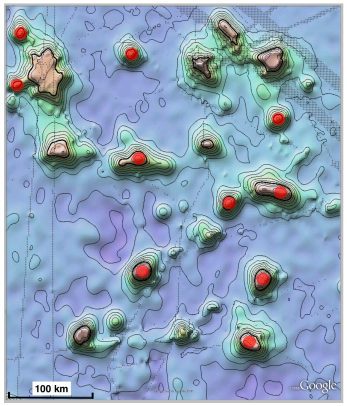
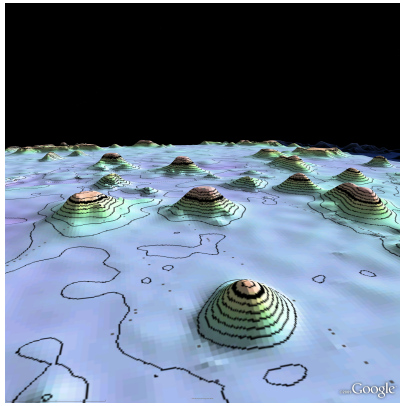


Exploring the Deep Ocean Basins with Satellites and Ships

David T. Sandwell - Scripps Institution of Oceanography

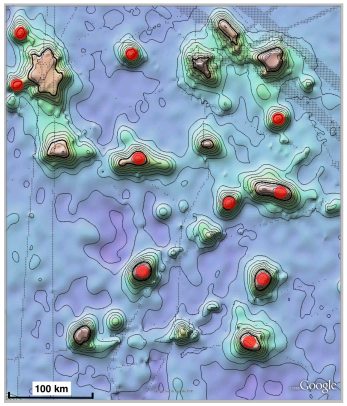
Walter H. F. Smith - Laboratory for Satellite Altimetry, NOAA

Joseph J. Becker - Naval Research Laboratory

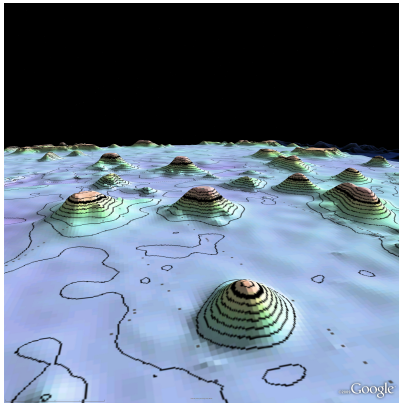


Objective – construct the best possible map of the deep ocean floor for science, public outreach, and applications.

- Needs for improved bathymetry
- What is missing?
- How can we do better?



Needs for Improved Bathymetry in the Deep Oceans



Science

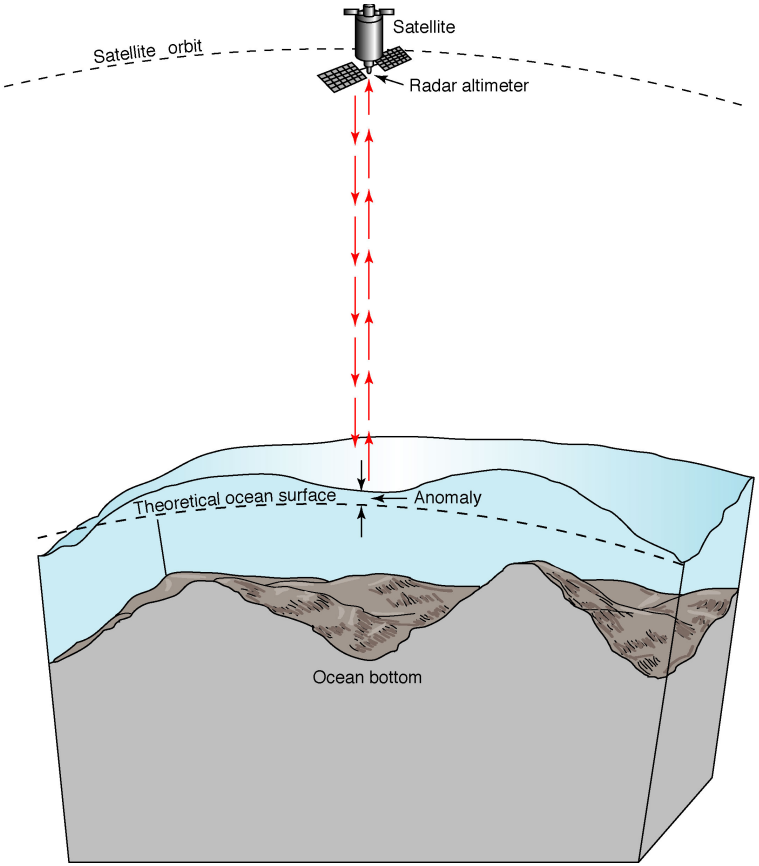
- global tectonics, seafloor roughness
- seamounts
- tsunami models
- ocean circulation and tides
- marine ecosystems
- planning tool

Outreach and applications

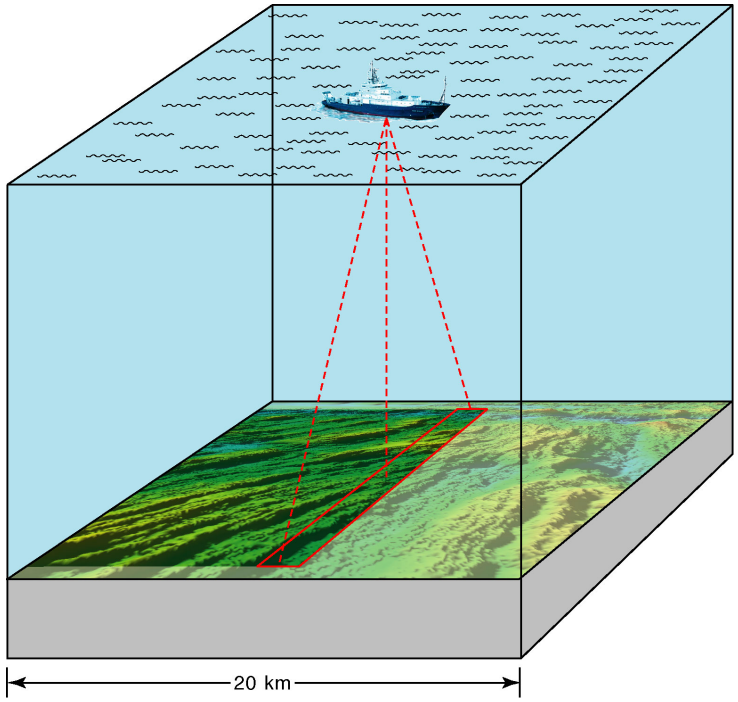
- education and outreach
- military applications
- Industry applications

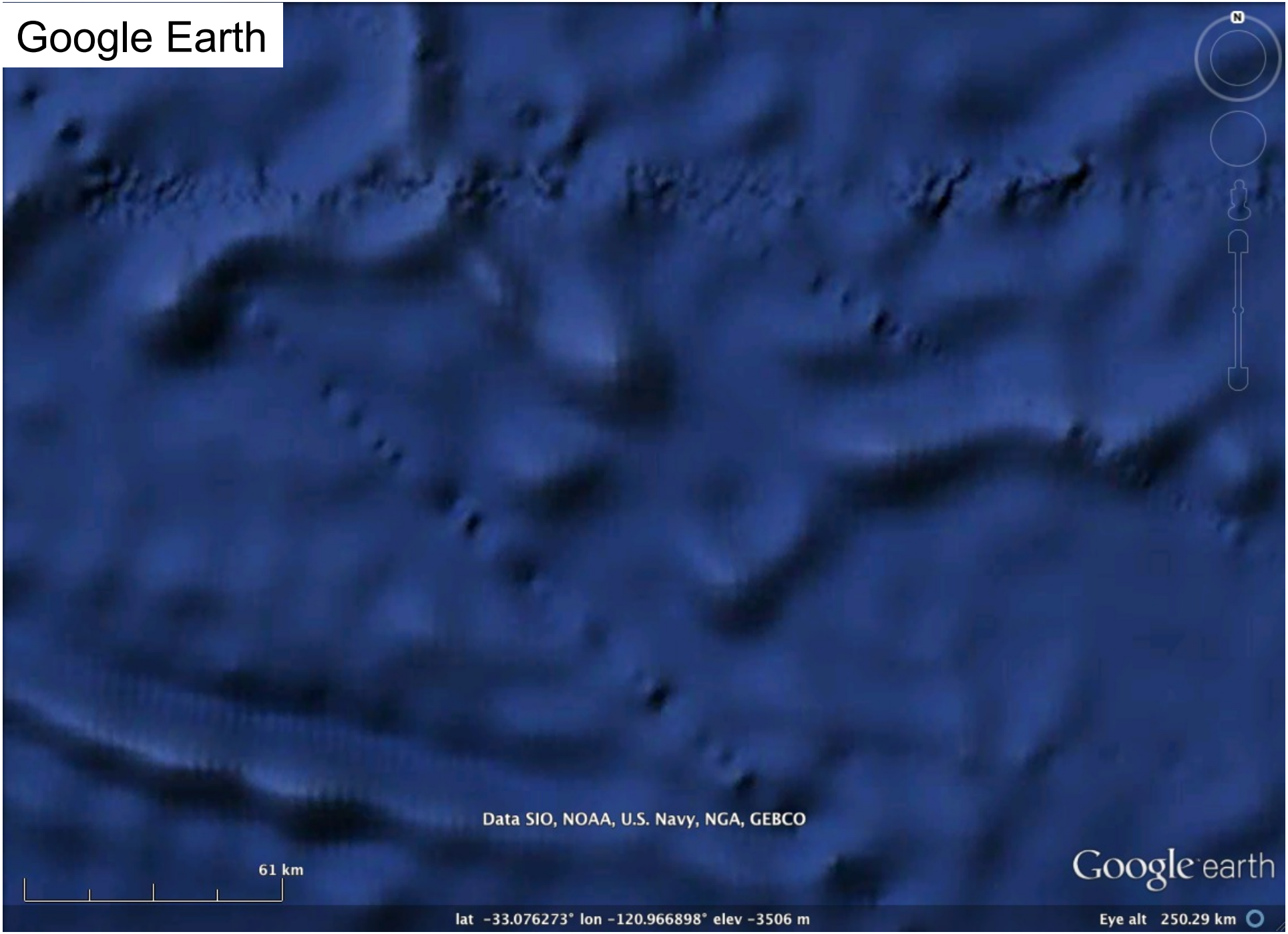
modern mapping tools

satellite altimeter

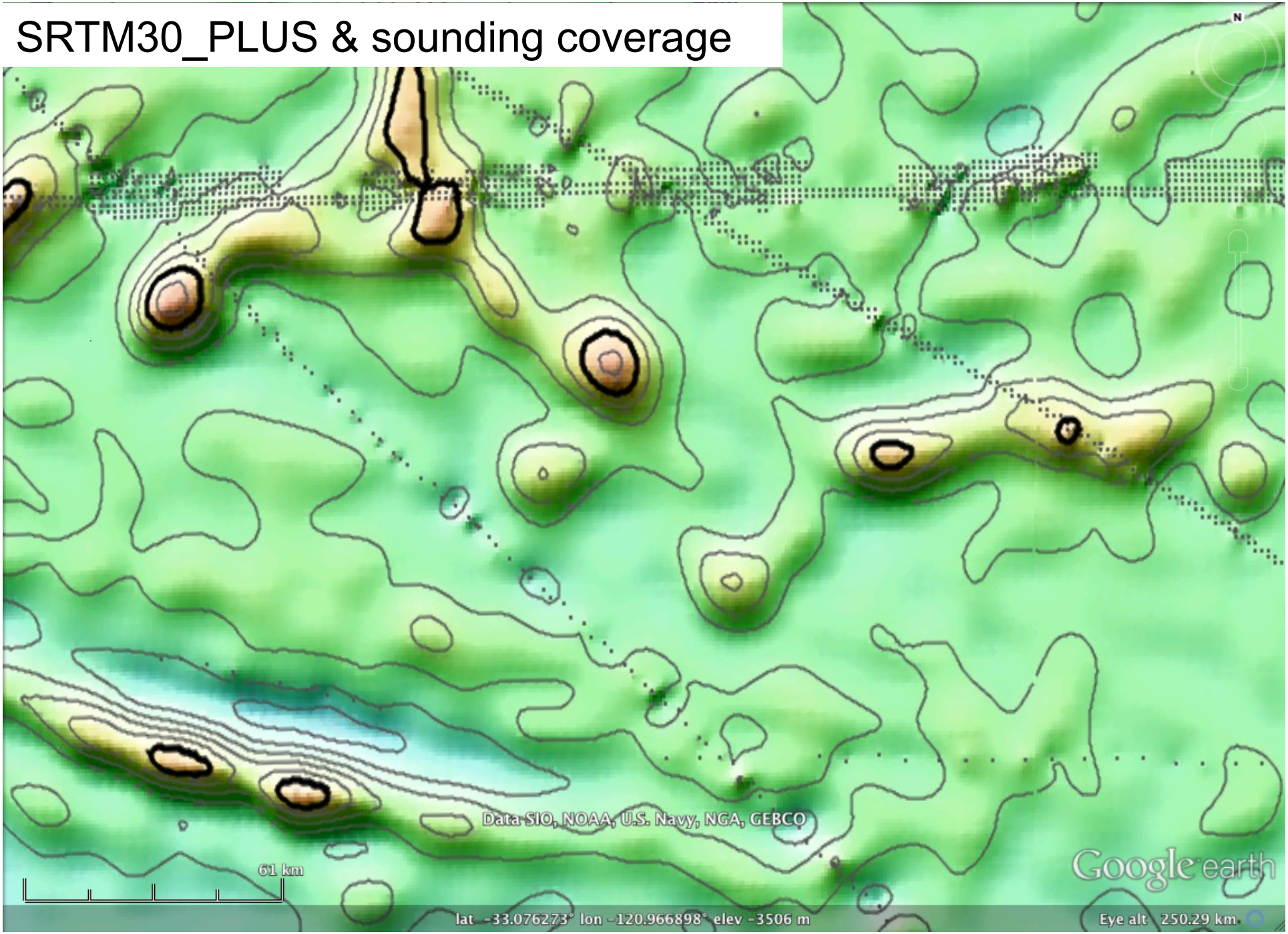


multibeam echo sounder

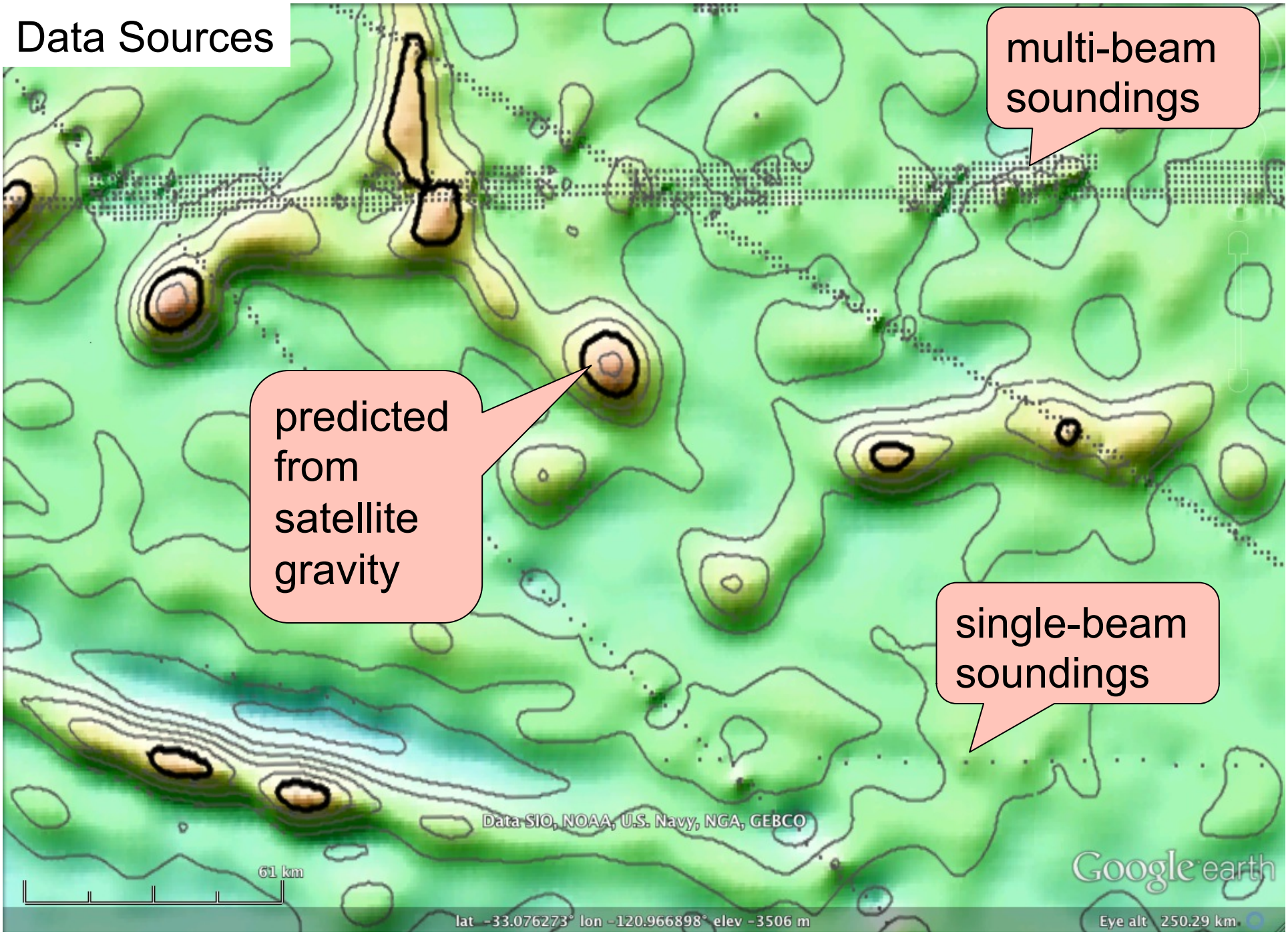



Google Earth
N
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
61 km
Google earth
lat -33.076273° lon -120.966898° elev -3506 m
Eye alt 250.29 km

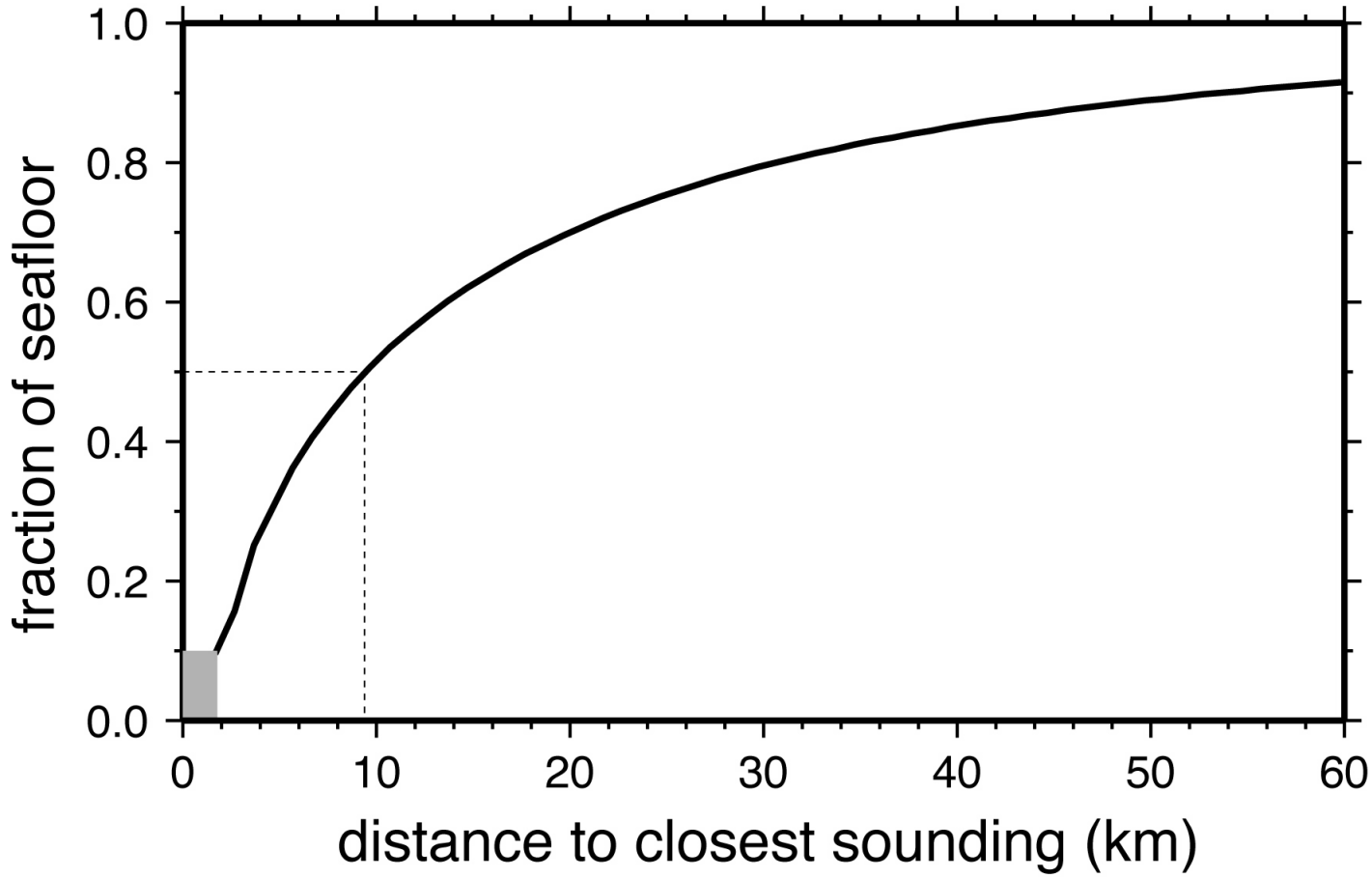
SRTM30_PLUS & sounding coverage



Data Sources



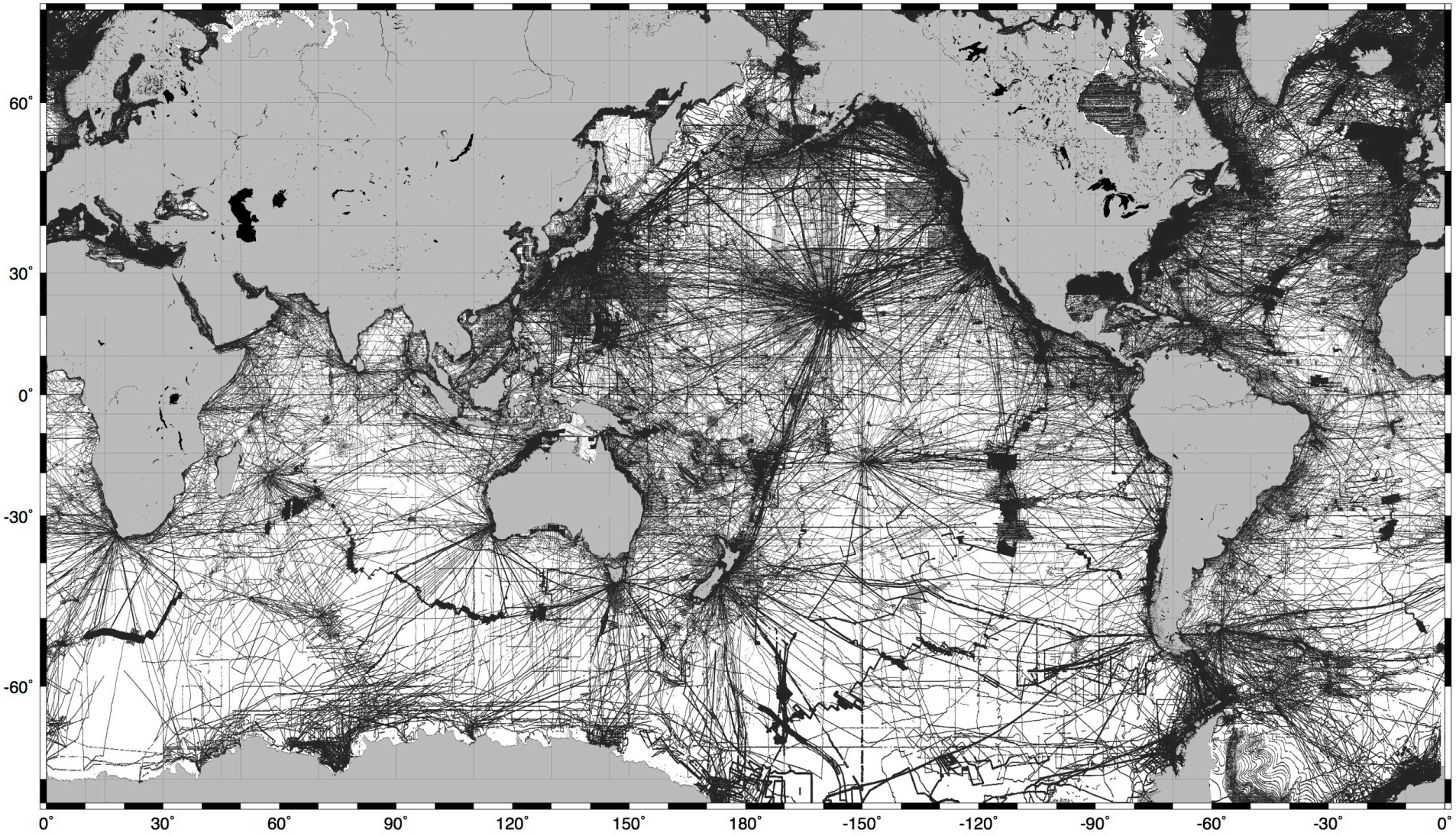
1/2 of global seafloor is more than 10 km from a depth sounding



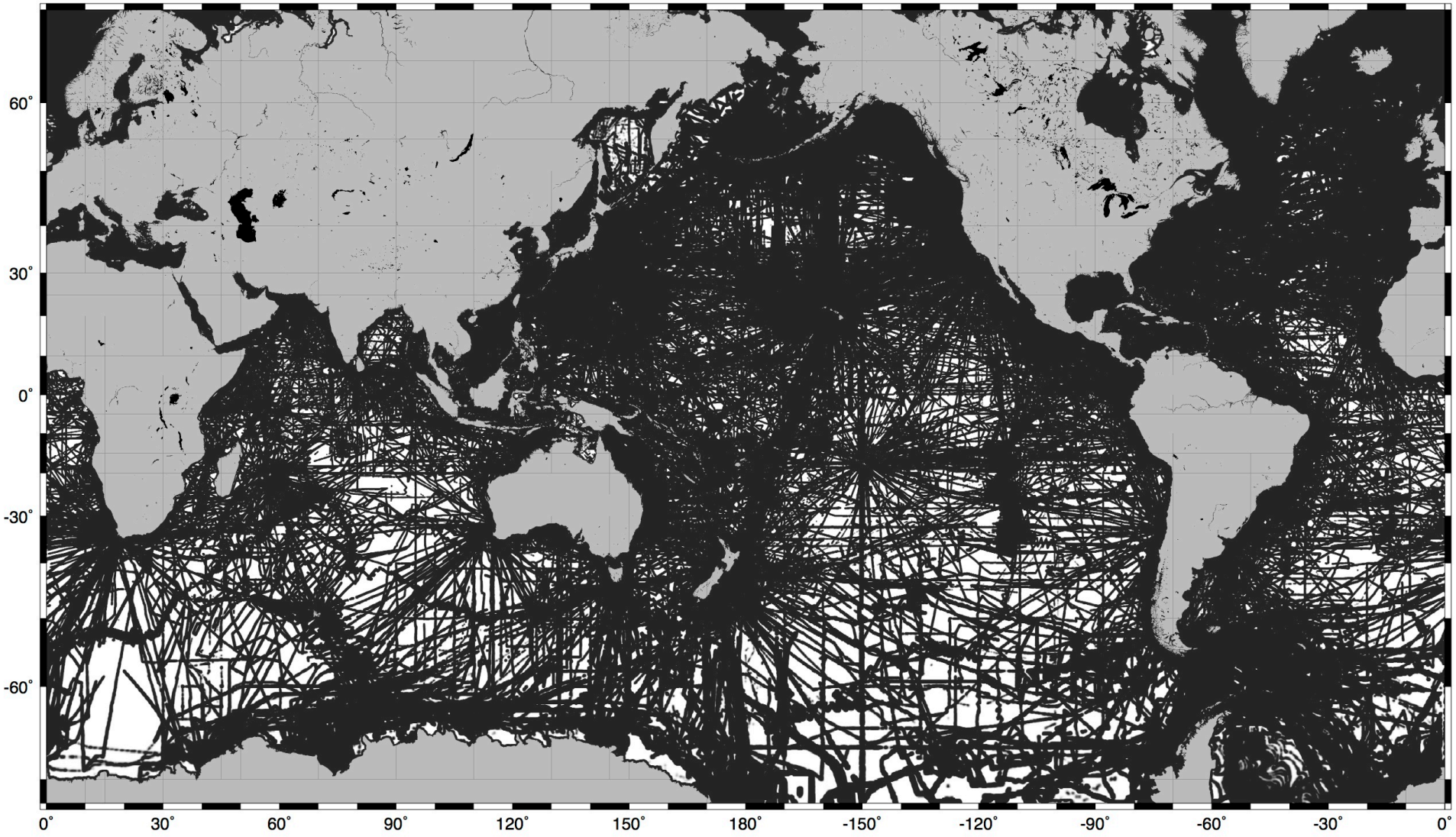
[Smith and Marks, 2009]

Soundings used in SRTM30_PLUS

multibeam, singlebeam, grids, . . .

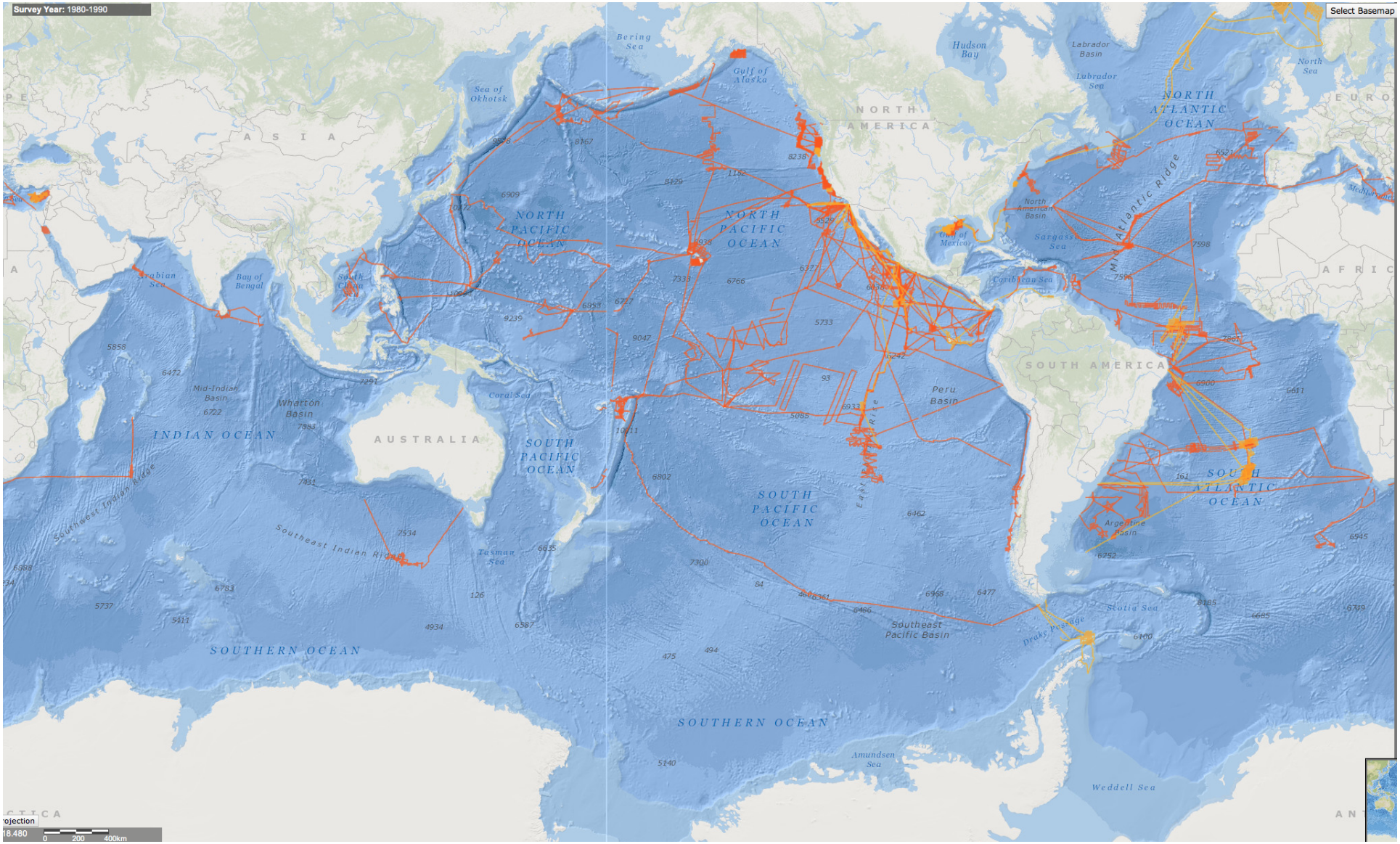


areas of seafloor more than 10 km from a sounding

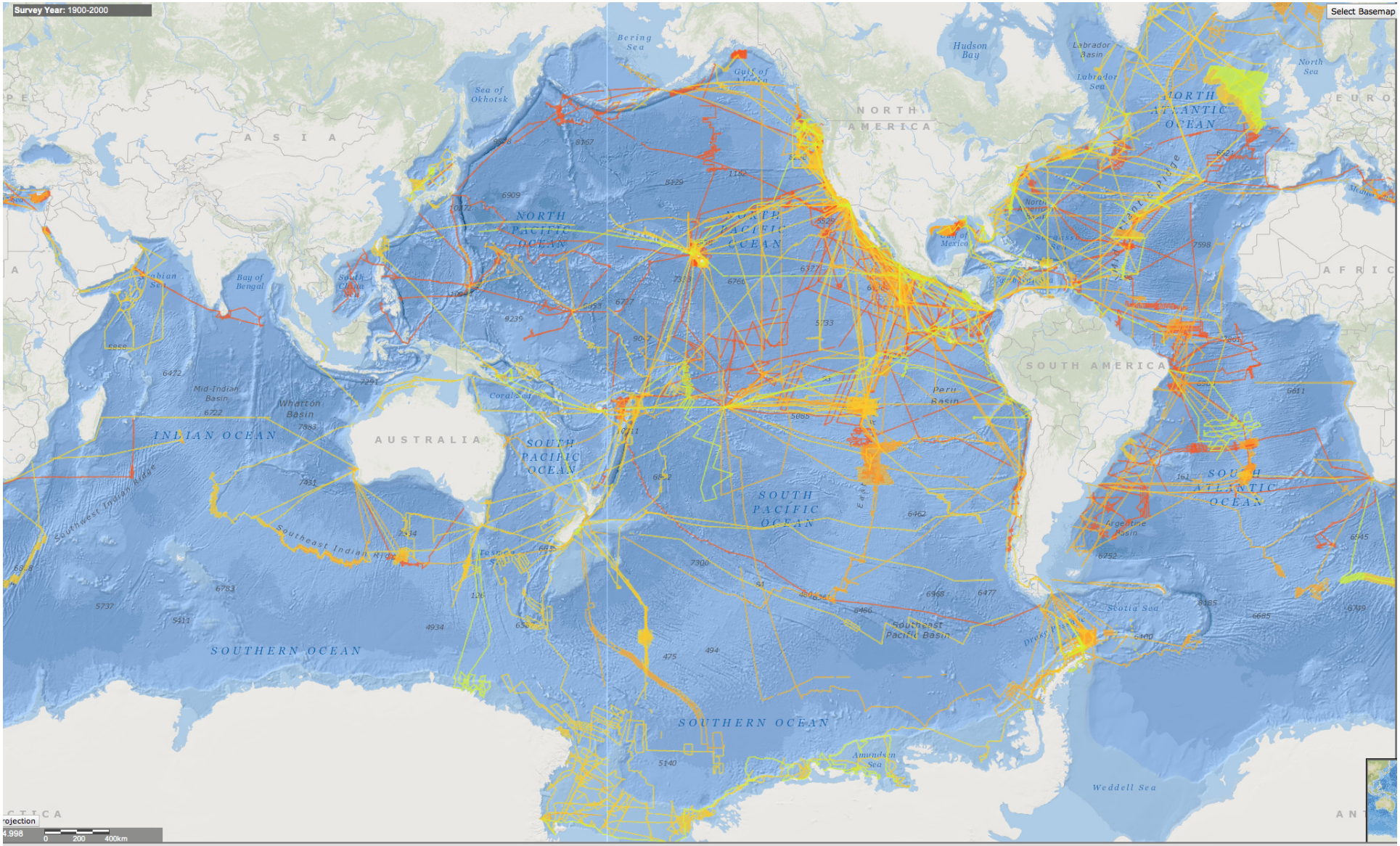


areas of seafloor more than 20 km from a sounding

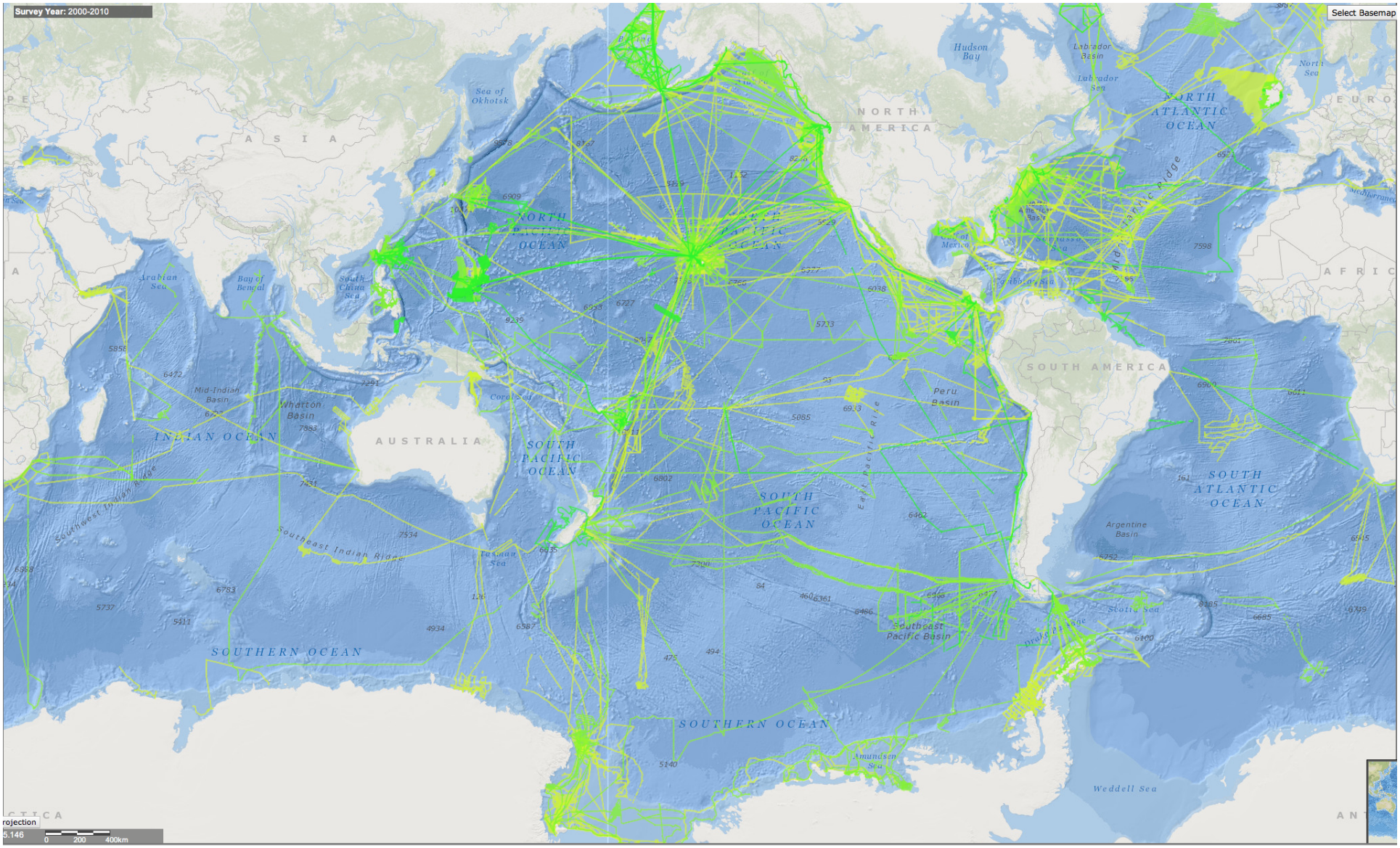
multibeam data at NGDC 1980-1990



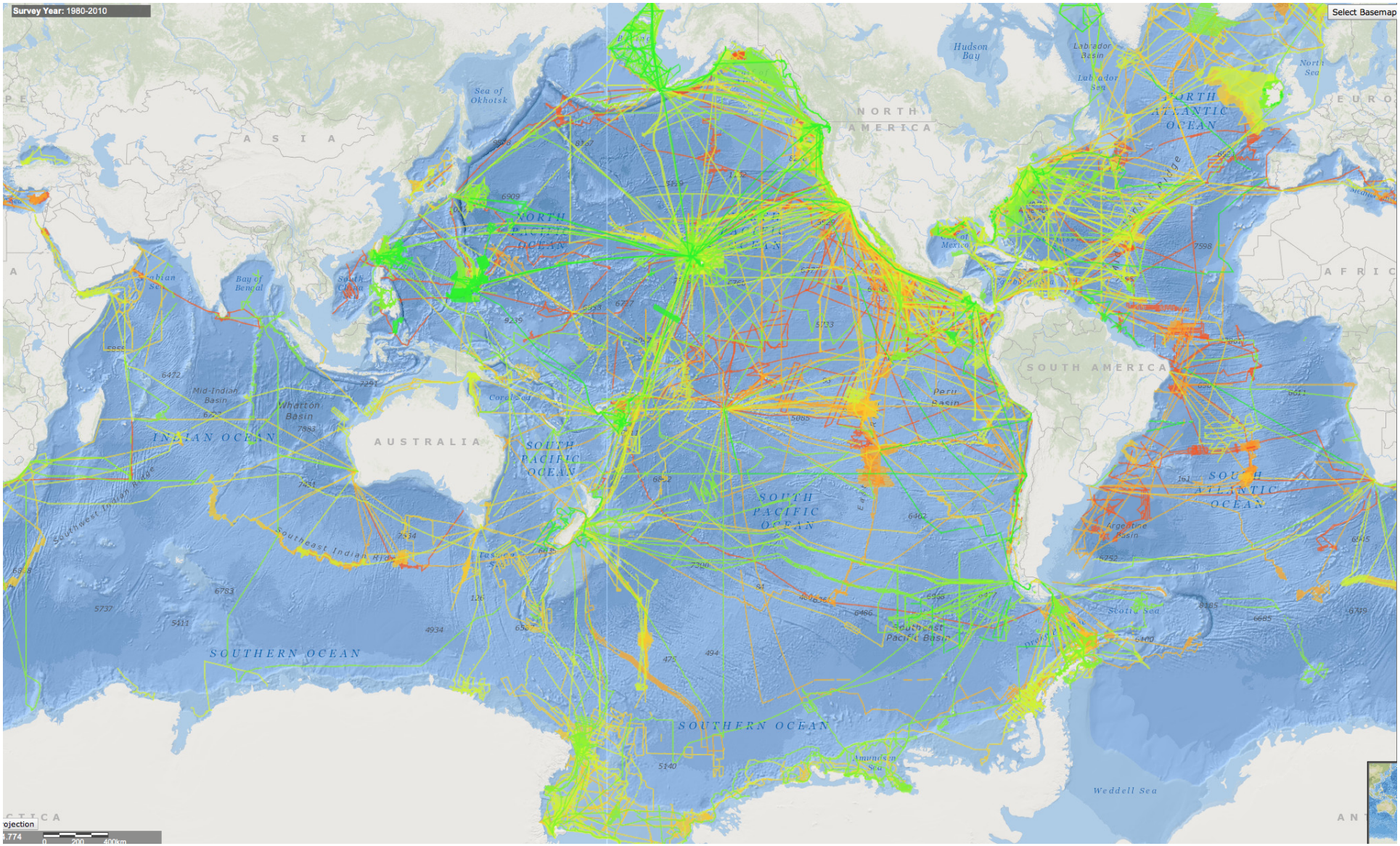
multibeam data at NGDC 1990-2000



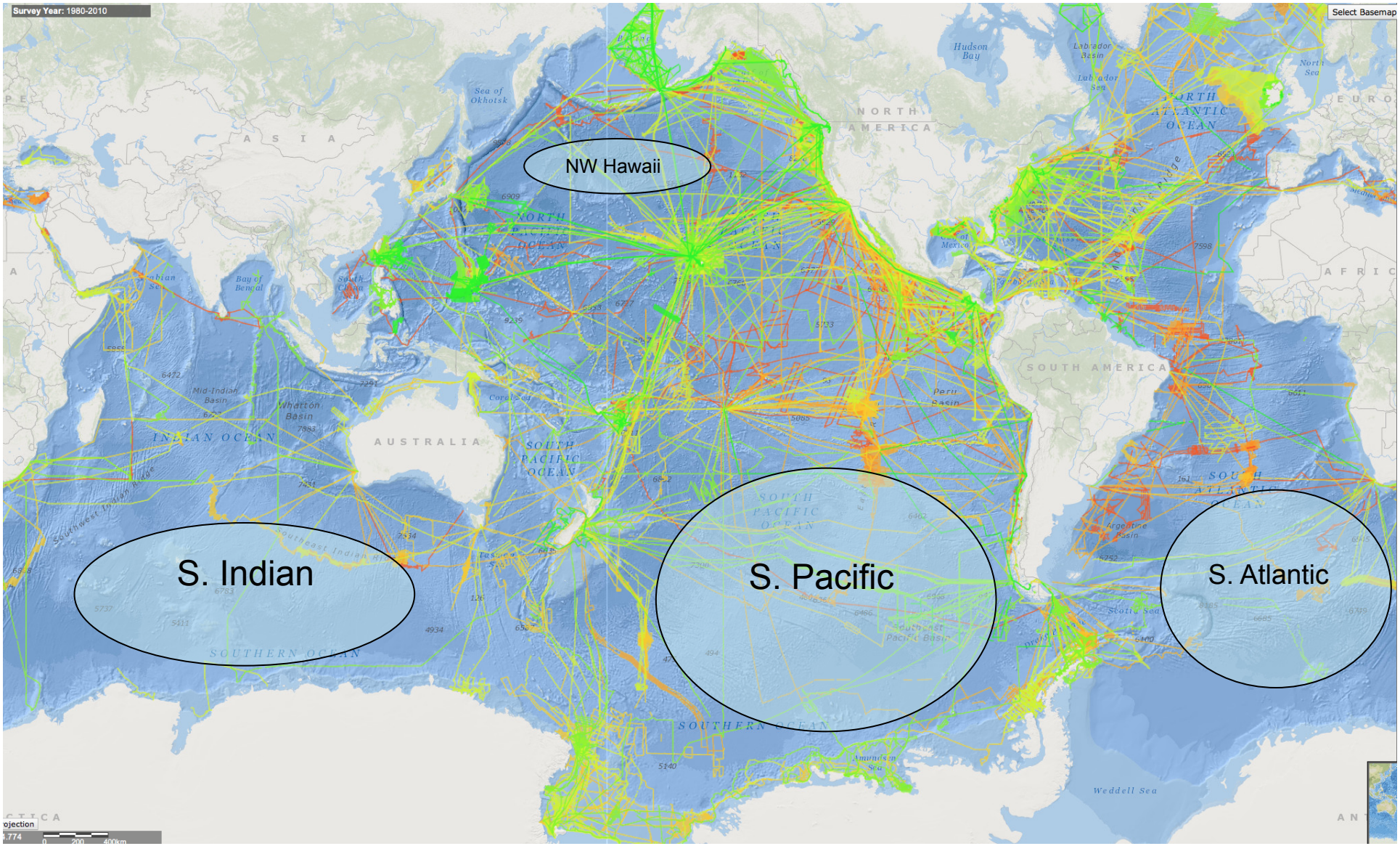
multibeam data at NGDC 2000-2010



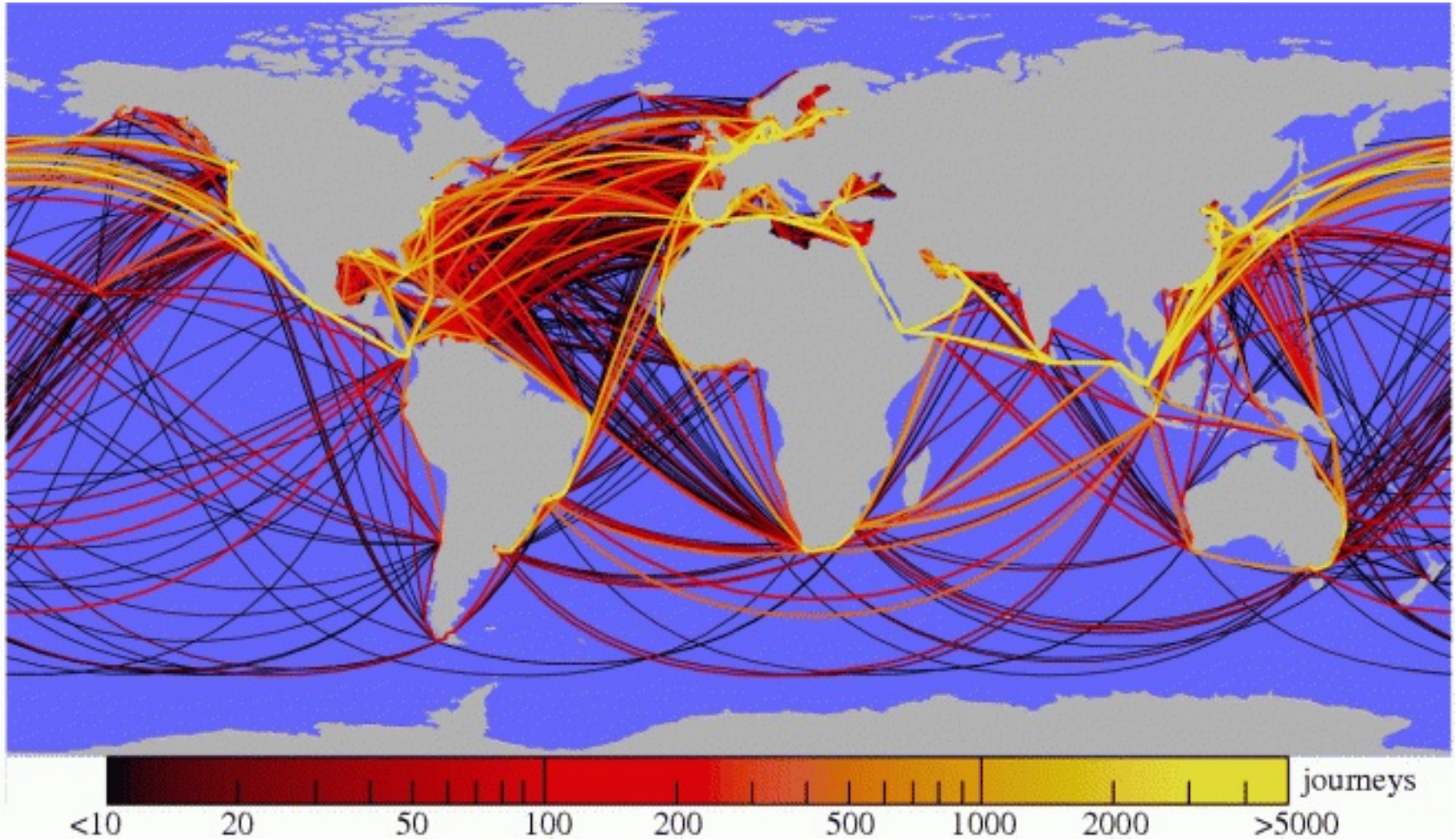
multibeam data at NGDC 1980-2010



multibeam data at NGDC 1980-2010
large uncharted areas

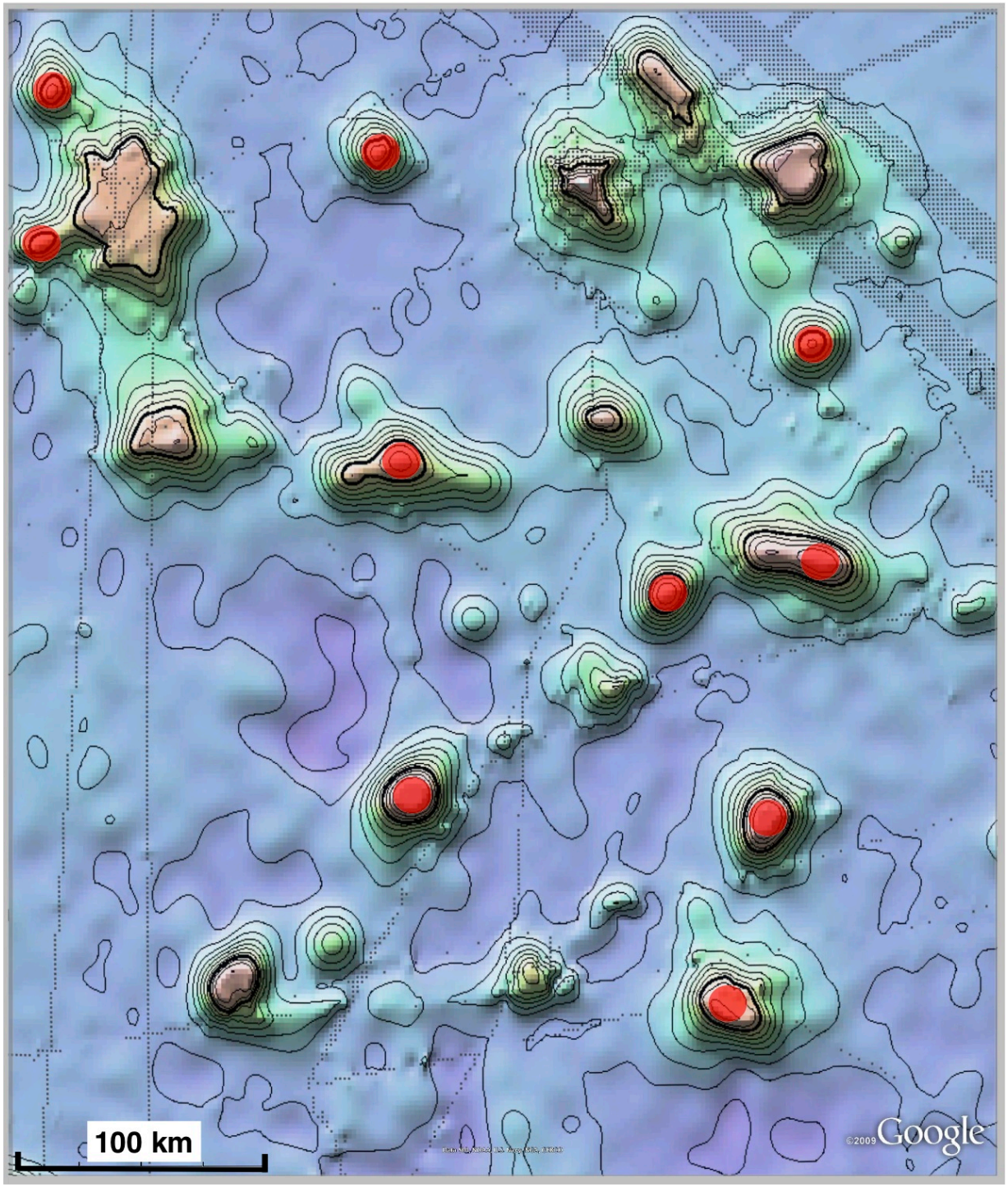


routes of cargo ships for the past year

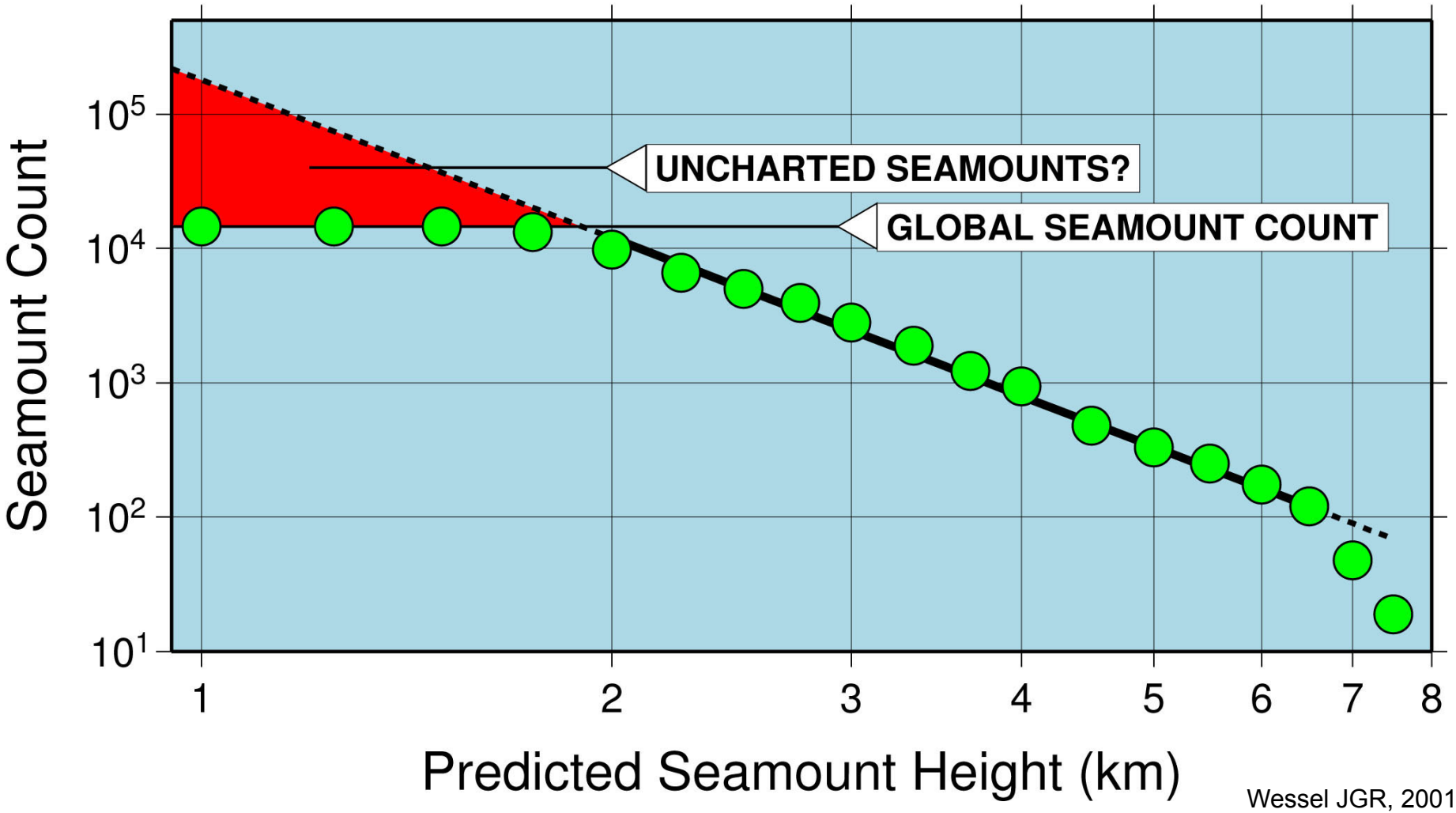


Citation: "The complex network of global cargo ship movements" Pablo Kaluza, Andrea Kölzsch, Michael T. Gastner and Bernd Blasius, J. Royal Society: Interface

uncharted seamounts > 3 km tall



size distribution of seamounts



Wessel JGR, 2001

Grounding of USS San Francisco on Uncharted Guyot

- Los Angeles class Submarine ran aground in route from Guam to Brisbane, Australia - 8 January, 2005
- One sailor killed, 120 injured
- Crash depth ~160 m, speed 33 kn, Sonar measured a depth of 2000 m, 4 minutes before crash
- 30-hour trip back to Guam, crew managed to keep the sub from sinking
- Area of discolored water noted on navigational chart 4.8 km, south of crash site
- Navy began basing attack submarines in Guam in 2002

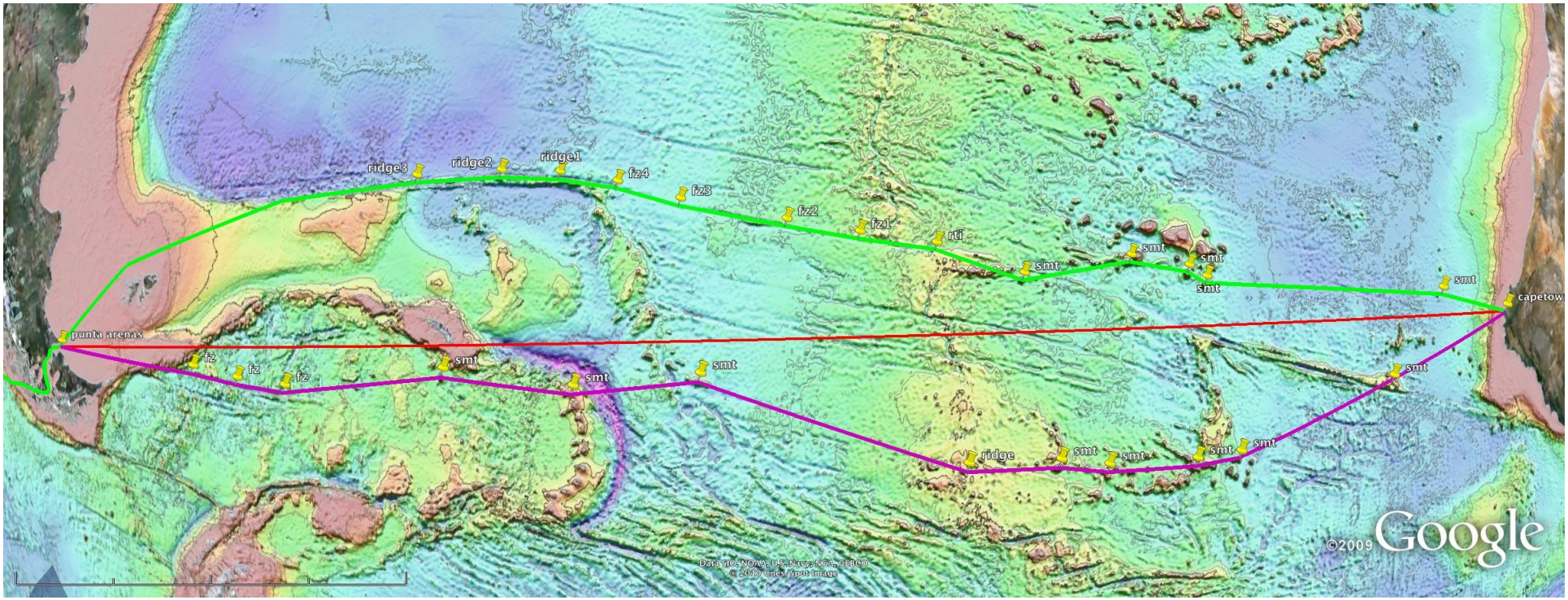
How can we do better?

- Improve public archives of bathymetry.
- **Map the oceans with multibeam echosounders - ships of opportunity.**
- Launch a new satellite altimeter.
- Declassify US Navy bathymetry data.

Ship of Opportunity Example

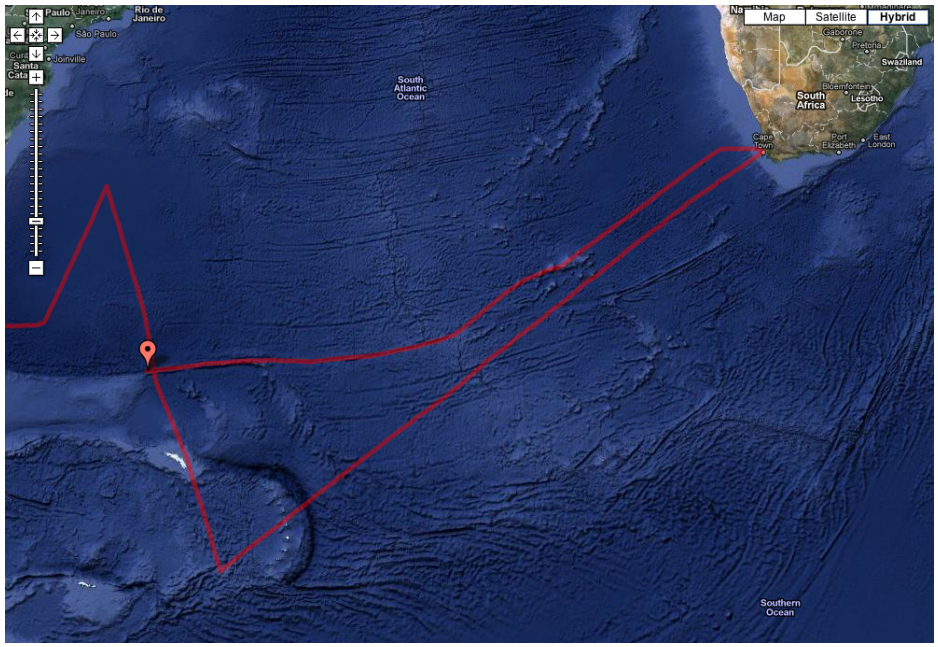
Capetown to Punta Arenas - Melville - Feb, 2011

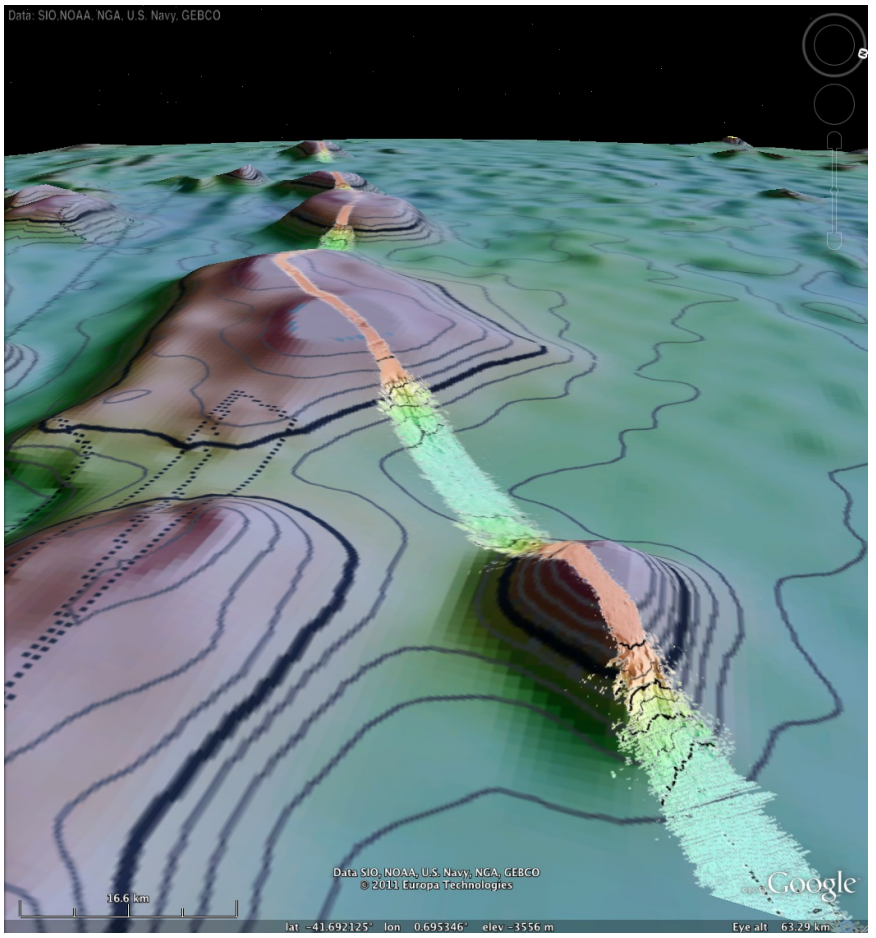
red - great circle = 6896 km
green - 10 new seamounts = 7130 km (1.034)
violet - 11 new seamounts = 7069 km (1.025)

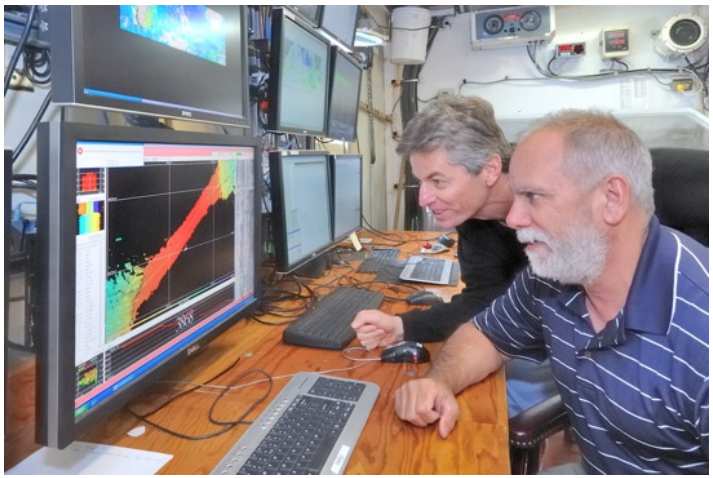


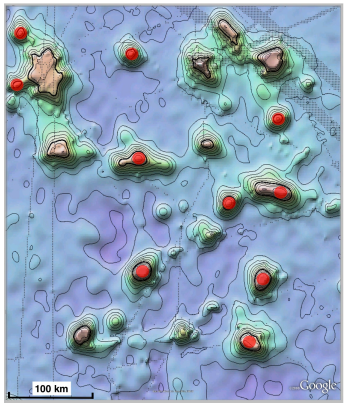
Actual tracks

Capetown to Punta Arenas - Melville – March, 2011

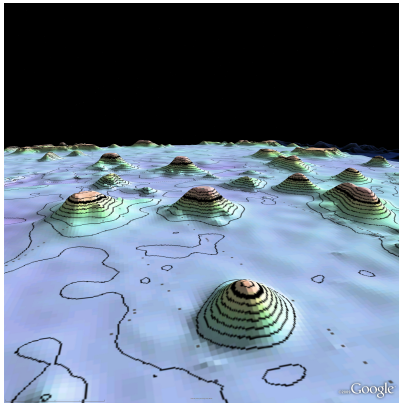








Conclusions



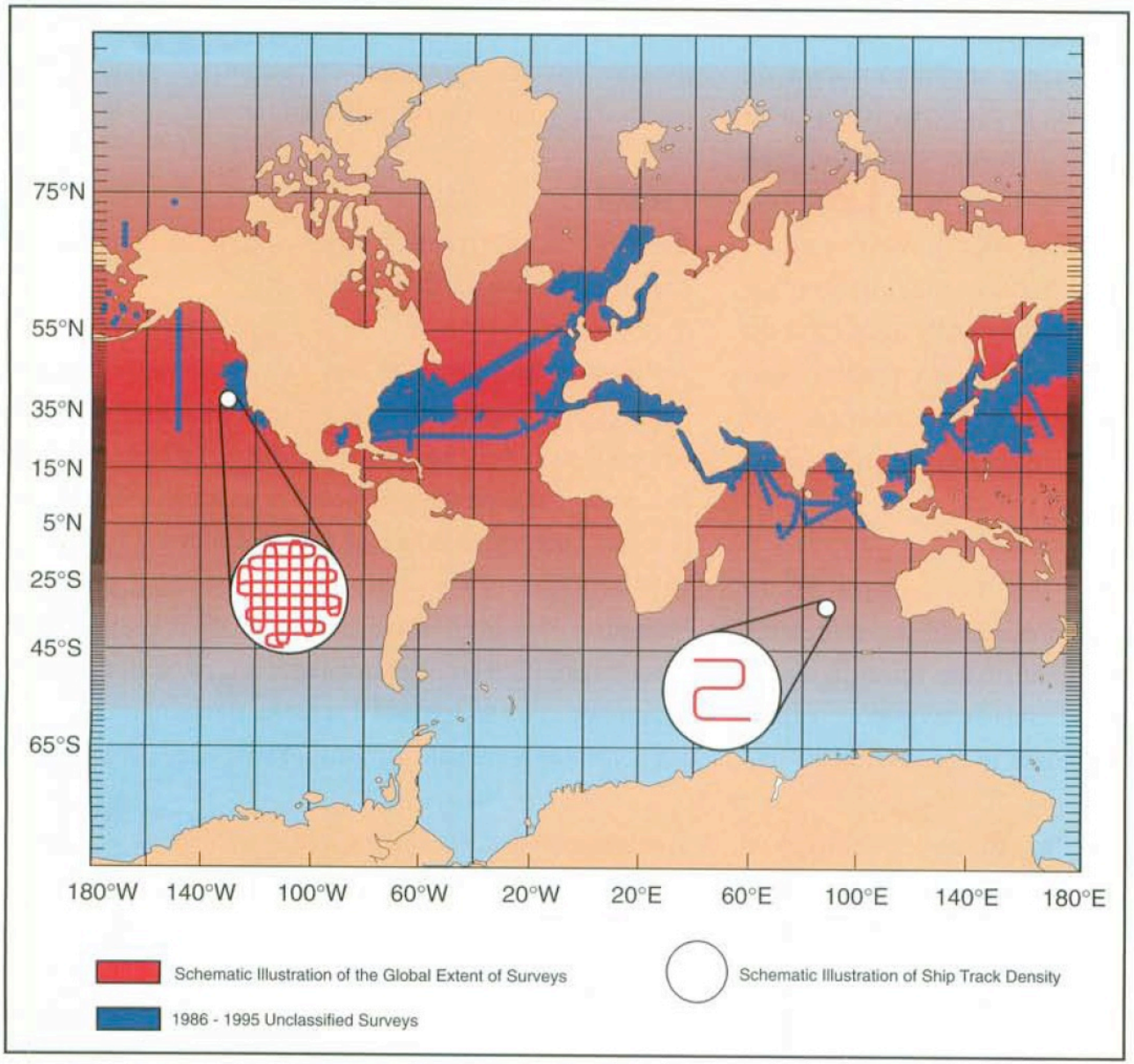
Objective – construct the best possible map of the deep ocean floor for science, public outreach, and applications.

- ½ of seafloor is more than 10 km from a depth sounding – mostly southern oceans

- We can improve deep ocean bathymetry by:
  - improve public archives and encourage data sharing (e.g. declassify US Navy data)
  - constructed low-resolution bathymetry from satellite gravity
  - map oceans with ships of opportunity guided by satellite gravity

MEDEA: Scientific Utility of Naval Environmental Data, **(Mitre, Co., June, 1995)**

FIGURE 2. WORLDWIDE SURVEY OPERATIONS



The red shaded area illustrates the global scope of the Navy's oceanographic survey and measurement program. As the tapered shading suggests, there has been a greater concentration of resources in the Northern Hemisphere than the Southern Hemisphere.

Also shown schematically are inset illustrations of how different the densities of ship tracks might be in different ocean areas. Tracks of naval oceanographic surveys (blue) from just the unclassified cruises covering the years from 1986 to 1995 show the worldwide nature of the sources of data.

Examination of all survey ship tracks from the entire cold war history of naval survey operations would show both a global breadth of coverage and a scientifically well founded spatial sampling of ocean processes.

MEDEA: Scientific Utility of Naval Environmental Data, **(Mitre, Co., June, 1995)**

TABLE 2. FINDINGS RELATED TO SPECIFIC DATA SETS

- ***Scientific Utility***

  We have singled out 10 data sets whose potential for supporting important science is so significant that our first recommendation to the Navy is to "...consider prompt declassification of the high priority environmental data sets identified here." Four of these data sets are in the domain of geology and geophysics (Marine Gravity, Geomagnetics, Geosat Altimetry, and Seafloor Sediment Properties), two are concerned with sea ice (Ice Keel Depth Acoustic Data and Historical Ice Morphology), and four are concerned with the volume and boundary properties of the ocean (Marine Bathymetry, Realtime Salinity and Temperature Fields [GOODS], Archival Salinity and Temperature Fields [MOODS], and Ocean Optics and Bioluminescence).

- ***Prioritization of Data Sets***

  The listing below shows a twofold prioritization of the probable scientific importance and uniqueness of the data, should they be made publicly available.

  First Tier
  - Marine Gravity
  - Geomagnetics
  - Ice Keel Depth Acoustic Data
  - Marine Bathymetry
  - Geosat Altimetry

  Second Tier
  - Historical Ice Morphology
  - Seafloor Sediment Properties
  - Realtime Salinity and Temperature Fields (GOODS)
  - Archival Salinity and Temperature Fields (MOODS)
  - Ocean Optics and Bioluminescence