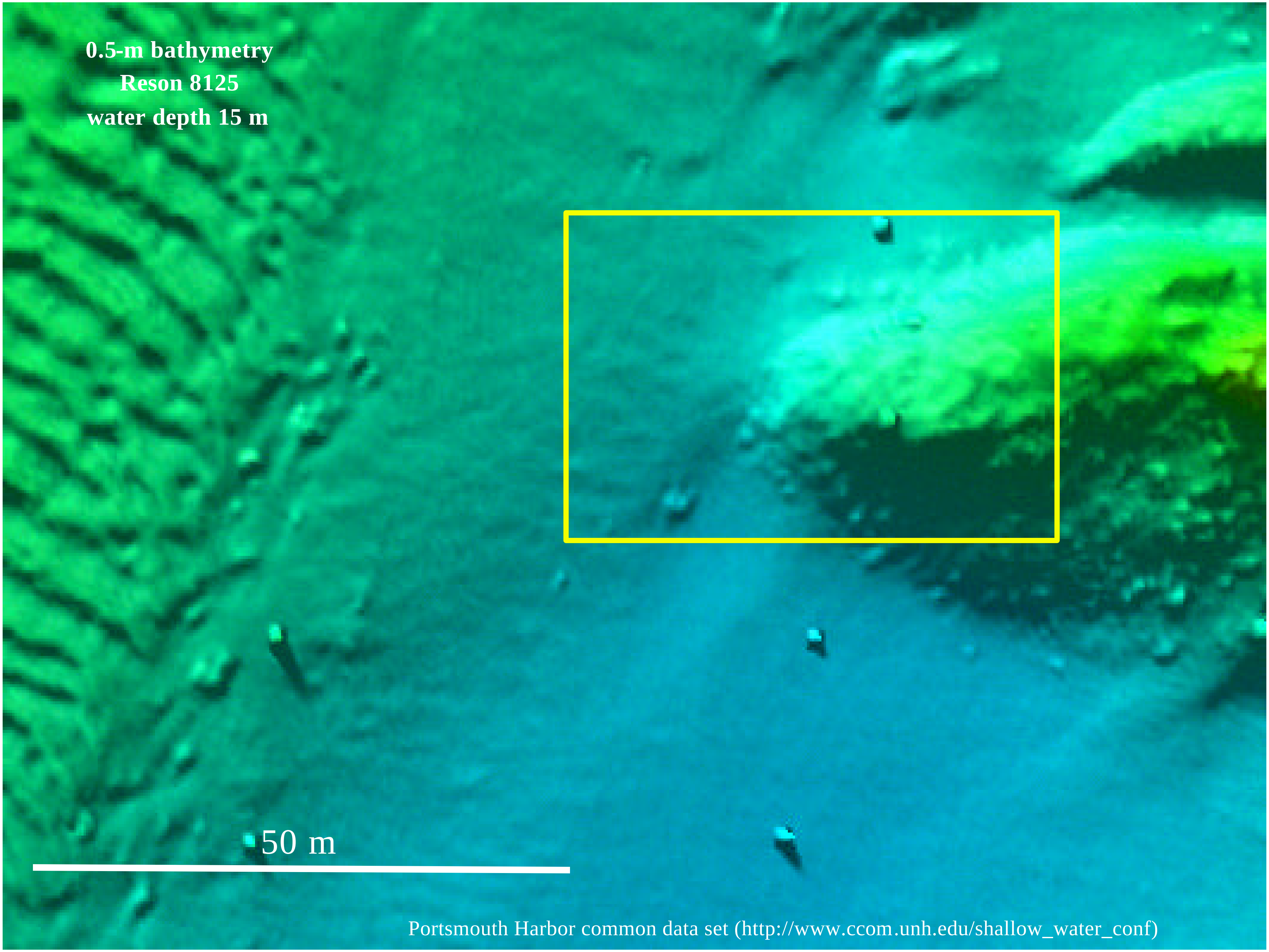

240 kHz

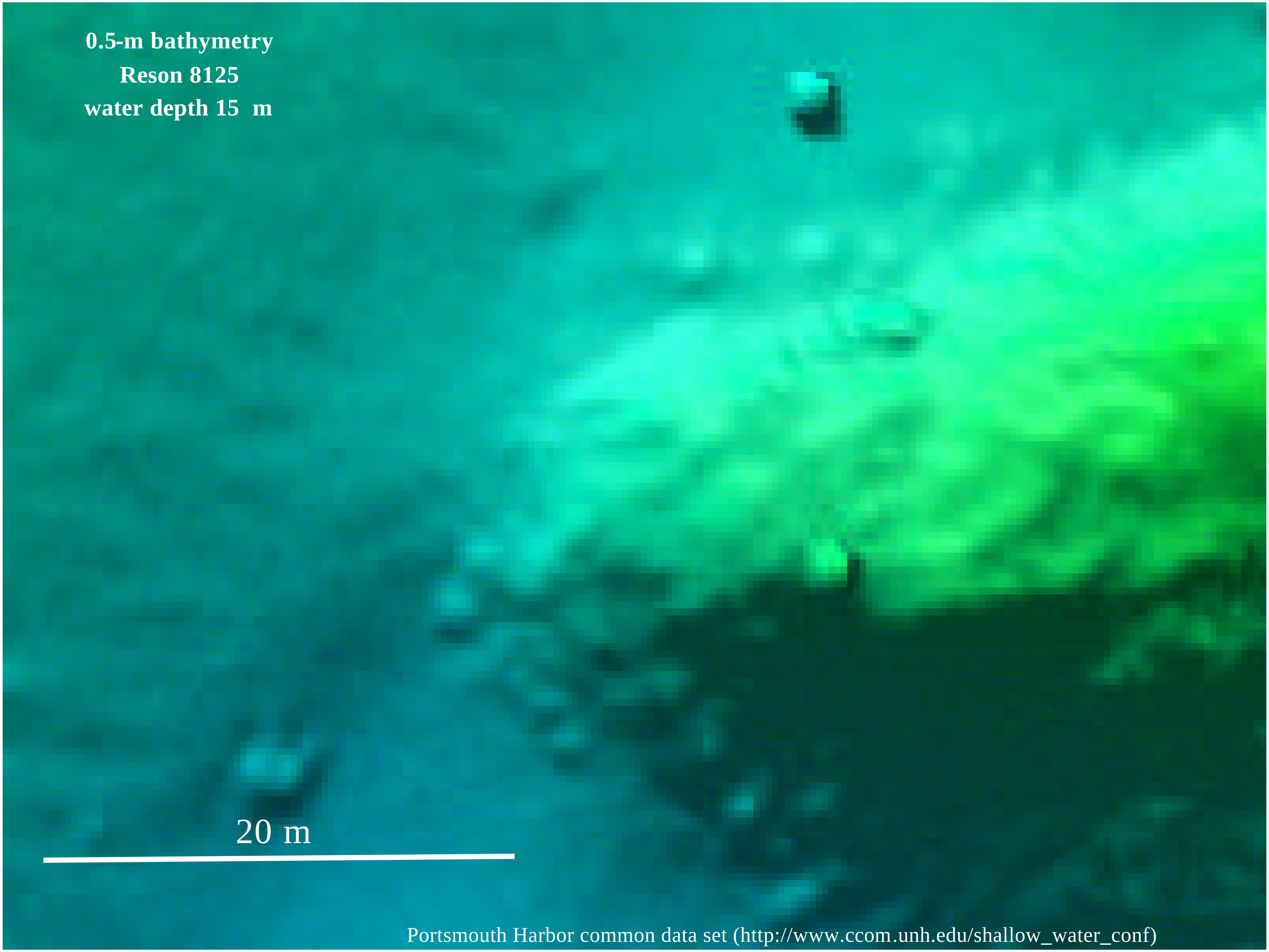

300 kHz

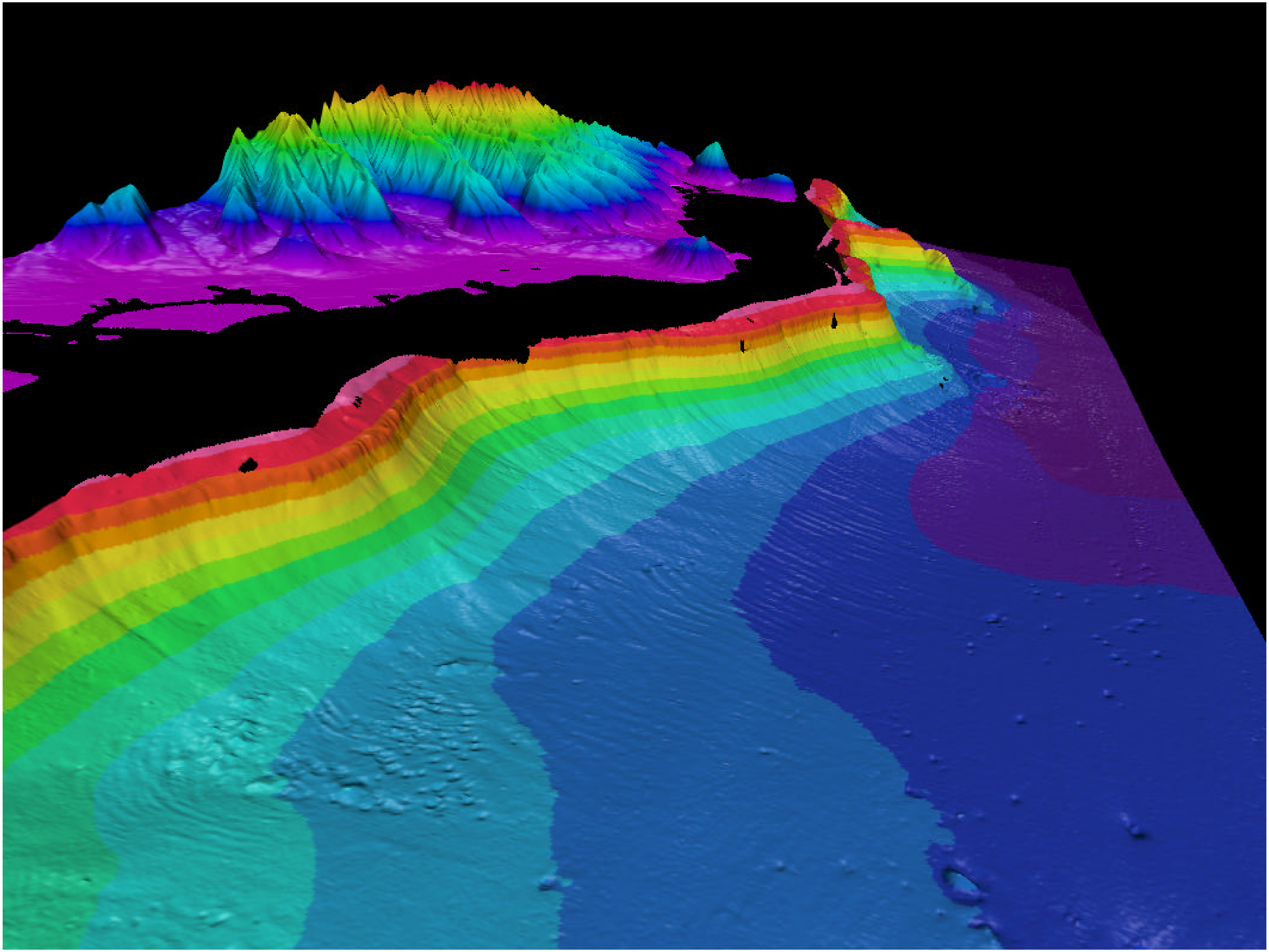

300 kHz
backscatter

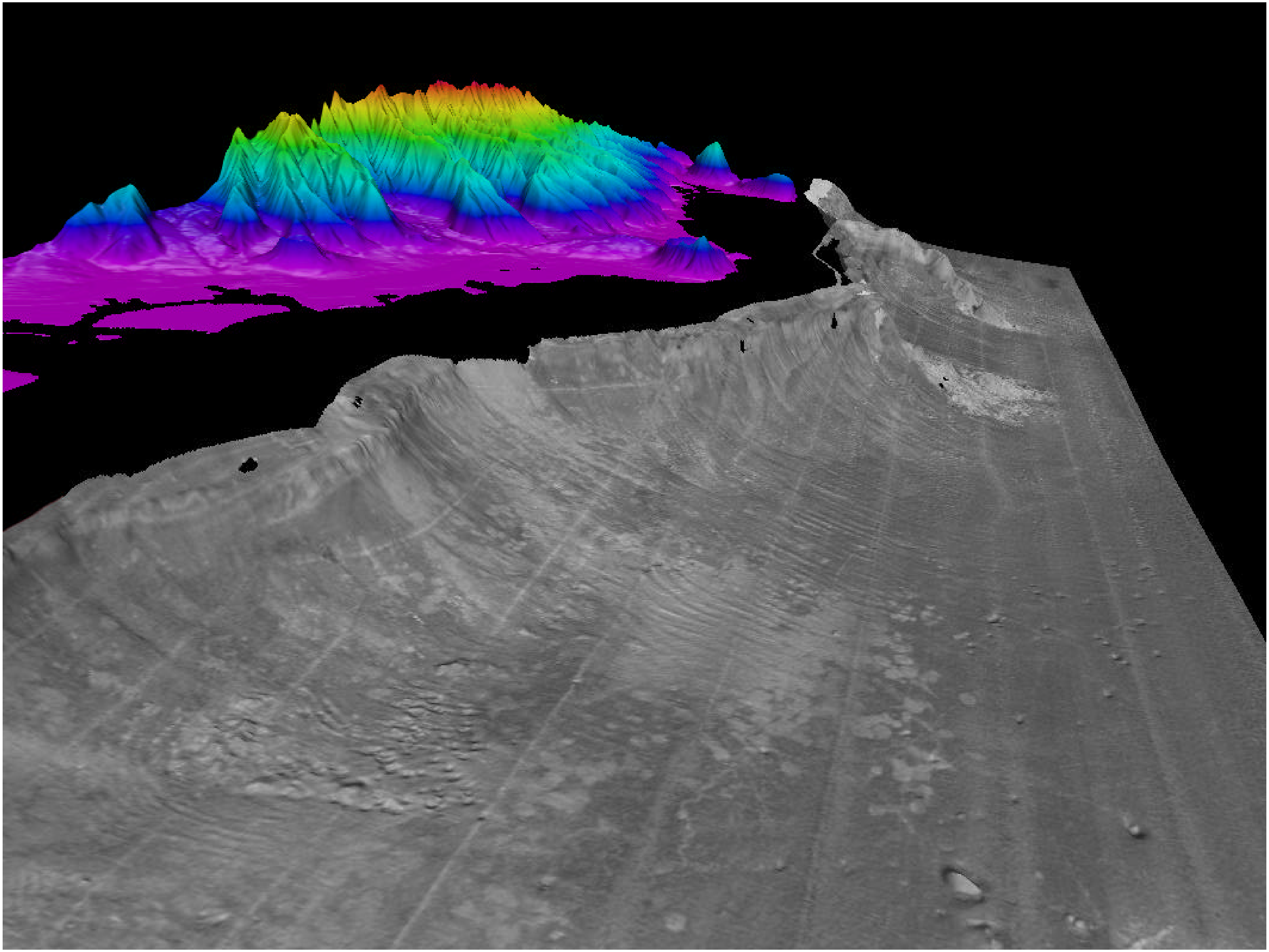

0.5-m bathymetry
Reson 8125
water depth 15 m
455 kHz
50 m

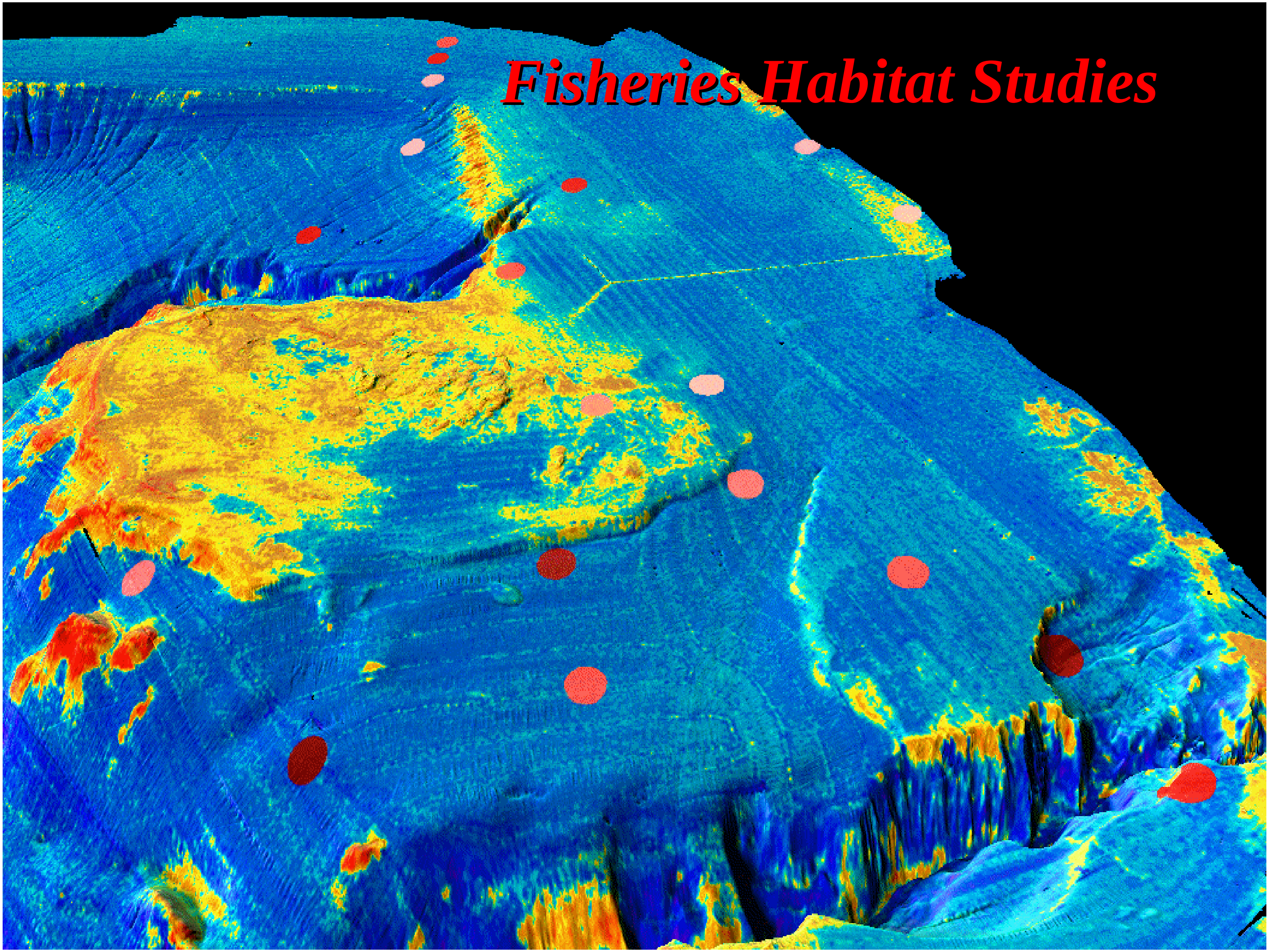

0.5-m bathymetry
Reson 8125
water depth 15 m
lobster pots
50 m
Portsmouth Harbor common data set (http://www.ccom.unh.edu/shallow_water_conf)


0.5-m bathymetry
Reson 8125
water depth 15 m
50 m
Portsmouth Harbor common data set (http://www.ccom.unh.edu/shallow_water_conf)

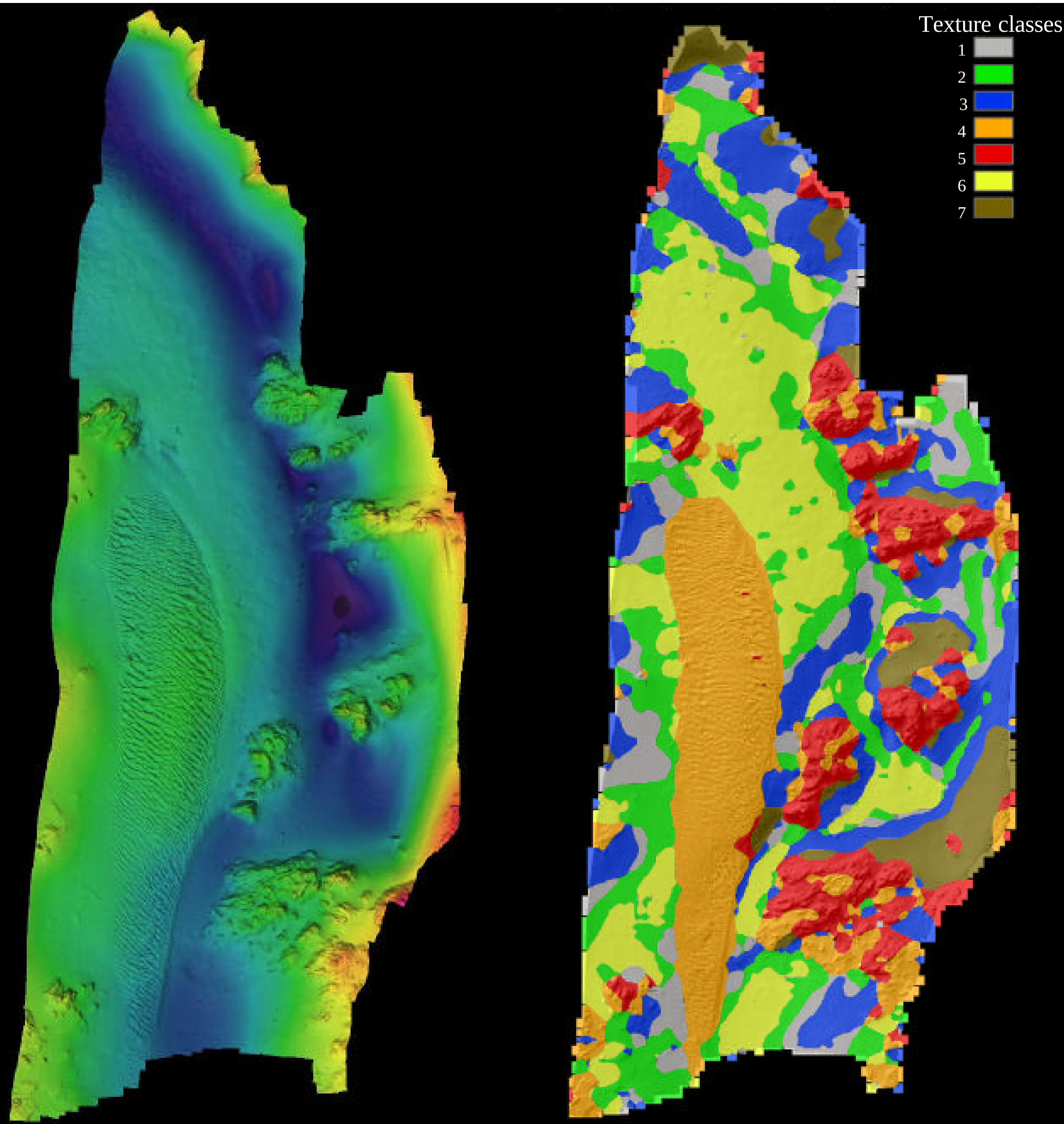

0.5-m bathymetry
Reson 8125
water depth 15 m
20 m
Portsmouth Harbor common data set (http://www.ccom.unh.edu/shallow_water_conf)






Fisheries Habitat Studies

MBES
bathymetry

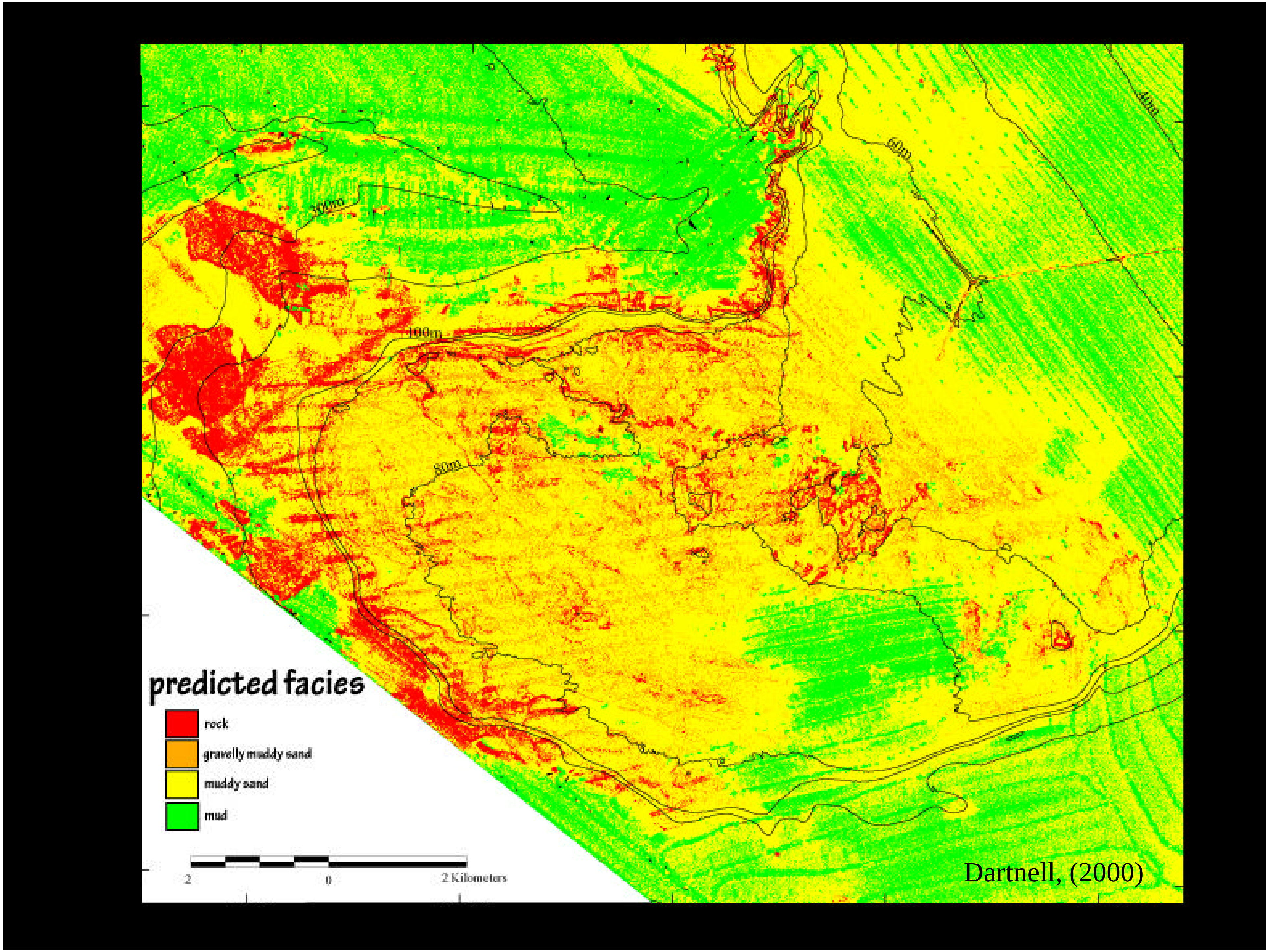


derived
seafloor
texture
classes

Local Fourier Histogram texture segmentation

Cutter et al. (in press)

R. Cutter, (UNH)


predicted facies
rock
gravelly muddy sand
muddy sand
mud
2
0
2 Kilometers
300m
100m
80m
60m
40m
Dartnell, (2000)

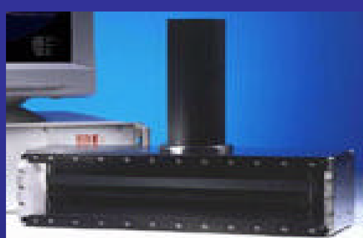
SONARS:

RESON 9001

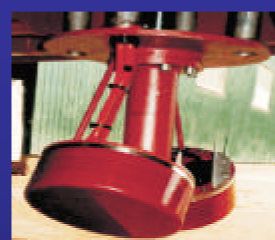
RESON 8101

RESON 8111

SIMRAD EM100

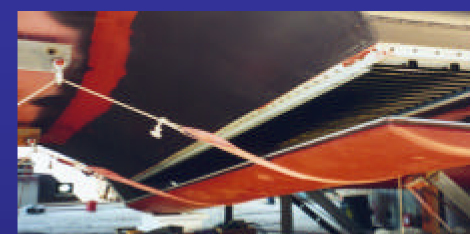


RESON 8125

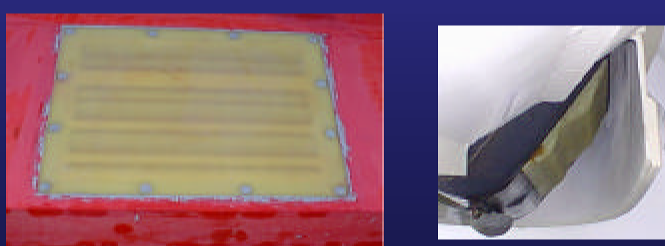


EM3000

ELAC 1050



SIMRAD EM121



FANSWEEP 20

ISIS100

ODOM ECHOSCAN

WHO HAS WHAT????

MULTIBEAMS on UNOLS SHIPS

- Revelle - EM120 (12 kHz)
- Atlantis - SB2000 (12kHz)
- Thompson - EM300 (30 kHz) + Hydrosweep DS (15kHz)
- Ewing - Hydrosweep DS-2 (15 kHz)
- Melville - SB2000
- Knorr - SB2000

WHO HAS WHAT????

MULTIBEAMS on UNOLS SHIPS

- Kilo Moana - EM120 (12 KHz) + EM1002 (95 kHz)
- Nathaniel Palmer - EM120 (12 kHz)
- Healy - SB2100 (0 kHz)
- New Delaware Vessel - Reson 8101 - 240 kHz

WHO HAS WHAT????

MULTIBEAMS on UNOLS SHIPS

- Several high-frequency systems (mostly EM3000 - 300 kHz) -- SUNY Stony Brook, USF, …

OTHER Mapping Assets:

- AUV's
  - ABE w/ Simrad SM2000 - 200 kHz
    - Mesotech and other 675 KHz sector scanners
  - MBARI w/ Reson 7000 series

WHO HAS WHAT????

OTHER Mapping Assets:

- ROV's - JASON and others - SM2000 sector scanning sonar - very fine bathy
- Towed Vehicles - single beam bathy and sidescan
  - DSL-120 - phase comp bathy
  - Deep-Tow

Swath-mapping sonars

- ***Beam forming sonars:***

  -bathymetry and co-registered backscatter with angular resolution

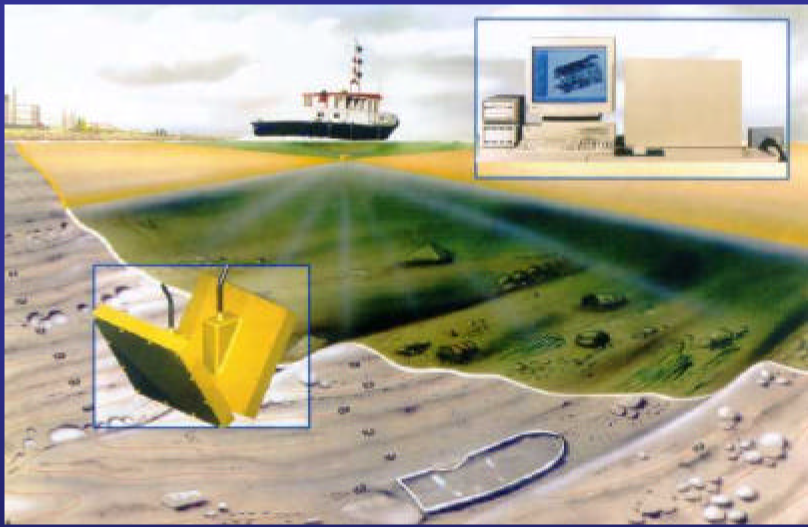
- ***Interferometric sonars:***

  -use phase comparison to generate bathy – sidescan sonar-like imagery

SONARS:

"Hybrid" sonars: use interferometry for high-quality imagery -- some beam forming for ambiguity resolution

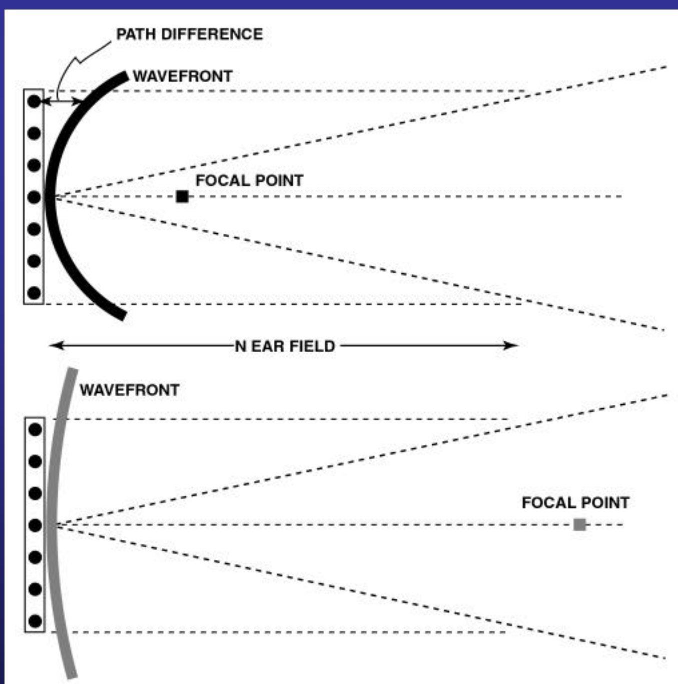
Trends: better algorithms for interferometric solutions = higher resolution bathymetry while maintaining high-quality, co-registered imagery and wide swath – also SAS

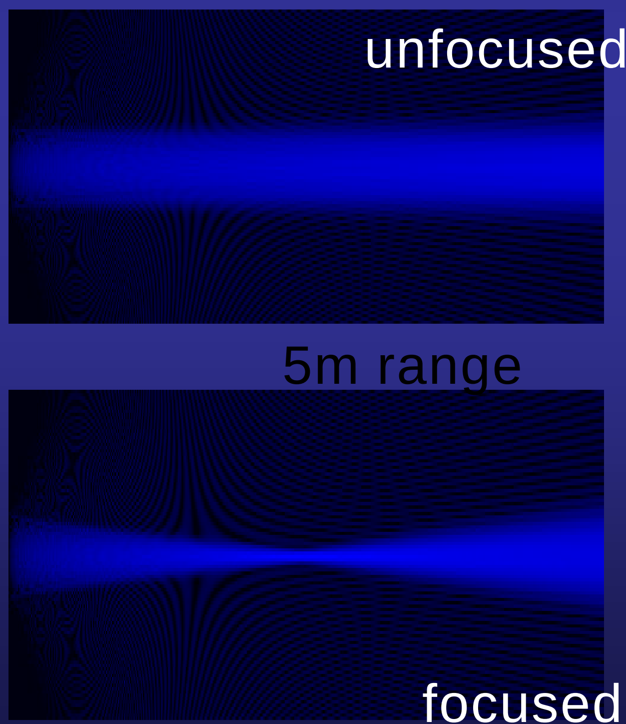


Atlas FanSweep 20

SONARS:

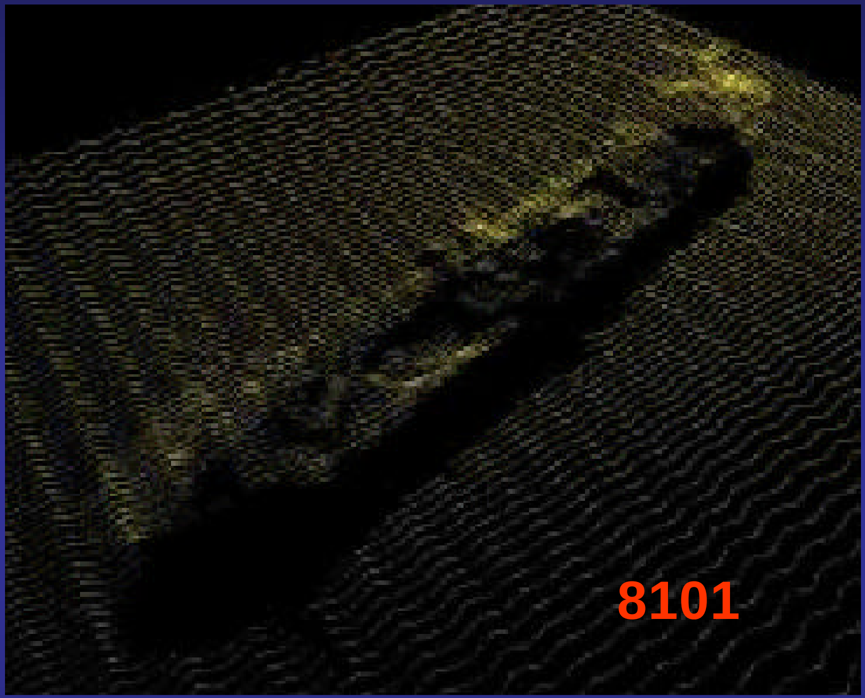
“Focused” sonars: compensate for wavefront curvature to allow focusing in the near-field. Much higher target resolution



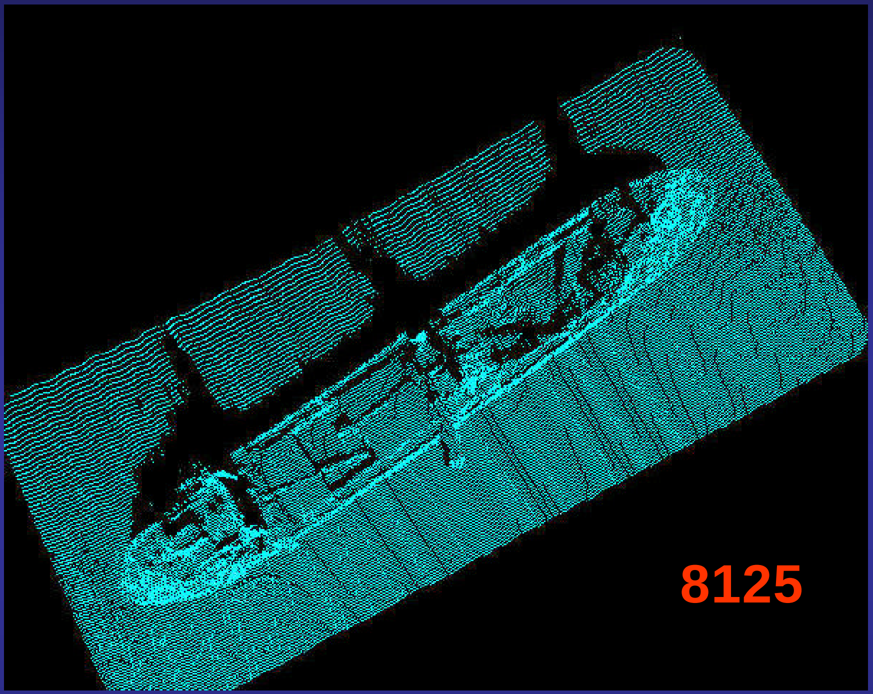


RESON 8125

Focused Sonar



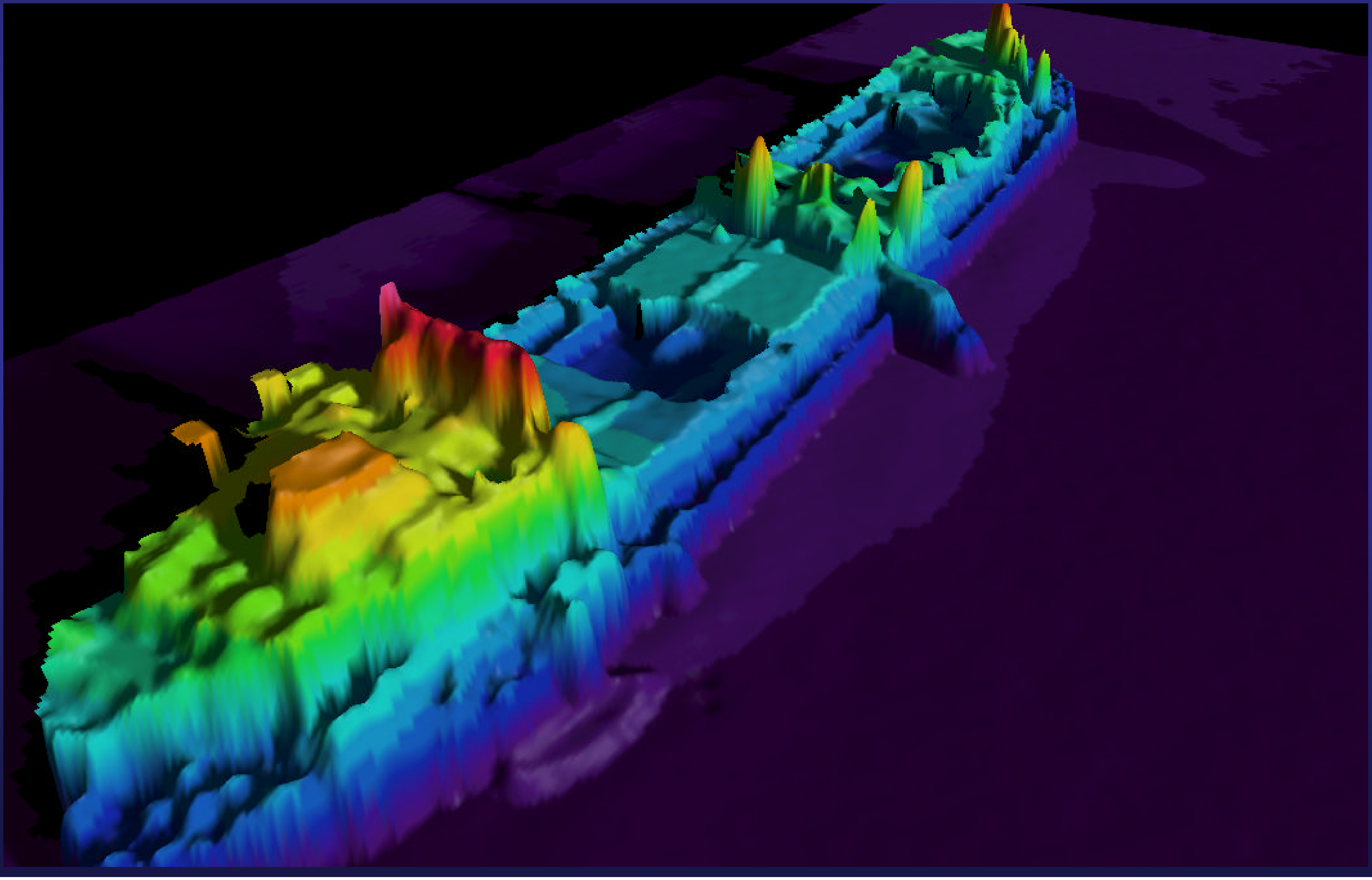
unfocused



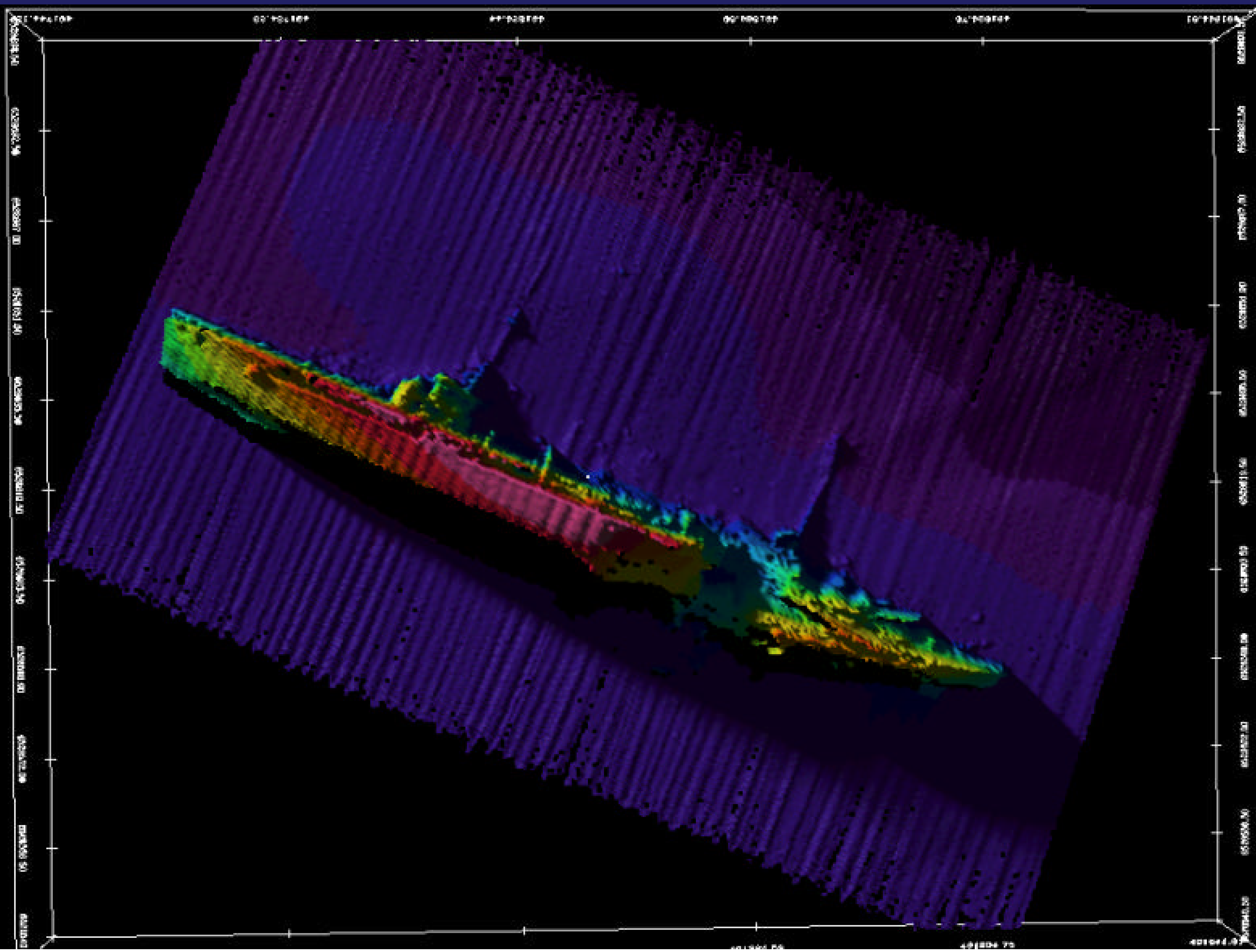
focused

SeaBat 8125 and 8101 bathymetry collected at 5 knots over the 103m long freighter, Al-Mansoura, in 50 m of water in the Persian Gulf after hitting a platform at night in 1985. (Courtesy of RESON)

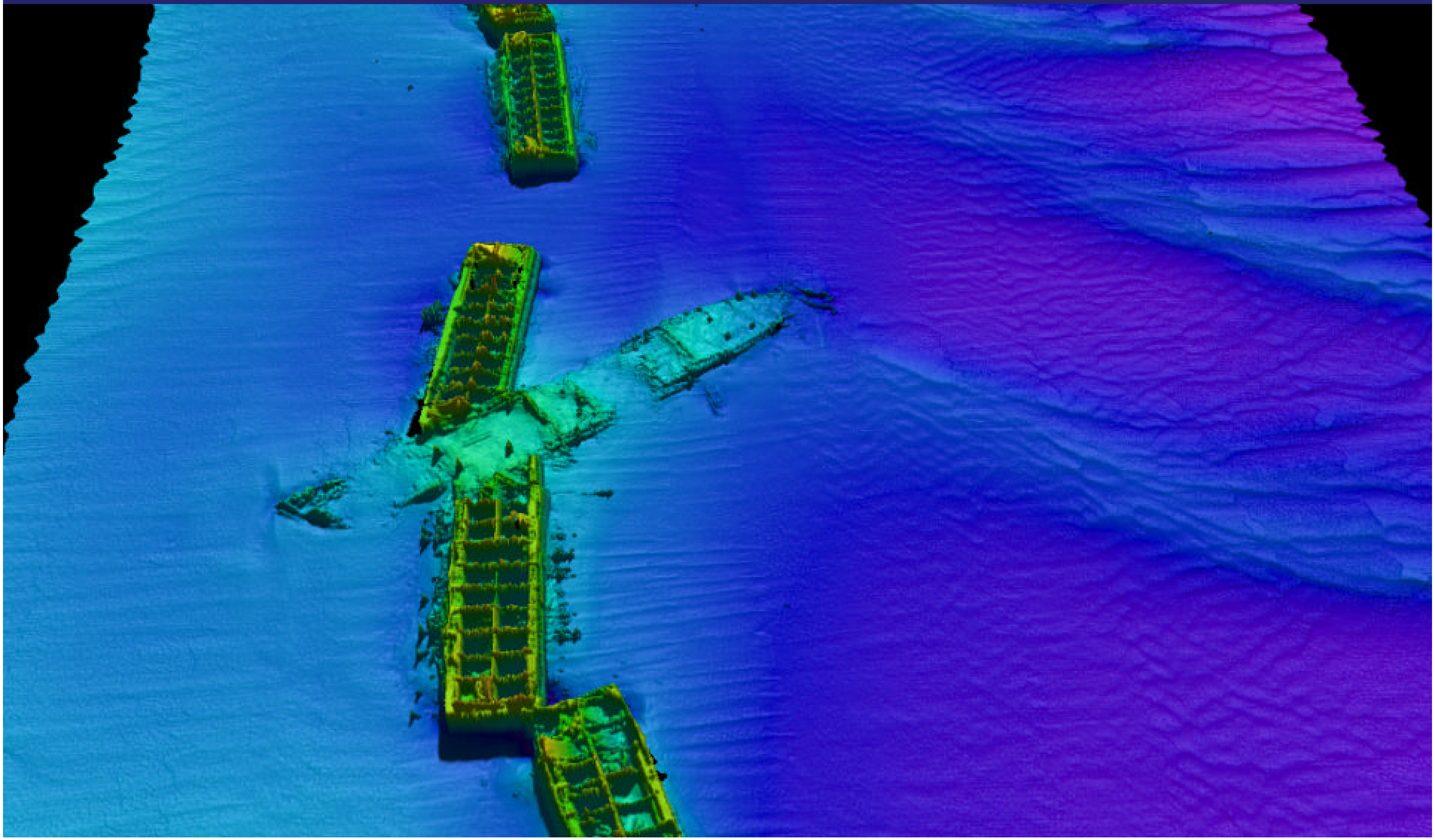
Reson SeaBat 8125 bathymetry collected at 5 knots over the 103m long freighter, Al-Mansoura, sunk in 50 m of water in the Persian Gulf in 1985. Visualized with Fledermaus interactive 3-D software



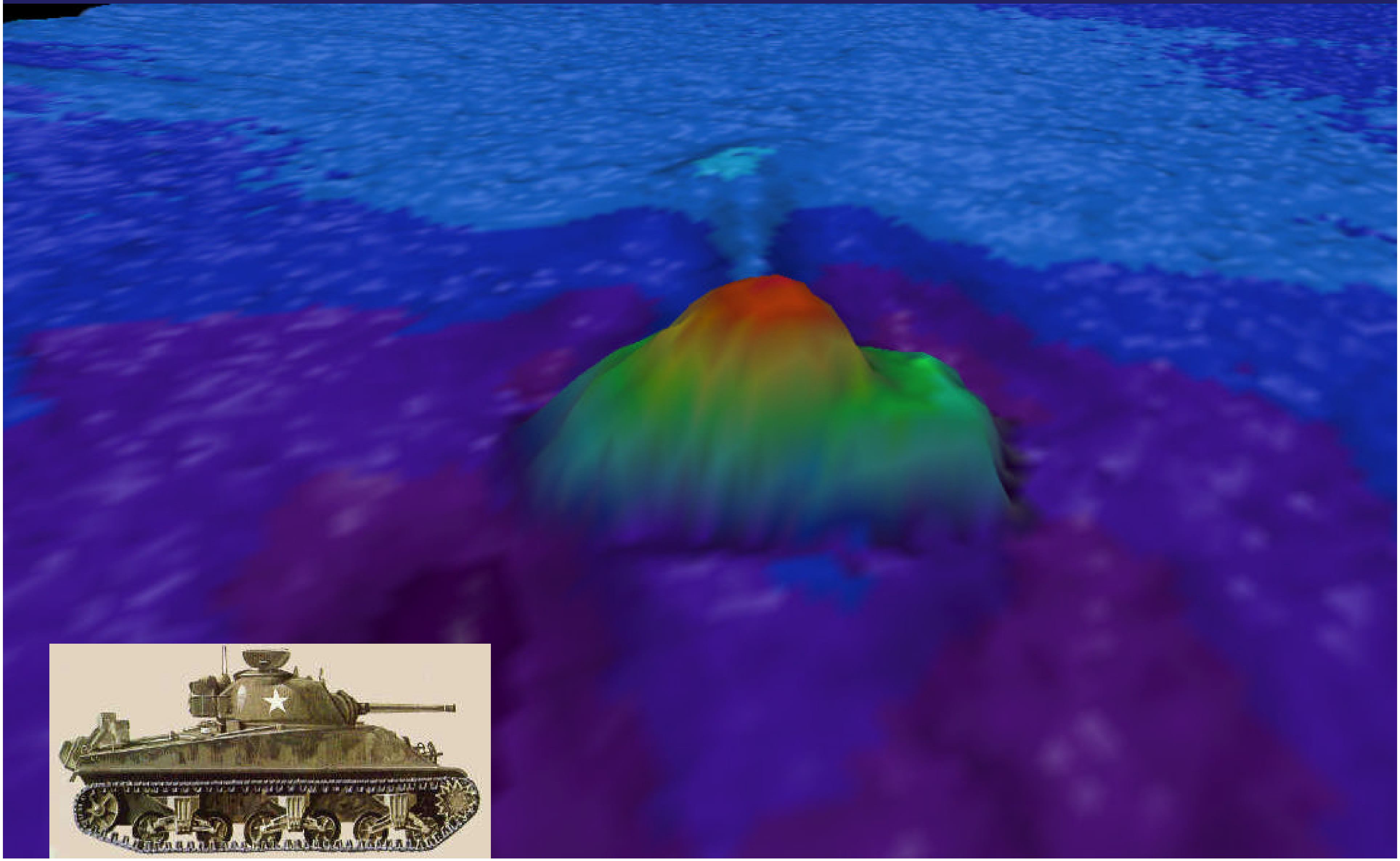
SCUTTLED GERMAN FLEET IN SCAPA FLOW

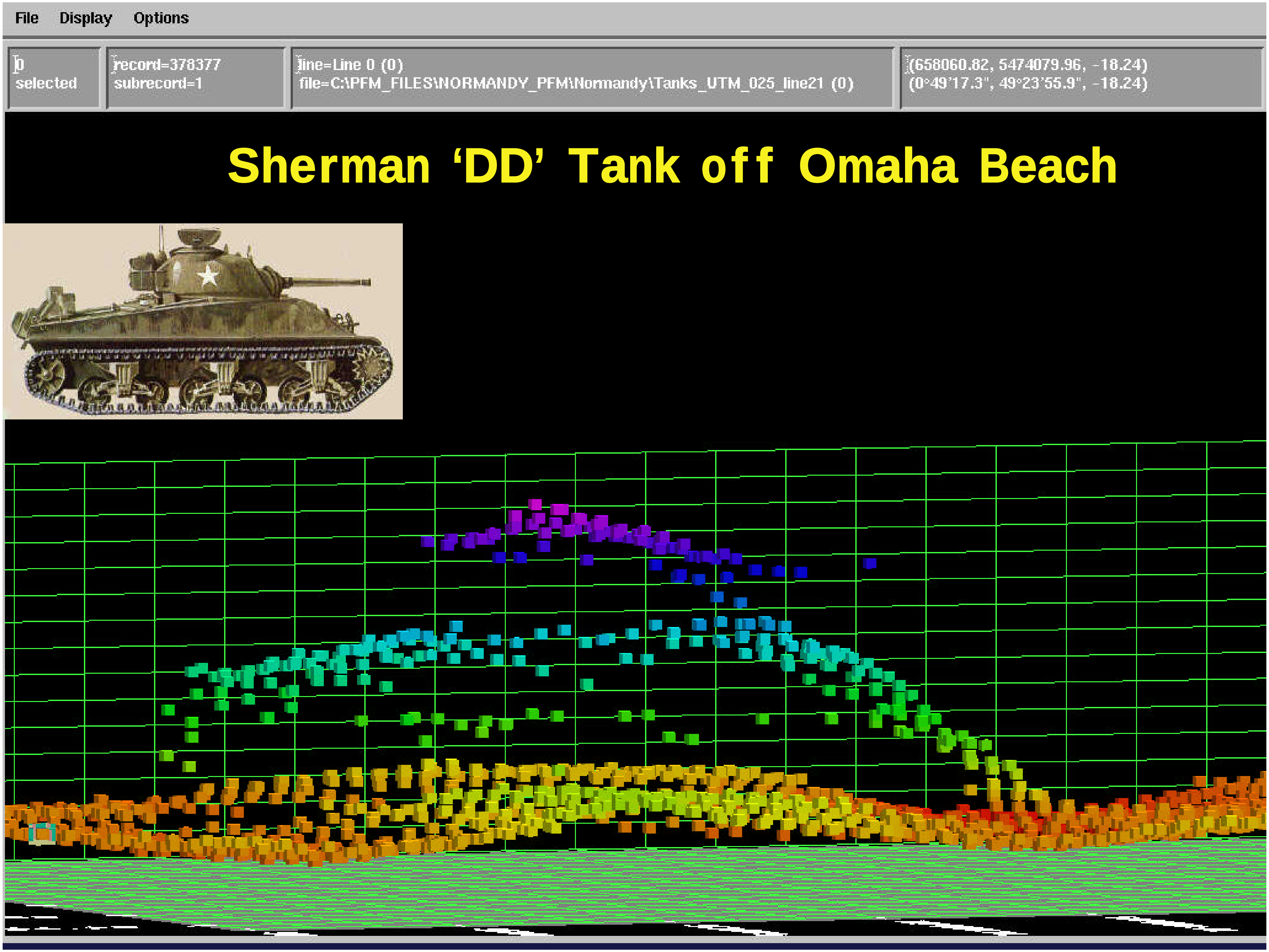


Mulberry Harbor off Omaha Beach



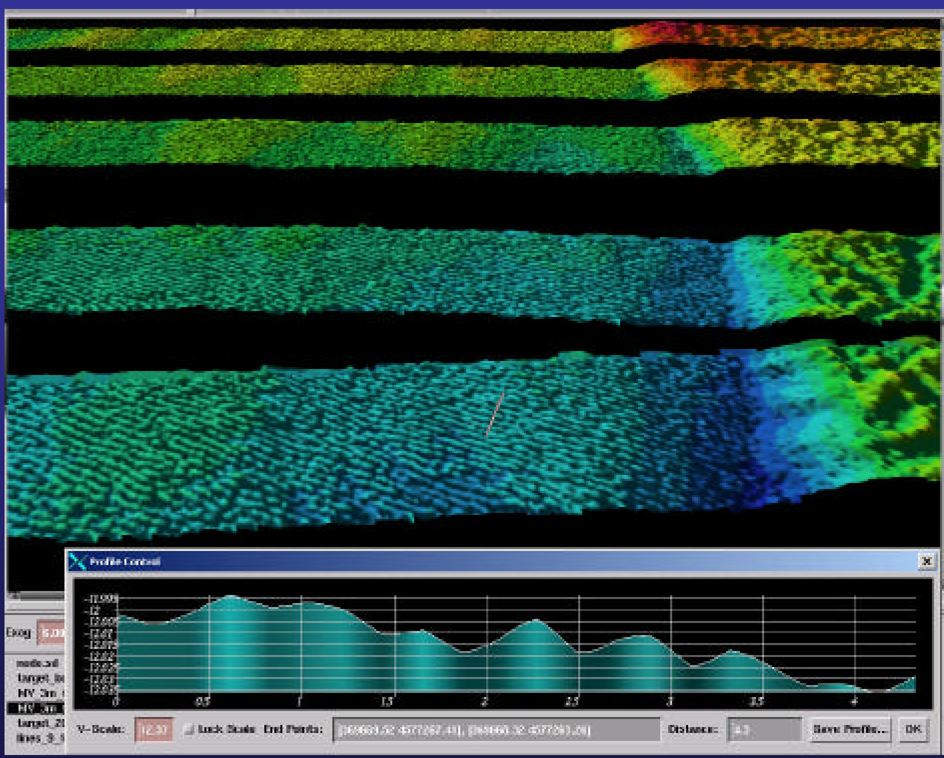
Sherman 'DD' Tank off Omaha Beach

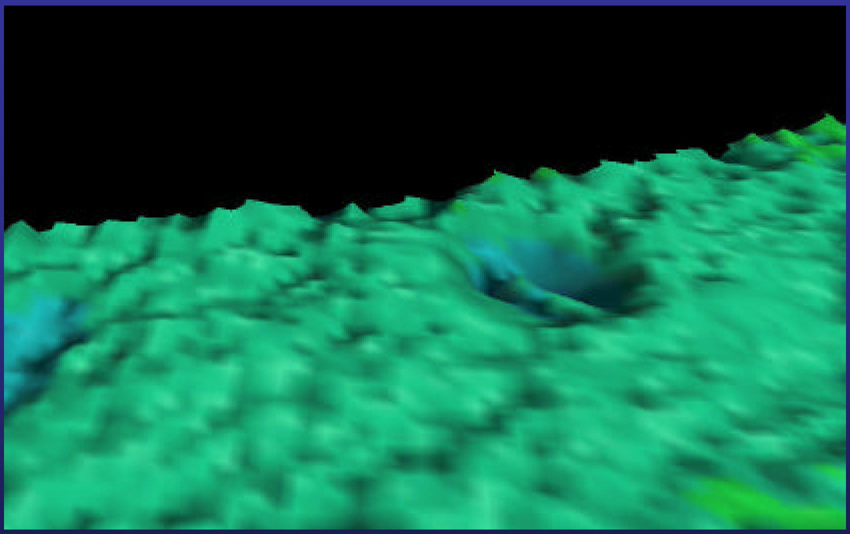



File
Display
Options
0
selected
record=378377
subrecord=1
line=Line 0 (0)
file=C:\PFM_FILES\NORMANDY_PFM\Normandy\Tanks_UTM_025_line21 (0)
(658060.82, 5474079.96, -18.24)
(0°49'17.3", 49°23'55.9", -18.24)
Sherman 'DD' Tank off Omaha Beach

Martha's Vineyard Mine Burial Site

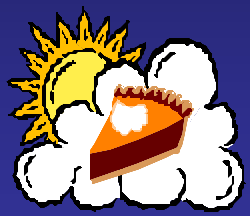
Go Live Here





SONARS:

"CHIRP" multibeam sonars:



- Increased bandwidth = increased temporal resolution
- Increased bandwidth = "multispectral" thematic mapping
- Increased bandwidth = multiple pings in water = increased sounding density

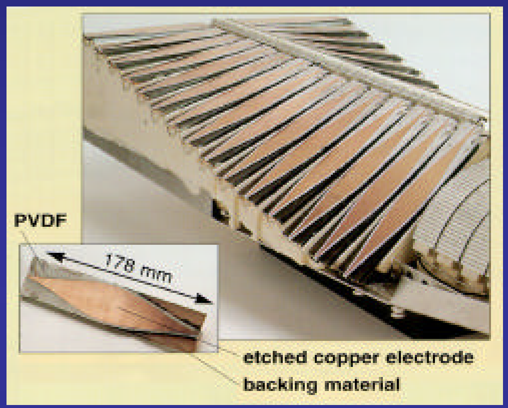
The Beauty of Bandwidth

Radarsat

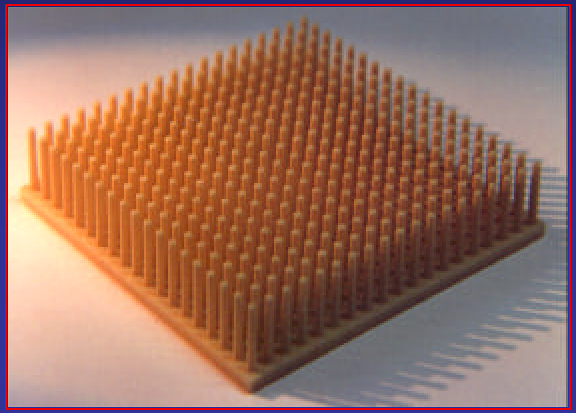
Narrow band

Full bandwidth

New Transducer Materials:

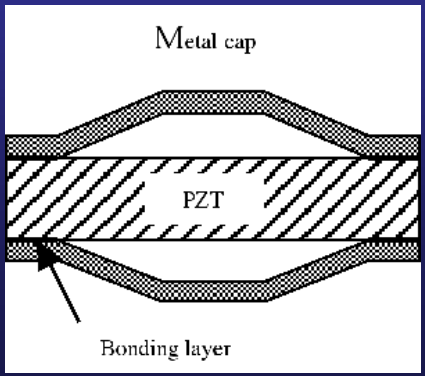


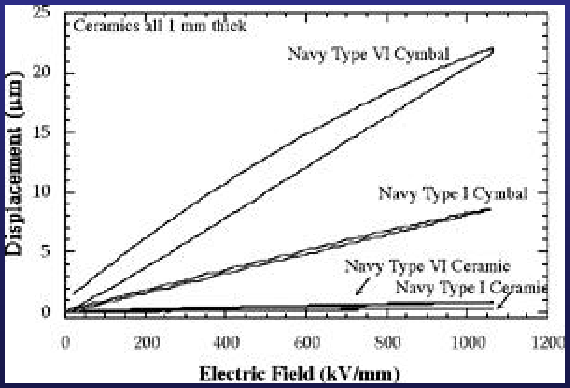
PVDF **p**oly**v**inyl**d**ene **f**luoride
(Airmar Corp)



1-3 Piezocomposite
(Materials Systems Inc)

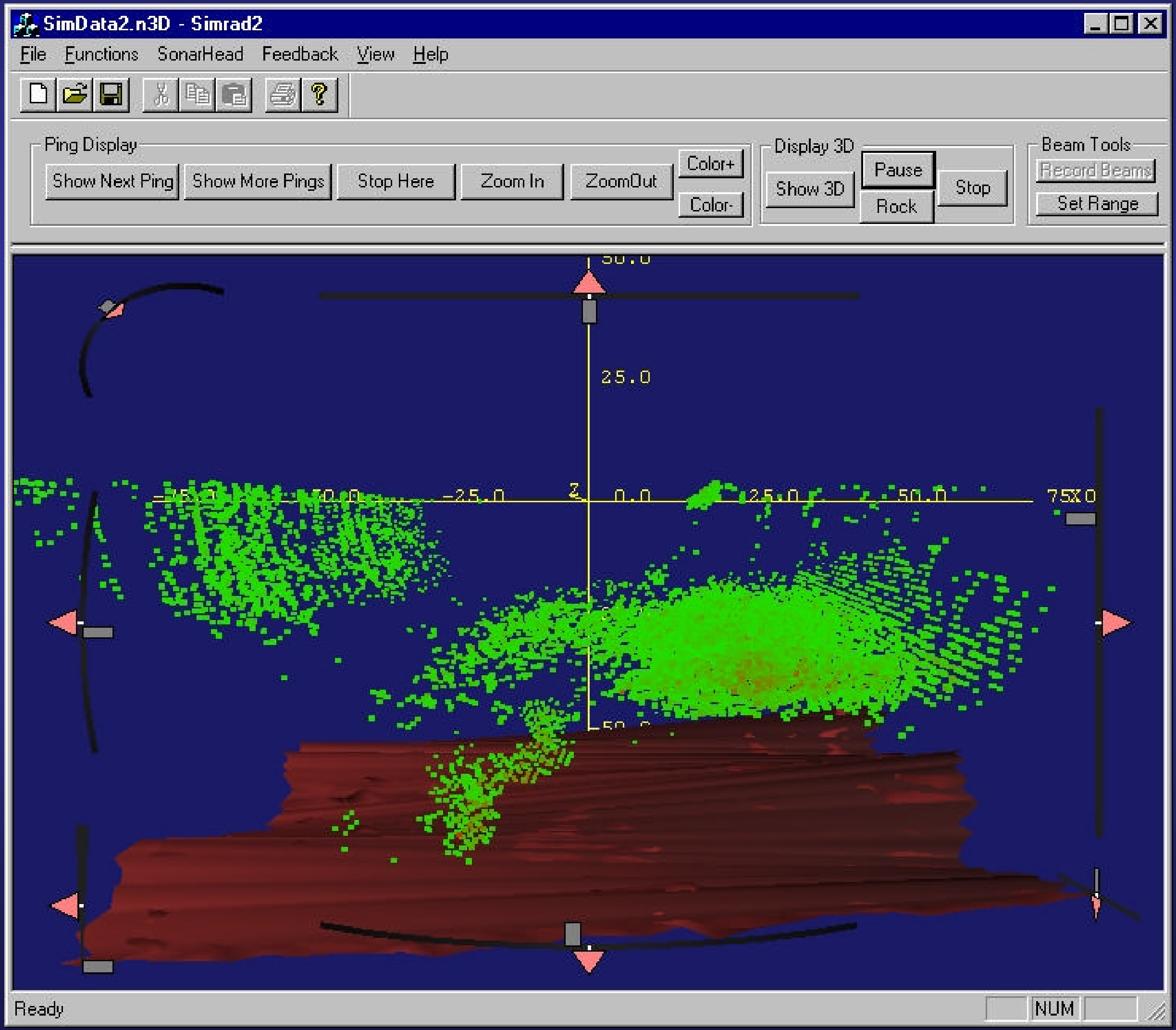
cymbals



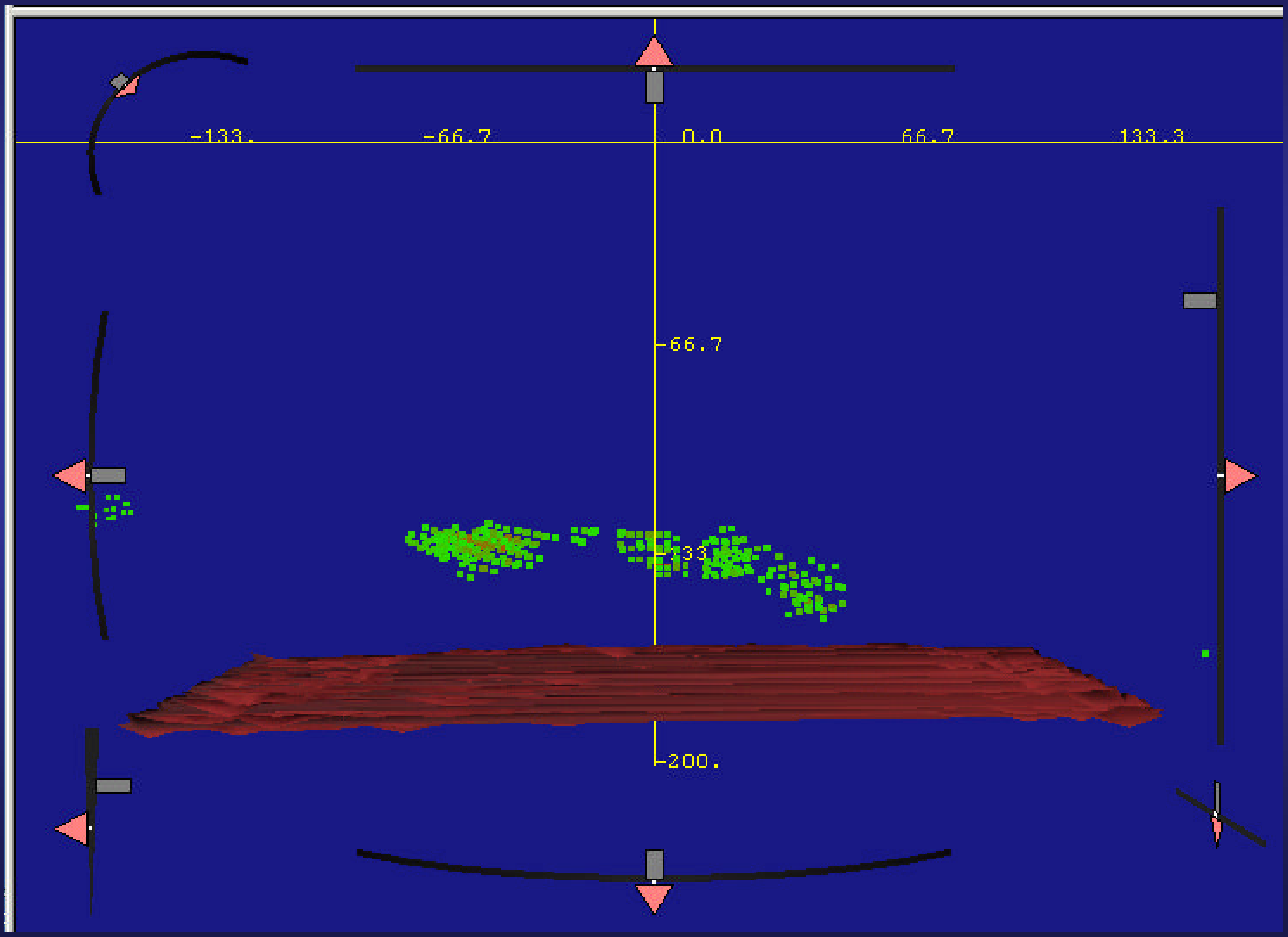


Mapping the water column:

SM2000



Midwater target mapping



SENSORS:

Motion Sensors:

Tightly integrated inertial/GPS

Attitude - .01 deg (RTK)
Heading - .02 deg (RTK or DGPS)
Velocity - .01 m/sec (RTK)
Position - .02 - .10 m (RTK)
200 Hz update rate

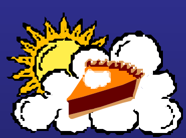
Continued improvements - not limiting factor

SENSORS:

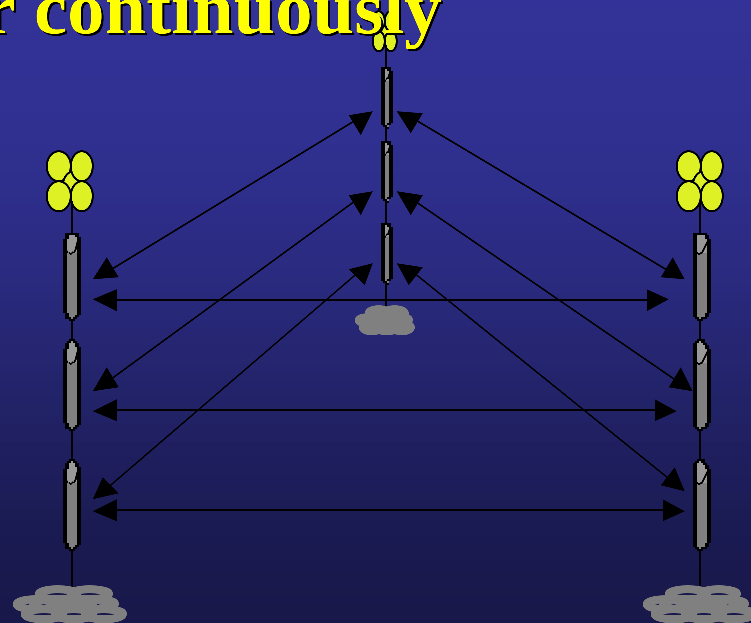
Sound Speed Profile:

Still biggest source of error

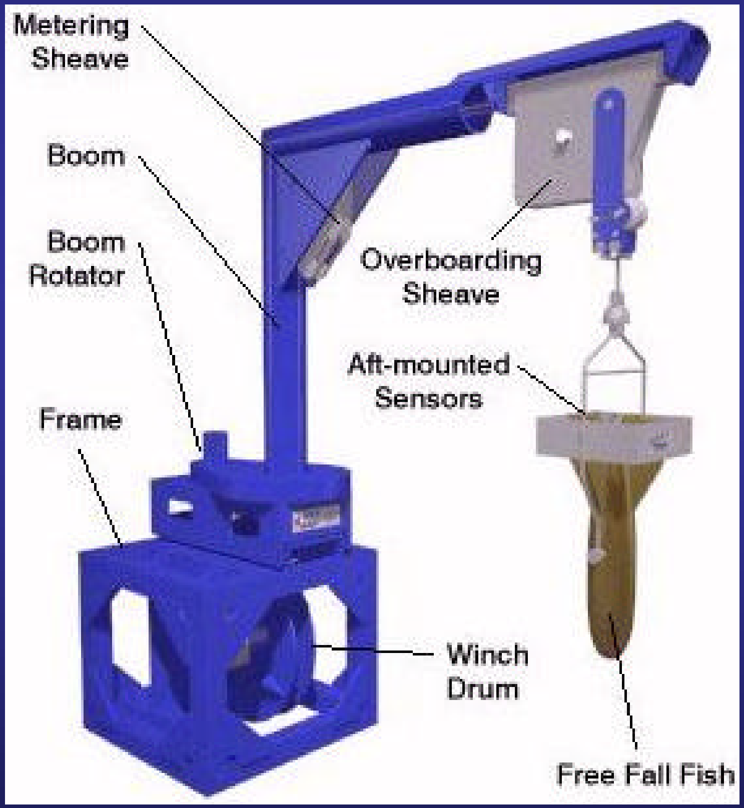
- **Improved MVP and other continuously profiling sensors**

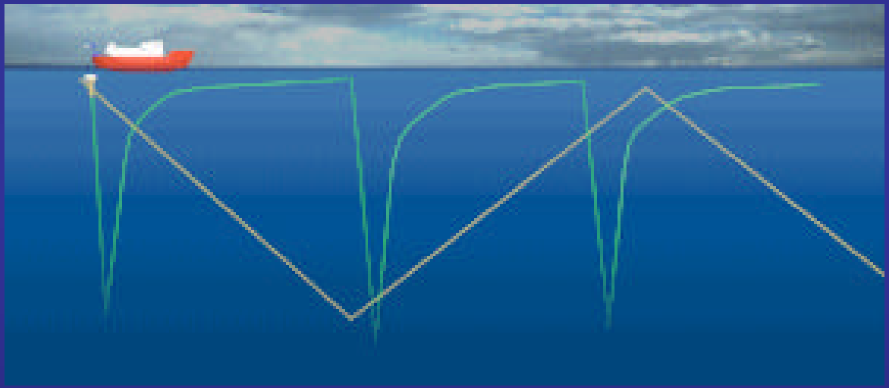


- **Tomographic arrays**



Moving Vessel Profiler





PLATFORMS:

The future of deepwater mapping is SHALLOW WATER MAPPING

Hugin AUV

PLATFORMS:

ROV's and particularly AUV's:

•**HIGH RESOLUTION BATHYMETRY**

Example - 2000m Depth:

Surface Ship - 7.0m Depth Resolution

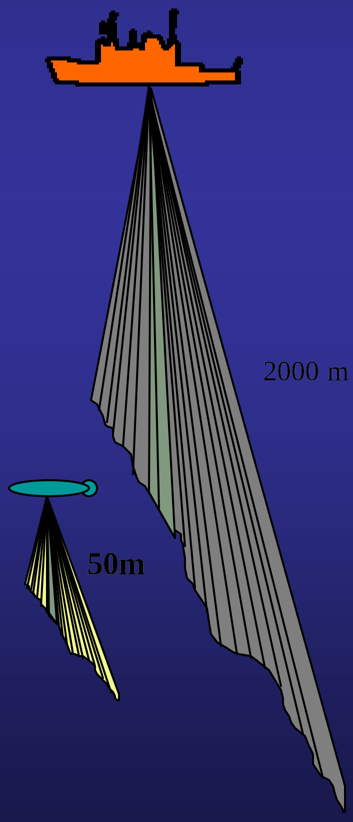
AUV - 0.2m Depth Resolution

•**HIGH RESOLUTION CO-LOCATED IMAGERY**

Example - 2000m Depth:

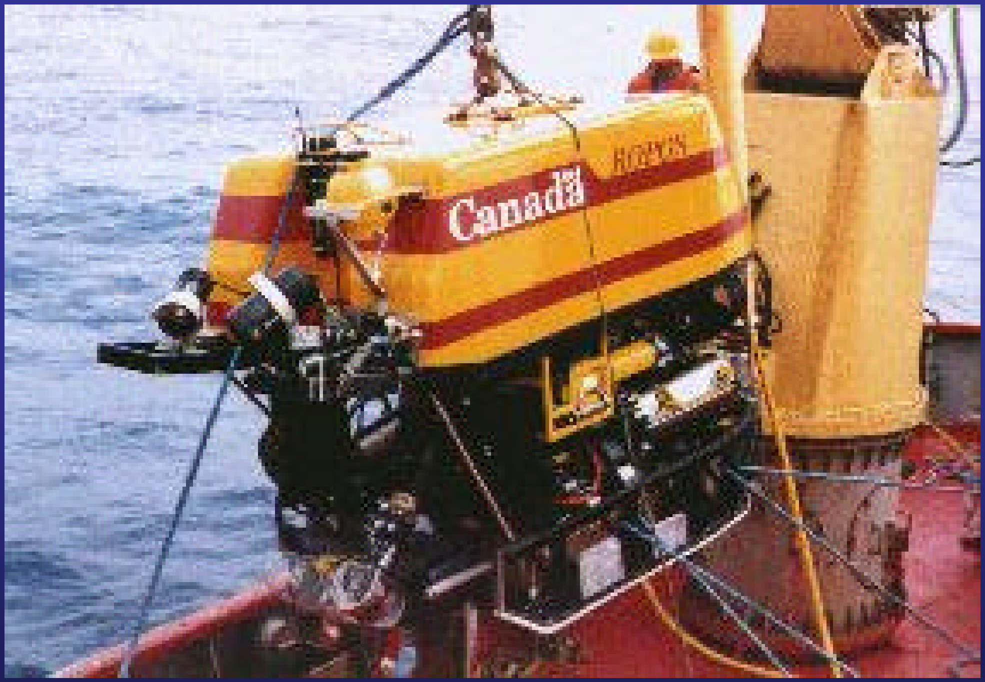
Surface Ship - 40.0m pixel

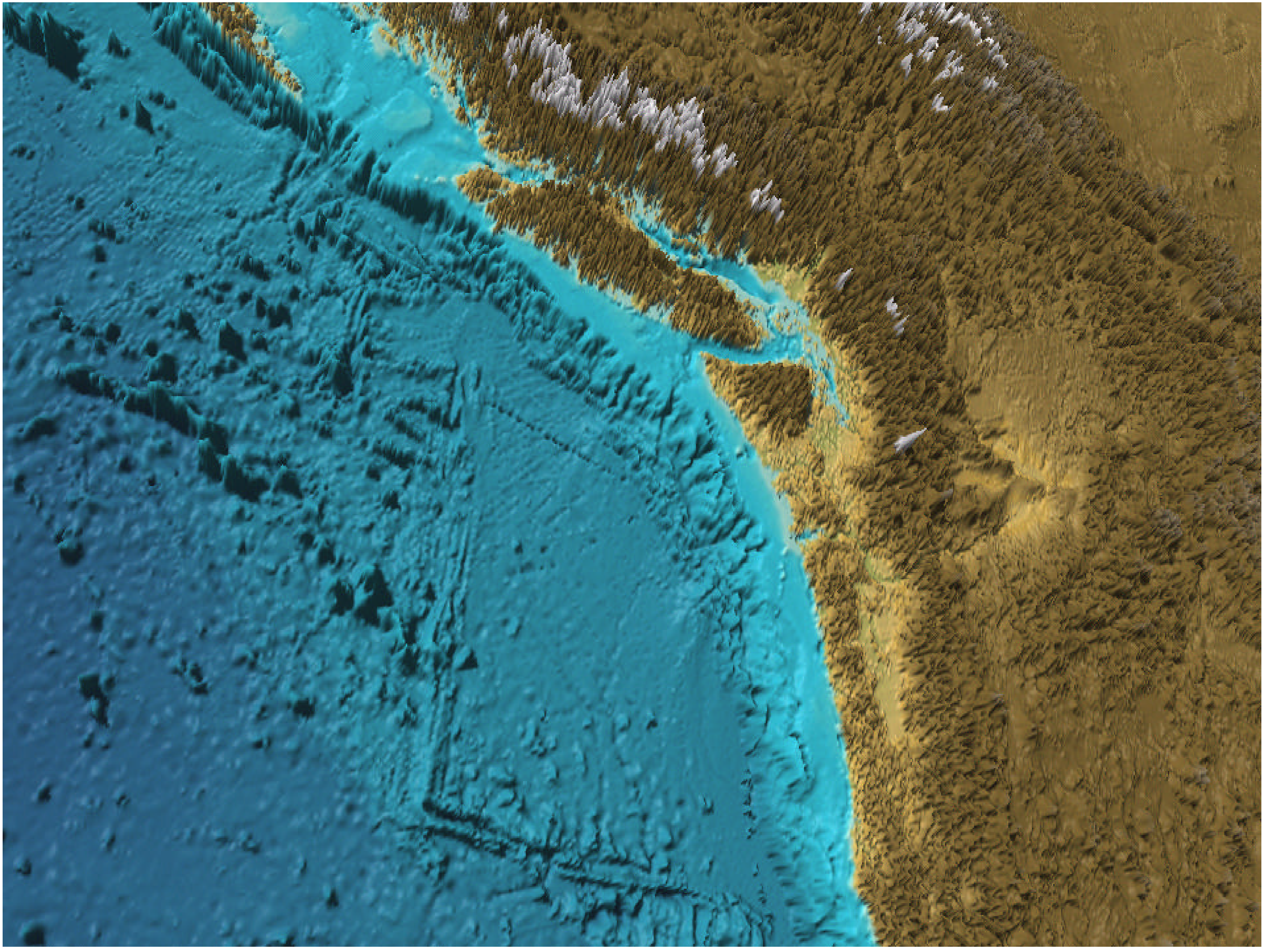
AUV - 0.5m pixel

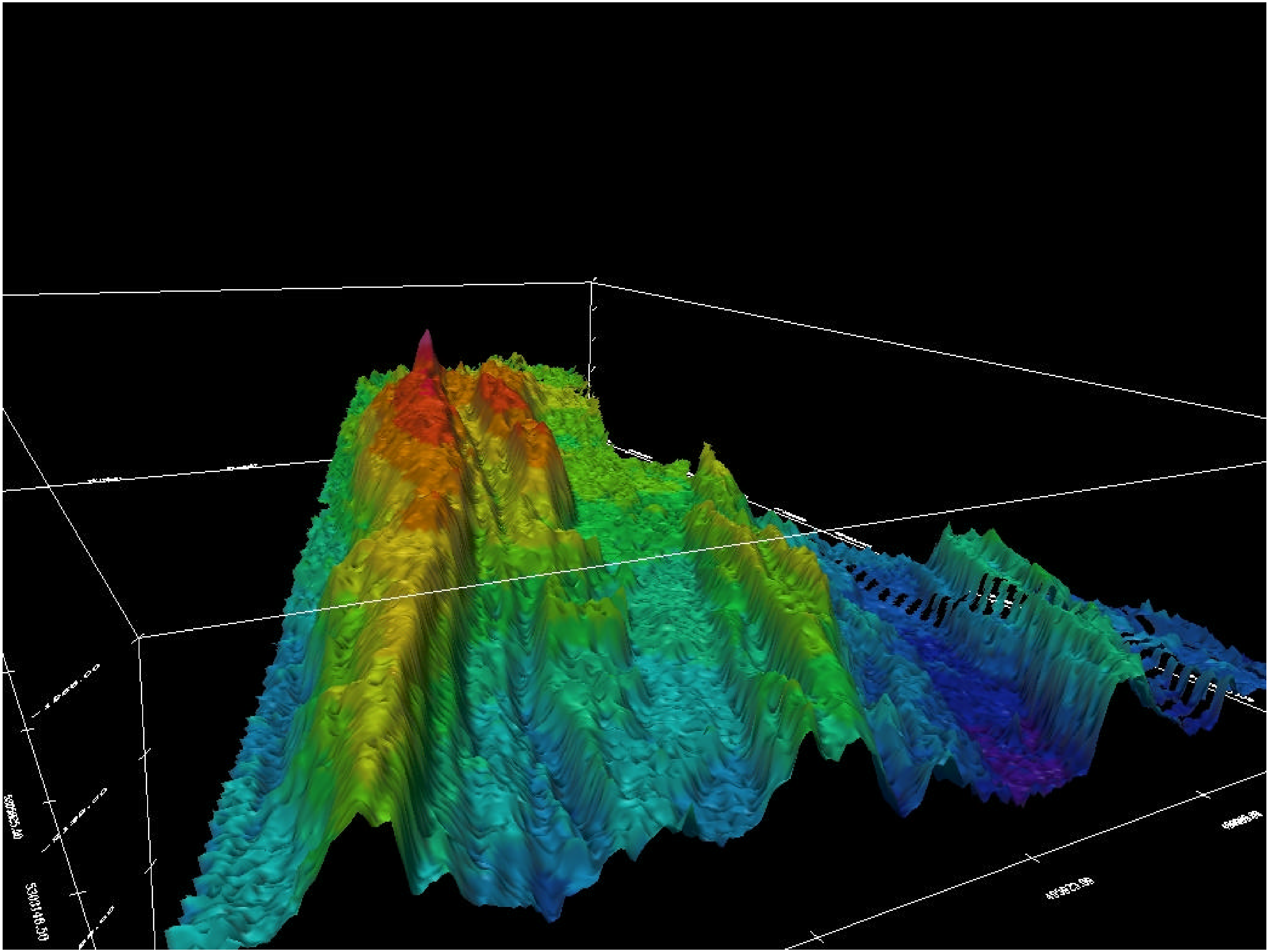


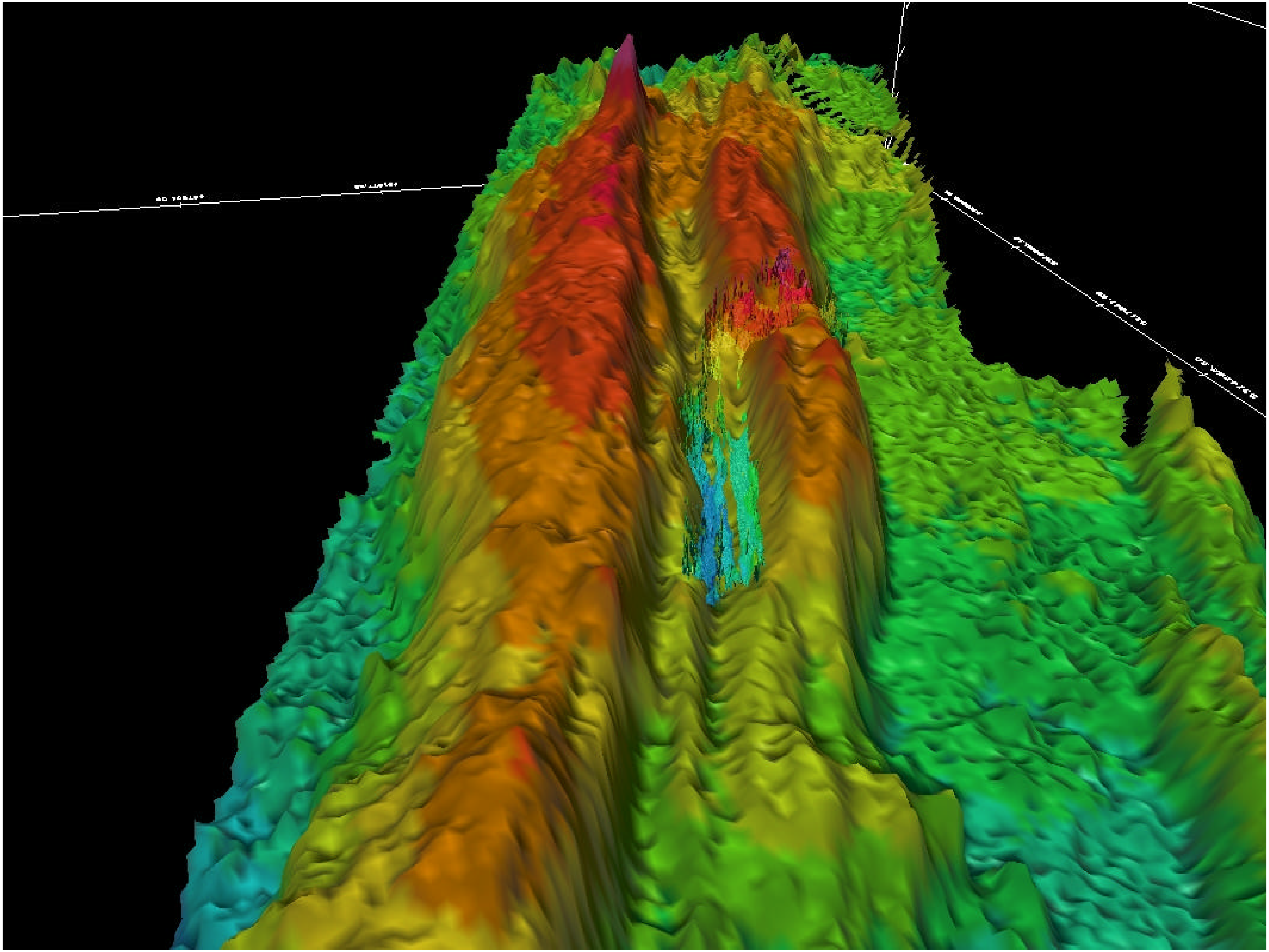
ROV

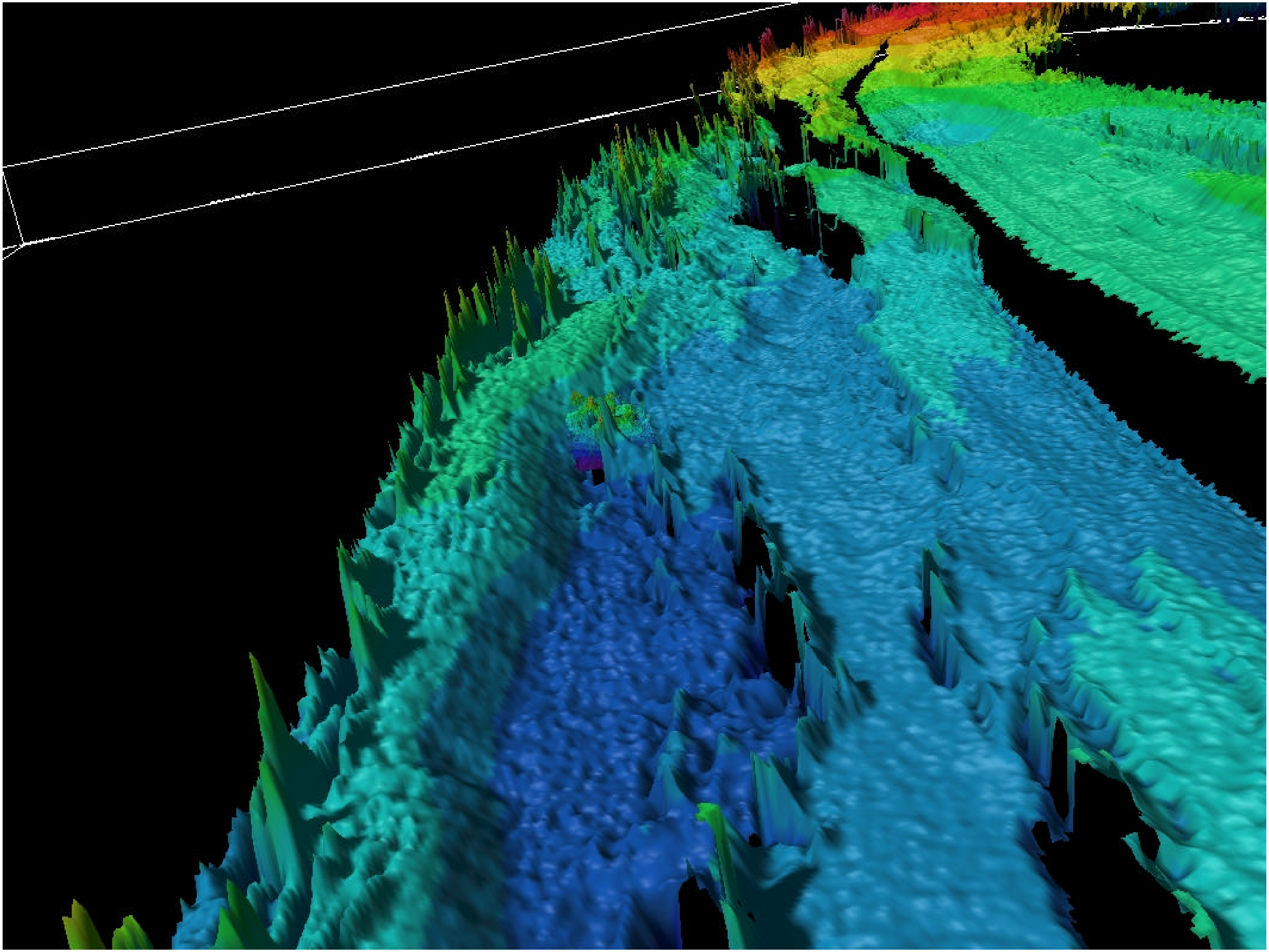
• an example from ROPOS -- poor man’s multibeam - IMAGENIX sector scanner

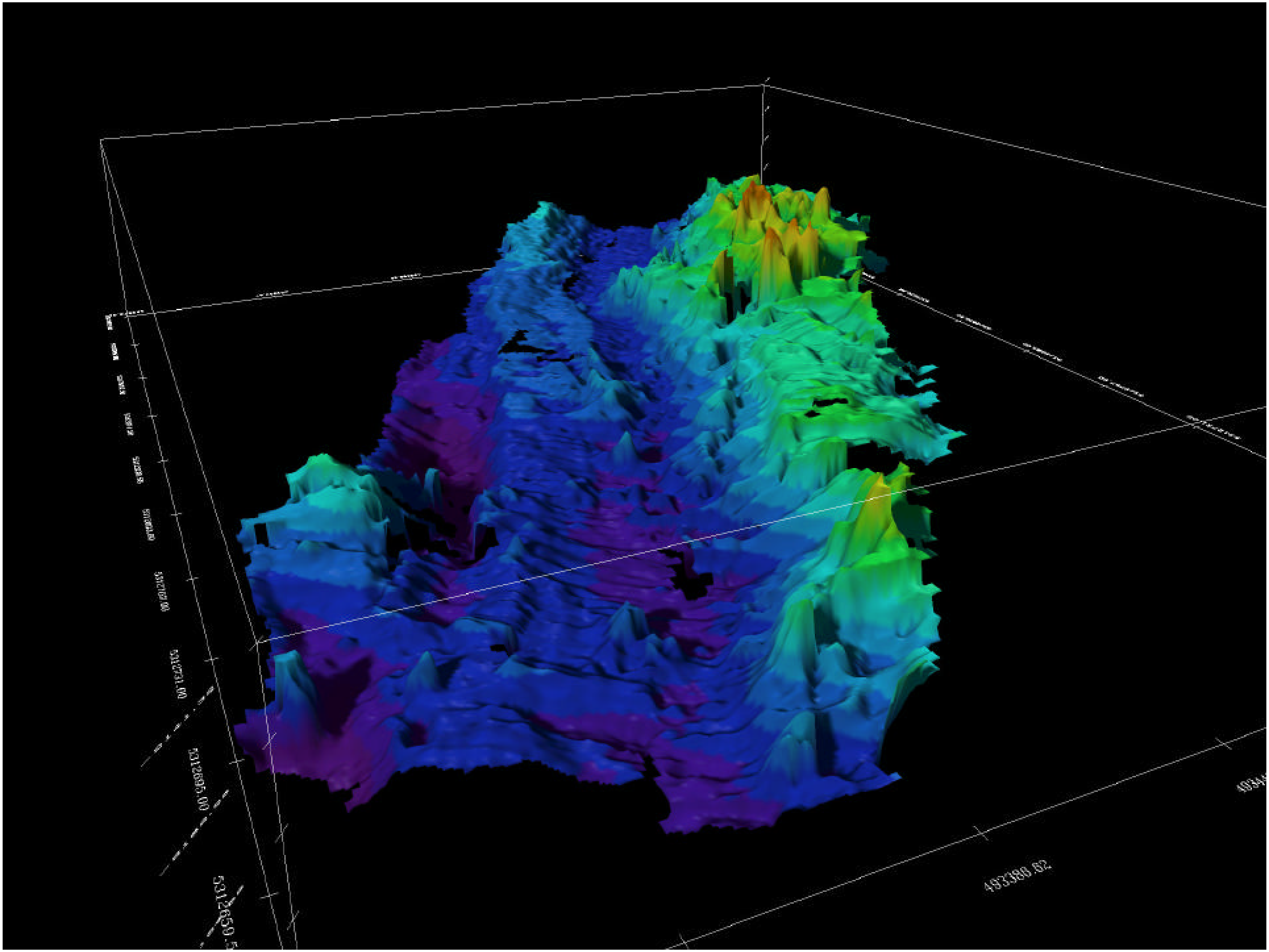








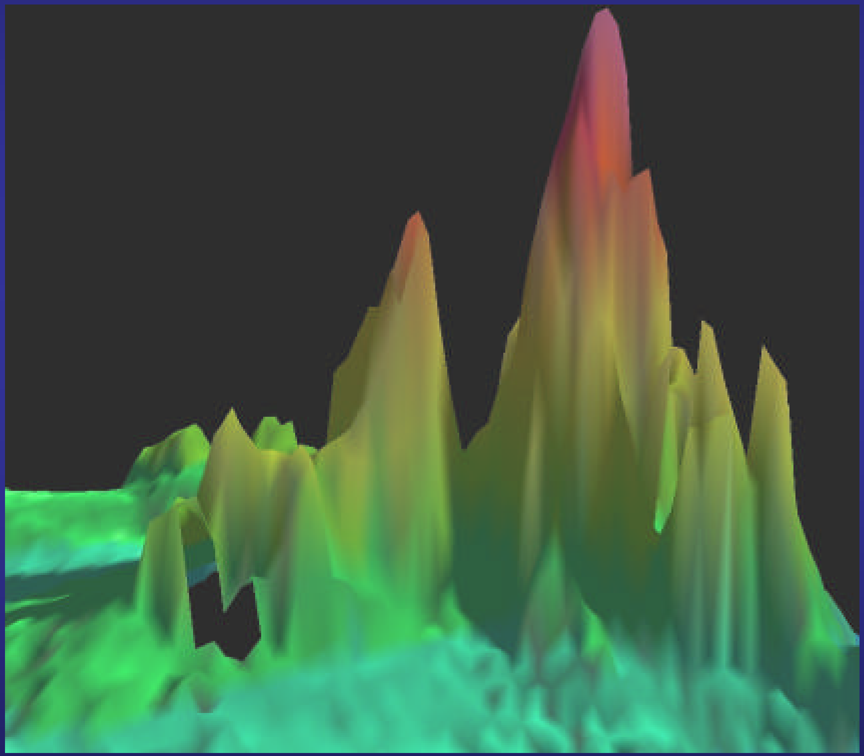




5312695.00
493388.62

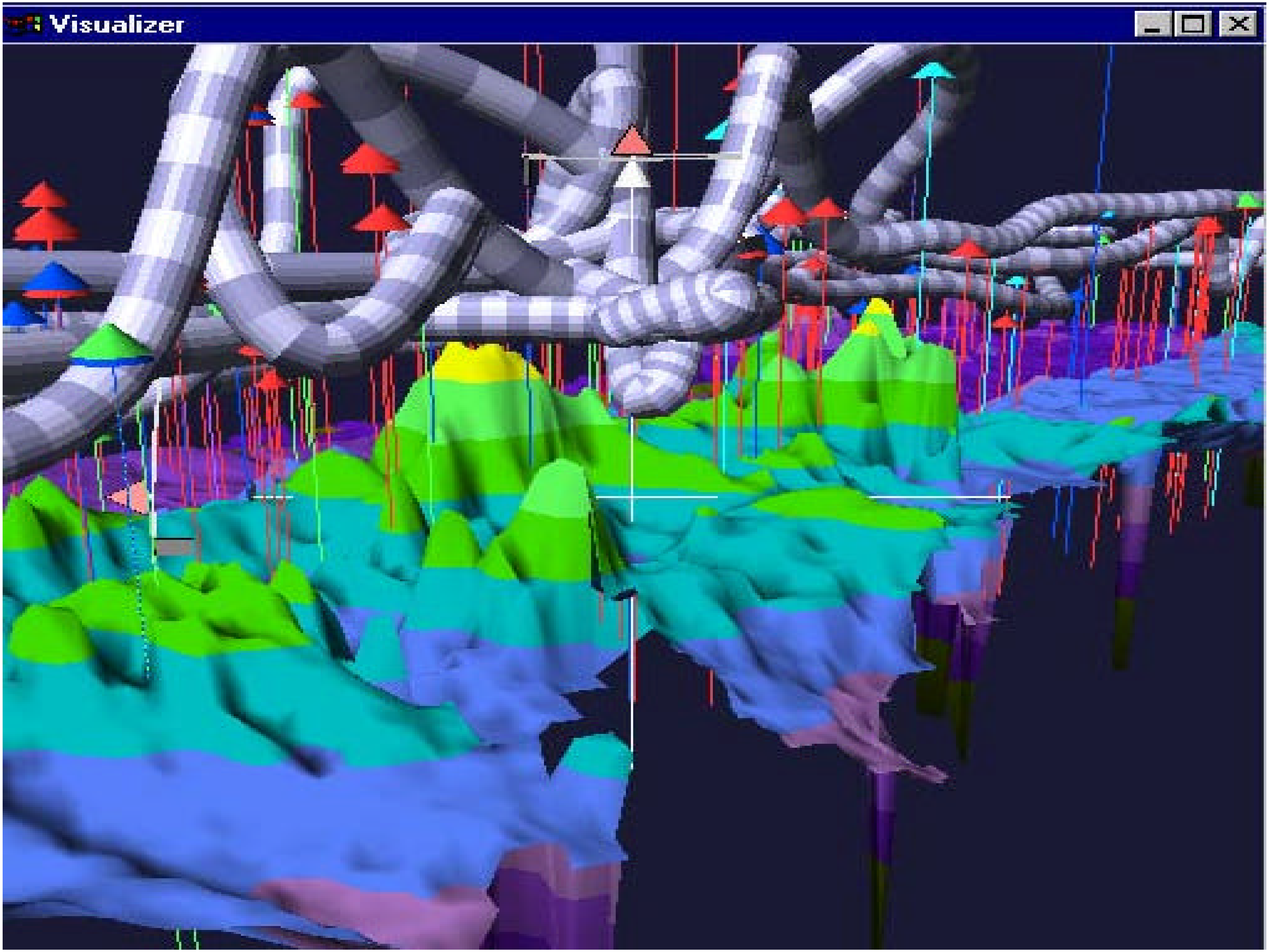
Juan de Fuca Ridge

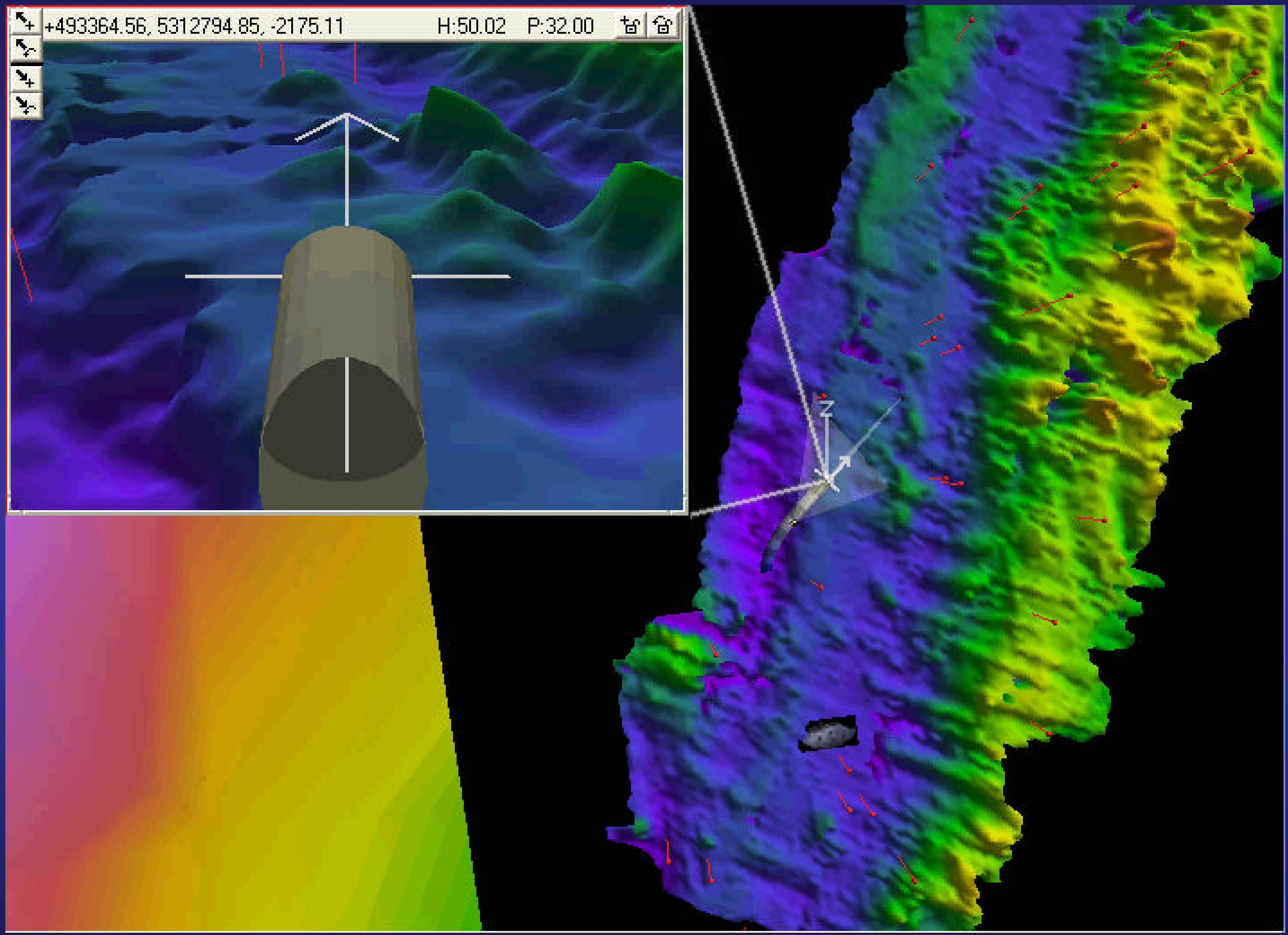
Mothra Hydrothermal Field

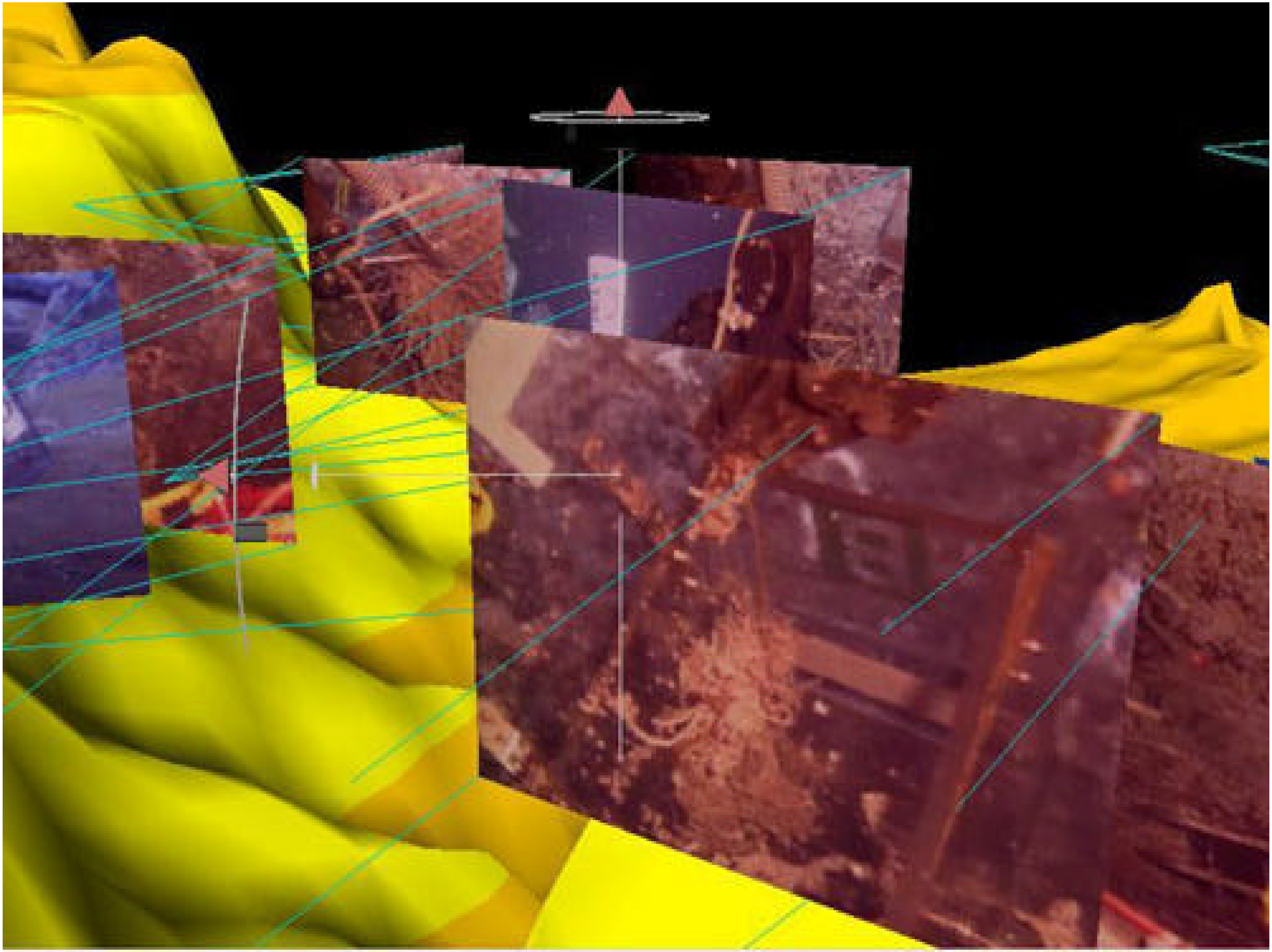


3-D acoustic image of Mothra field from Imagenix sonar data. Data from collected with WHOI Jason ROV - Dana Yoerger

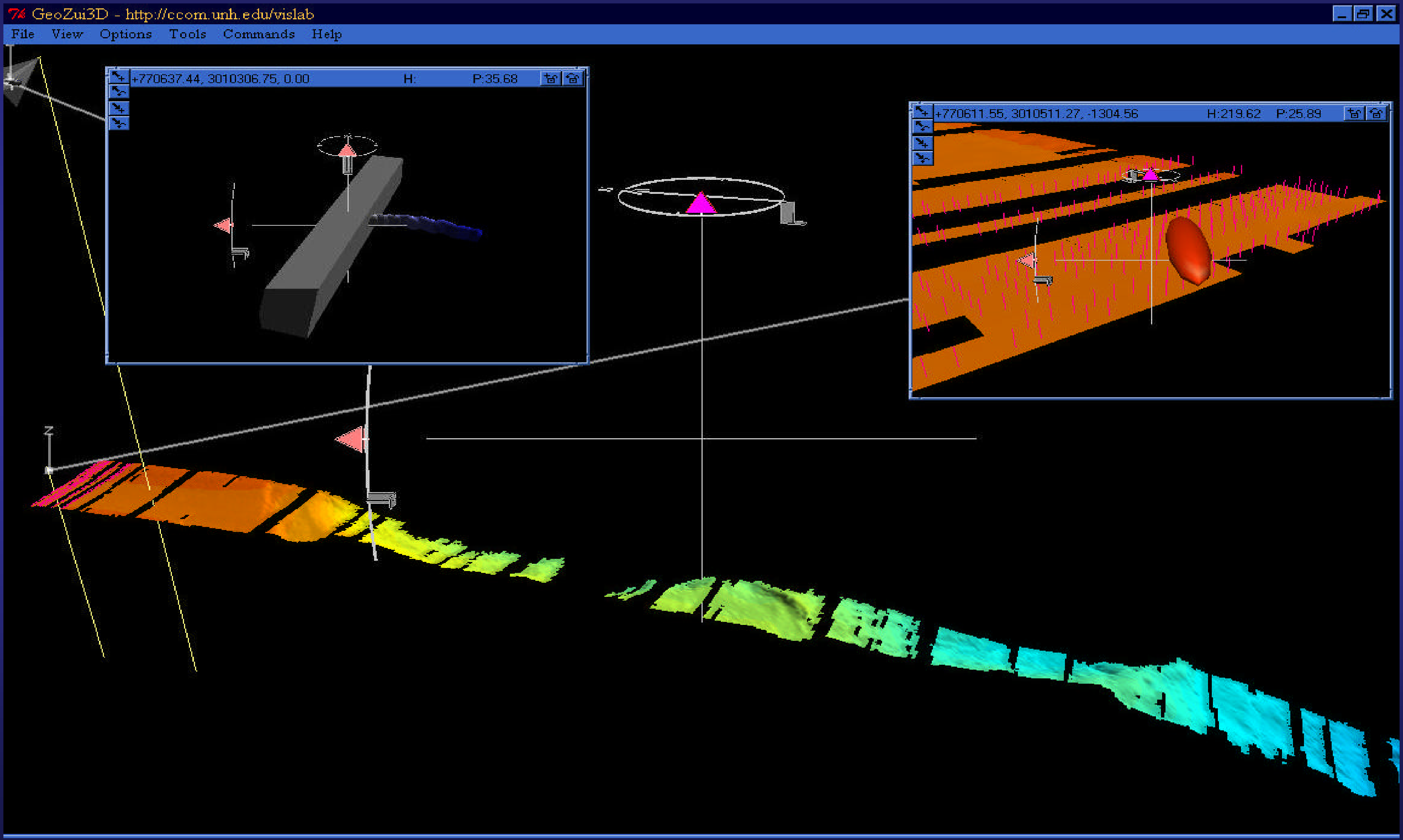
Photomosaic of Mothra field generated by Univ. of Washington. Data collected with WHOI Jason ROV - Dana Yoerger


Visualizer


+493364.56, 5312794.85, -2175.11
H:50.02
P:32.00
Z



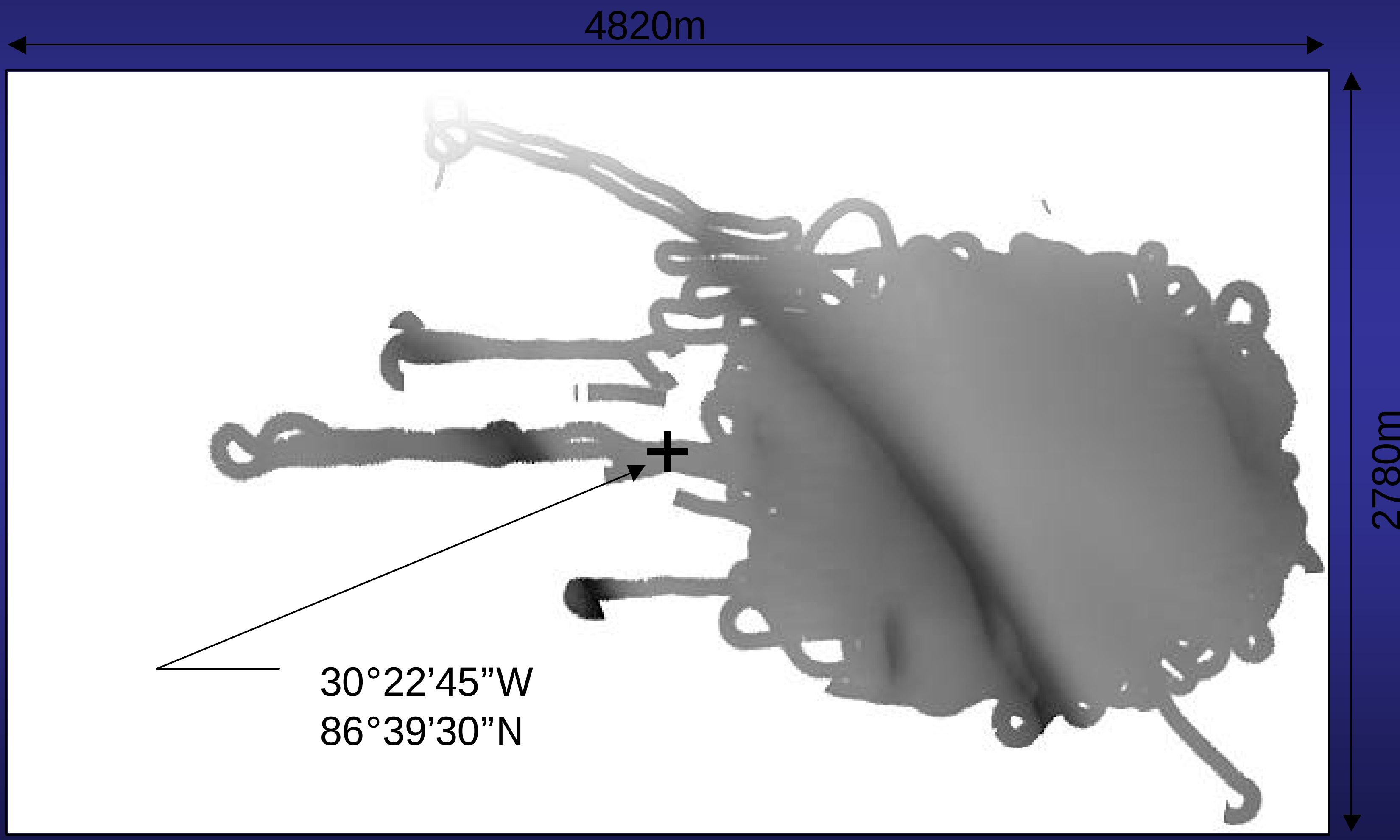
Real-time 3-D visualization of AUV data



PROCESSING:

- Faster
- Cheaper
- Better

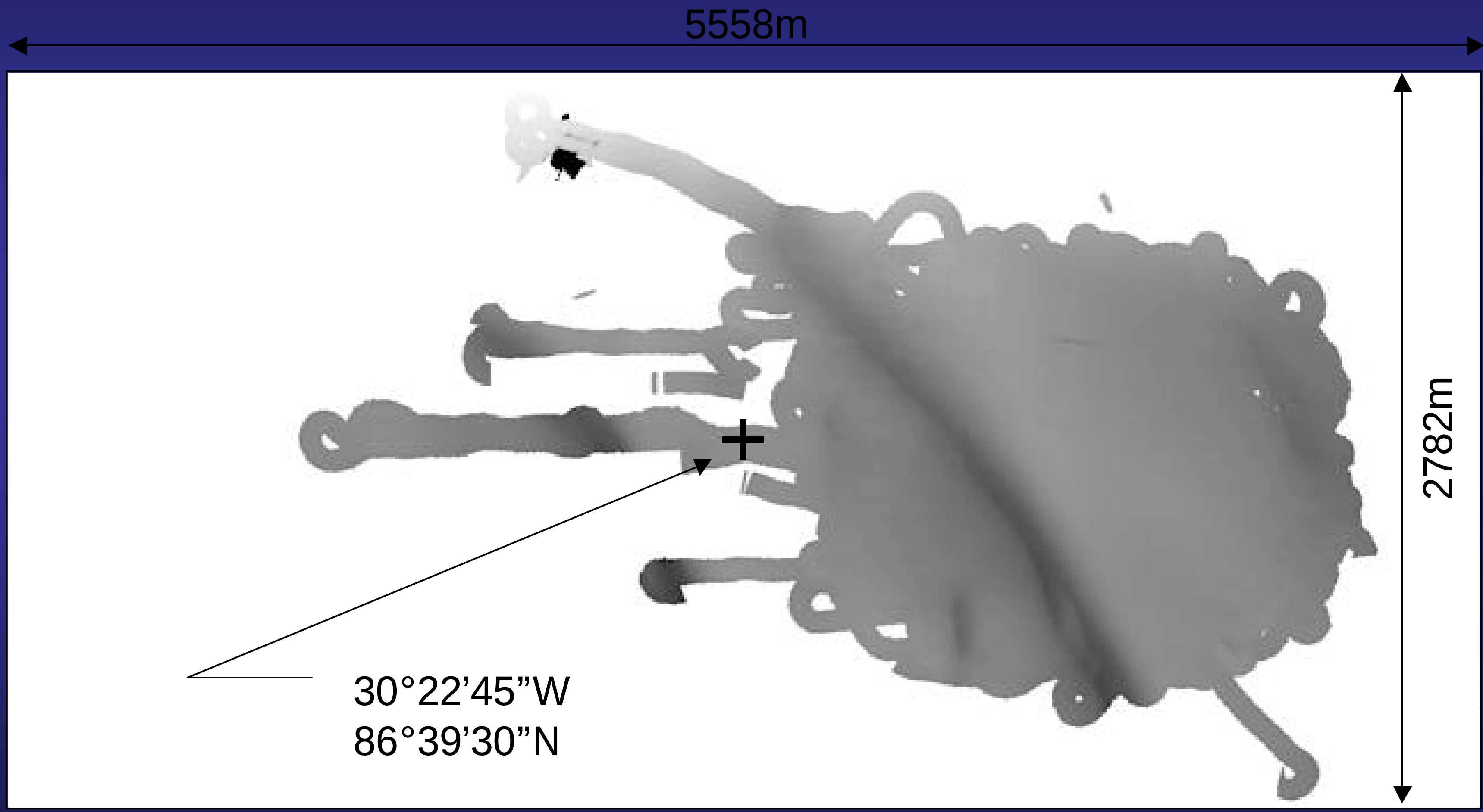
Hand Edited Mosaic – 48 hours



Projection: Mercator
Ellipsoid: WGS84

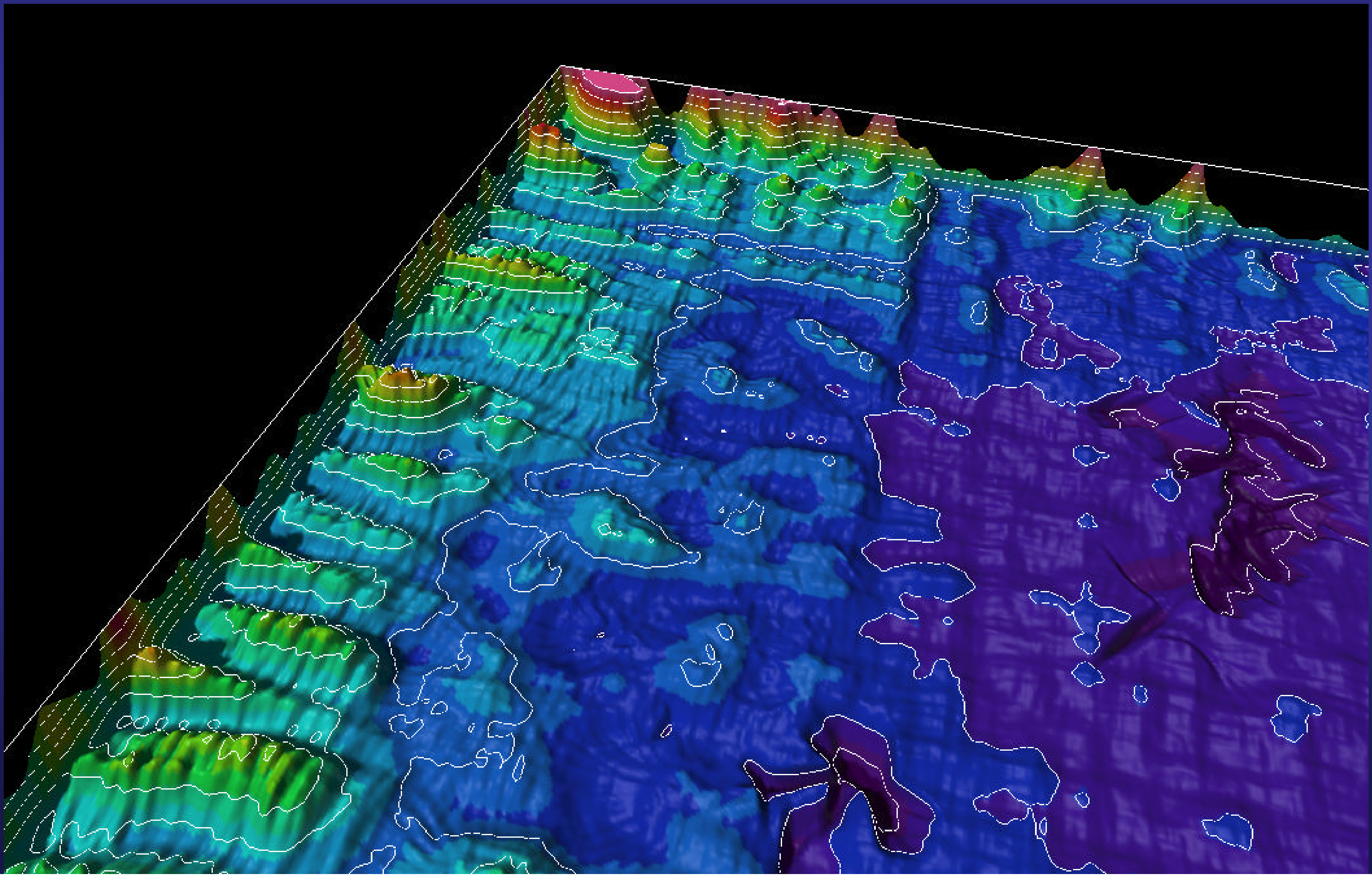
Source: Roger Flood, SUNY, Stony Brook

Automatic Mosaic – 10 minutes

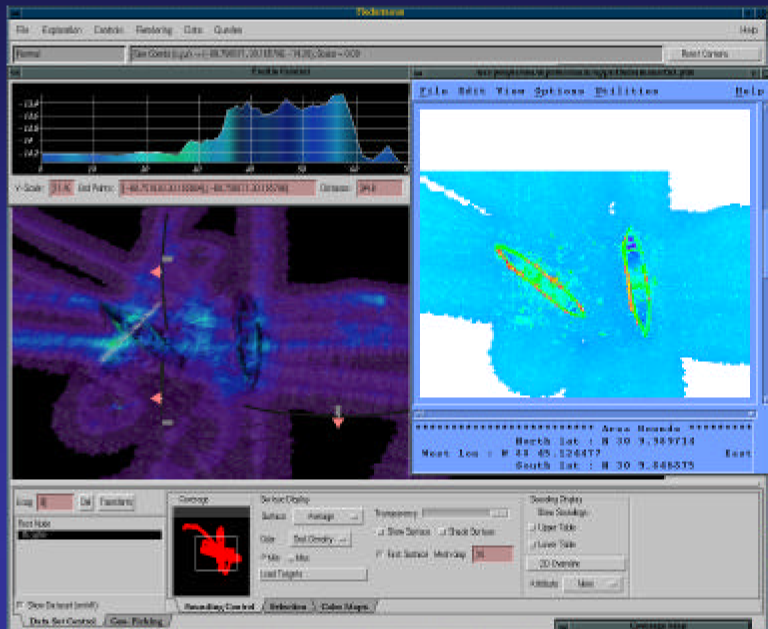


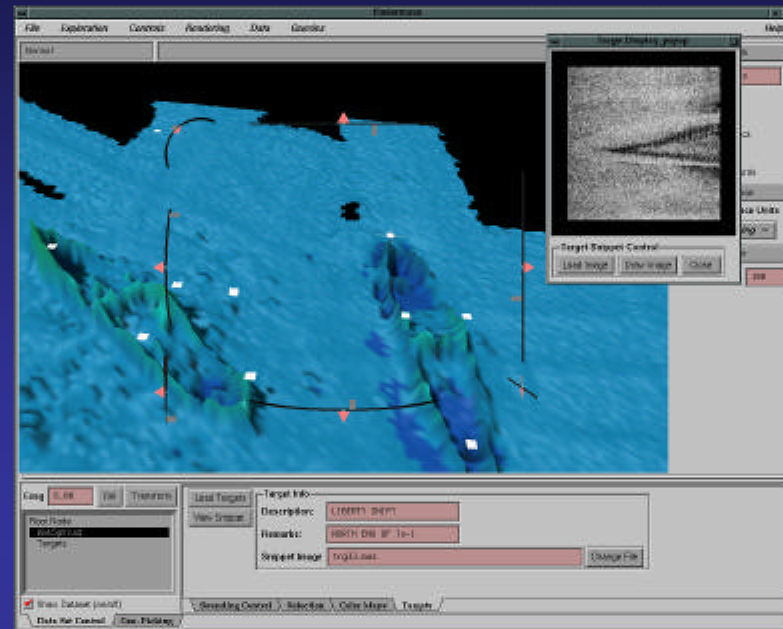
Projection: UTM
Ellipsoid: WGS84

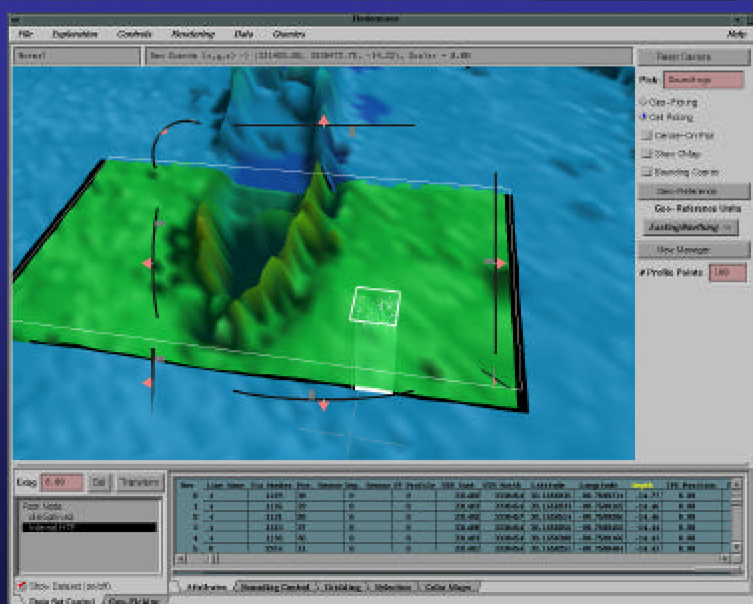
CUBE - Uncertainty Surface

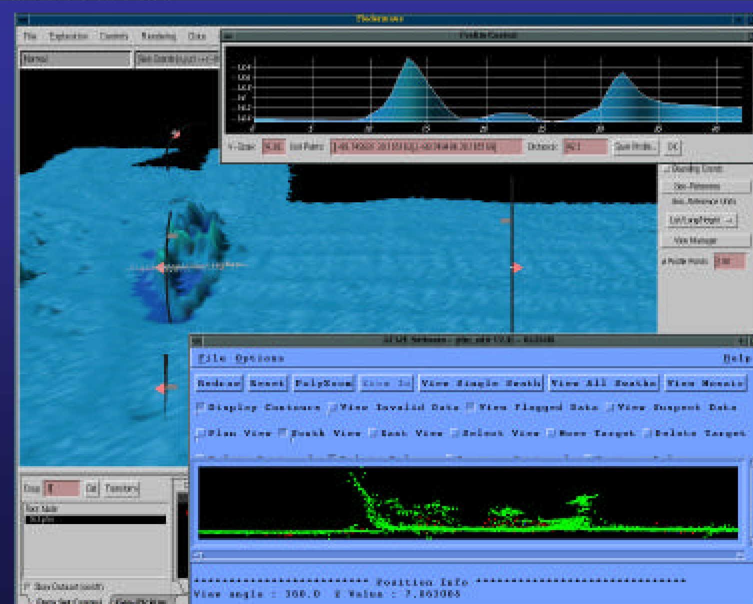


NAVO AREA-BASED EDITOR in Fledermaus:









PRODUCTS:

- Real-time 3-D updates and data fusion for QC and interpretation
- Near-real-time derivative maps

A new perspective → new insights