Such a Big Ocean but our Footprints are so Small
(Sonar Footprints)

Larry Mayer
Center for Coastal and Ocean Mapping
University of New Hampshire
Oh to be an ocean explorer……..
It's easy to image the earth
But what about the $\frac{3}{4}$ of the Earth that's BLUE?

How inappropriate to call this planet Earth when clearly it is Ocean – Arthur C. Clark
~ 600,000,000,000,000 photos

~ 10 Billion years
Bathymetry Predicted from Satellite Altimetry
Satellite Predicted Bathymetry
(Sandwell and Smith)
2km DTM
Direct Mapping

Lead Line:

2000 BC
Direct Mapping

Lead Line:
Direct Mapping

Lead Line:

1450

1940
Single Beam Echo Sounder
Single Beam Echo Sounder
Singlebeam Sonar Shiptracks
Singlebeam Soundings per 2/km

From Jenn Jencks and Brian Meyer NCEI
Multibeam Sonar: Mills Cross or Mills T Array
Image derived from theoretical sonar model interacting with artificial seabed DTM using “SynSwath”
Image derived from theoretical sonar model interacting with artificial seabed DTM using "SynSwath"
What a difference a swath makes..
A new perspective → new insights and many new applications
UNH CCOM-JHC U.S. Law-of-the-Sea Bathymetric Mapping to Date

- **Arctic**

- **Gulf of Alaska**
  - 2005

- **Gulf of Mexico**
  - 2007

- **Marianas**
  - 2006
  - 2007, 2010

- **Kingman Reef-Palmyra Atoll**

- **Bering Sea**
  - 2003

- **Necker Ridge**
  - 2011

- **Mendocino**
  - 2009
  - 2014

- **Atlantic**
  - 2004, 2005

\[ > 2,450,000 \text{ km}^2 \]
Beringian Margin
Marianas

16.4 m

10 seamounts < 500 m
USS San Francisco (SSN 711) - in drydock after hitting uncharted seamount

Arctic Ocean
~420,000 km²
9 cruises
Four Canadian - U.S. Joint Cruises in Arctic

CCGS Louis S. St-Laurent

USCGC Healy
9 Arctic Cruises: 2003-2012
420,000 km²
Seafloor Backscatter

To What?
Seafloor Backscatter -- Habitat Mapping...

From Geological Survey of Canada
WATER COLUMN MAPPING

Pollock
Water Column Mapping:

Global Methane Fluxes

Gas Seeps

Multibeam Sonar Fan

Acoustic backscatter from gas seep

1350 m

5000 m

Tom Weber
MID-WATER MAPPING FOR WRECK IDENTIFICATION

Duncan Mallace and the Port of London
PHYSICAL OCEANOGRAPHY - internal waves, pycnoclines...

(Rob Hare, John Hughes Clarke and Jonathan Beaudoin)
<12% of global ocean covered with MBES data
We’ve been at this for 40 years and still only about 12% of deep ocean has been mapped with MBES – Why?

- Physics – tradeoffs between propagation, resolution and system size
- Belief that deep ocean is boring and uninteresting
- Cost – systems are not cheap – shiptime even more costly

HOW MUCH WOULD IT COST TO MAP THE ENTIRE WORLD OCEAN WITH MULTIBEAM SONAR?
IGNORE SHALLOW WATER

Cumulative Cost of Surveying Atlantic and Gulf EEZ with Multibeam vs Depth
SHALLOW WATER MAPPING

Autonomous Surface Vessels

C-Worker
ASV Global

Teledyne Oceansciences
Z-Boat

Hydronaulix
“EMILY” Boat
SHALLOW WATER MAPPING

Satellite Imagery-Derived Bathymetry
MAPPING THE WORLD OCEAN WITH MBES (94%)

GEBCO 2014 Depth Distribution

Assuming:

- $>150$ m!
- 4x swath width
- 10 knots

Number of Days: 65,246

Ship Cost: $45,000/day

Total Cost: $2.94 Billion
THE MOON

100m pixel resolution

~$600M


http://spie.org/x25472.xml?highlight=x2418&ArticleID=x25472

TOPOGRAPHY OF MARS

HIRISE Imagery NASA/JPL/UAriz/USGS
http://www.uahirise.org/dtm
1 m DTMs

2-3 B$
And Earth?
And Earth?
AUVs

SURFACE VESSELS

HOW?

GLIDERS

ARGO FLOATS

ARGO FLOATS

3566 Floats
16-Apr-2013
MULTIBEAM BARGE

30 m x 15 m long array → 17 x 34 m resolution in 4000 m water
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remotely operated via telepresence
MULTIBEAM BARGE

30 m x 15 m long array → 17 x 34 m resolution in 4000 m water
remotely operated via telepresence
Other remote measurements (atmosphere, ocean, etc)
MULTIBEAM BARGE

30 m x 15 m long array → 17 x 34 m resolution in 4000 m water

~1/3 the cost of a research vessel
THE BEGINNING
There is so much more to map and explore!