Trends in Seabed Mapping Technology

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Hand lead-line

The Hand Lead-line

CHART OF MARKERS

2 fathoms - two strips of leather.
3 fathoms - three strips of leather.
5 fathoms - a piece of white cloth.
7 fathoms - a piece of red cloth.
10 fathoms - a piece of leather with a hole.
13 fathoms - a piece of blue cloth.
15 fathoms - a piece of white cloth.
17 fathoms - a piece of red cloth.
20 fathoms - a string with two knots.

1. Color the spool brown.
2. Color the rope light brown.
3. Color the markers according to the chart above.
4. Color the weight gray.

1 fathom is equal to 6 feet.

If the sounding is 13 fathoms, how deep is the water in feet?
Try your skill at finding the depth at other soundings.
Nautical chart
Global Navigation Satellite System (GNSS)

Seapath 1996: Tracked 25 satellites. 1.5 m position accuracy.

Seapath 2016: Tracks unlimited satellites. dm accuracy with differential GNSS and augmentation services. cm accuracy with RTK.
Multibeam versus single beam

Kongsberg introduced its first multibeam echosounder in 1986

Singlebeam survey:
Large unmapped gaps between lines

Multibeam survey:
100% coverage of seafloor
Resolution matters
Multibeam echosounder 1986 - EM 100

• 95 kHz frequency

• 27 or 32 receiving beams

• Beam widths:
  – 2 × 3°
  – 2.5 × 3°
  – 5.5 × 3°

• 100° coverage

• Stabilization
  – Roll: electronic
  – Pitch: mechanical
Multibeam echosounder 1999 - EM 1002

- 95 kHz frequency
- 111 receiving beams
- Beam width: 2.0 × 2.3°
- 150° coverage
- Stabilization
  - Roll: electronic
  - Pitch: mechanical

Pock marks at the Troll oil and gas field in the North Sea.
Multibeam echosounder 2016 - EM 712

- 40 to 100 kHz frequency
- 512 receiving beams (max 1600 soundings/ping)
- Beam widths:
  - 0.25 × 0.5°
  - 0.5 × 0.5°
- 140° coverage
- Stabilization
  - Roll: electronic
  - Pitch: electronic
  - Azimuth: electronic

Image provided with permission of Fugro.
Wideband systems

 Courtesy of Marine Research Vessel KAIO-MARU No7, Nippon Kayo Co,Ltd

objet_2d_400Khz_50us.
Shallow to full ocean depth

THE COMPLETE MULTIBEAM ECHO SOUNDER RANGE

From the shallowest waters to full ocean depth, we’ve got it covered.

M3 ........................................ 50 m
GeoSwath Plus .......................... 200 m
EM® 2040C ................................. 500 m
EM® 2040P ................................ 550 m
EM® 2040 .................................. 600 m
EM® 712 .................................... 3600 m
EM® 302 ................................... 7000 m
EM® 122 .................................... 11000 m
Mapping the Mariana Trench

EM 122 data. Courtesy of Naval Oceanographic Office.
EM 122 on RV Sonne

16 m TX frame array, 8 m RX frame array: $0.5^\circ \times 1.0^\circ @ 10$ kHz
Backscatter

Courtesy Geological Survey of Norway
Interpreted bottom types

Sandy mud
Muddy sand
Sand with mud and gravel
Muddy, sandy gravel
Sand, gravel and stone
Sand, gravel, stone and rock
Mud/sand with stone/rock
Stone and rock with sediment cover
Mountain with partial sediment cover

Courtesy Geological Survey of Norway
Water column data

Courtesy of: Universität Hamburg
Zentrum für Meeres- u. Klimaforschung
Leitstelle Deutsche Forschungsschiffe
Water column data and multiple detections

GB Church, Sidney, B.C. Canada
Water Column Data – from a single pass

Courtesy of John Hughes Clarke – Ocean Mapping Group / University of New Brunswick
Trend: Research vessels, hydrographic vessels

- Automation and Data Management
- Underwater Mapping
- Marine Robotics
- Marine Ecosystem Monitoring
- High Precision Acoustic Positioning
- Underwater Environmental Monitoring
- Camera and Light Systems
- Launch and Recovery Systems
- Position Reference Systems
- Dynamic Positioning
- Integrated Bridge Solutions and Navigation Systems
- Automation and Power Management
- Simulation Systems
Merging shallow and deep water data

Image courtesy Stockholm University. EM 2040 and EM 122 data.
Sub-bottom profiler

Data courtesy of NAVAL OCEANOGRAPHIC OFFICE
Fishery stock estimation

Schooling Sand Eel close to bottom in the North Sea mapped with Simrad ME70 scientific multibeam
Trend: portable systems for shallow water
Trend: marine robotics
Gulf of Mexico commercial AUV survey 2000 - 2001

Courtesy C & C Technologies
GPS - USBL

AUV survey position accuracies
Gulf of Mexico 2000 / 2001:

- 1300 m: 2 m \( (1\sigma) \)
- 2100 m: 4 m \( (1\sigma) \)
Detailed seabed mapping with AUV

Data courtesy of Fugro
Synthetic aperture sonar long range example

Submarine wreck
Range 205-245 m

HISAS 1030 on HUGIN 1000-MR
Range 25-325 m
AUV altitude 40 m
Speed 2.3 knots

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Interferometric SAS and MBE for hydrographic mapping

Interferometric SAS
- High area coverage rate, typically 2km²/hr.
- Blind zone directly below the vehicle (nadir gap)

MBE
- Beamformers have advantage at nadir
- Less coverage than interferometric SAS
EM 2040 bathymetry (400 kHz)
Merged bathymetry
Pipeline survey
Pipeline survey
Trends in data processing

- Instruments produce cleaner data
- Higher data density, richer data sets – more processing and data handling
- More automated processing
- Ecosystem on open standards
- Value added services
- Land and ocean mapping meets

Courtesy Geological Survey of Norway
What holds the future?

- Cleaner data
- Improved accuracy
- Multifrequency seafloor classification
- Synthetic aperture sonar
- Continued robotization
- Extending from mapping to monitoring
- Connected operations
- Automated processing
- Open standards
MAPPING THE OCEAN

Connected Specialist Solutions for Underwater Sensor Systems and Marine Robotics

CENTRE OF OPERATIONS

THE CLOUD

MARITIME BROADBAND RADIO

VESSELS

GLIDERS

AUVs

USVs

SCALEABLE SENSOR CARRIER

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