Combing multibeam from many sources – challenges and promises

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"Many earth scientists share the dream of having the entire surface of the earth... mapped seamlessly to a fine resolution."

- "Seamlessly" is a very powerful word:
  - vertical datum problem between seafloor and land maps
  - horizontal fitting of abutting data sets
  - horizontal fitting of data sets with space between them

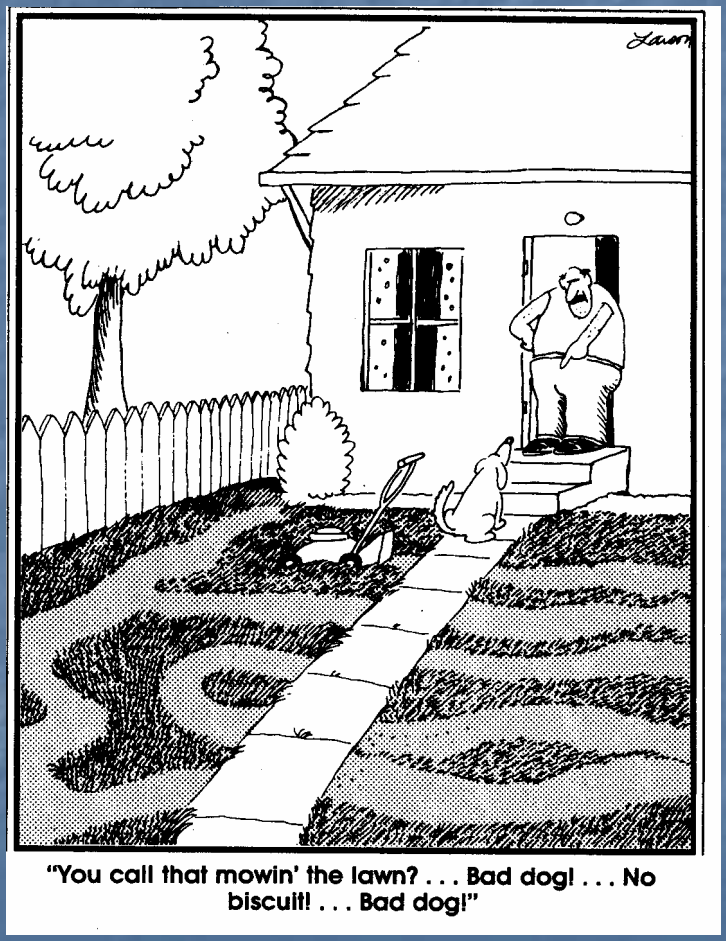
Not all the world is covered by multibeam and it will be a long time before it is

- No systematic program to map deep ocean appears likely.
- MBES surveys will be conducted for many reasons, using different equipment operated to different standards, covering limited areas
- The data they collect will be wonderful within the survey area
- BUT
- GEBCO has to map the entire world ocean
- Consequently
- MUST BLEND ALL THE DIFFERENT SURVEY DATA SETS AND THE GAPS BETWEEN THEM

Where will deep MBES data be collected in the next ten years?

- On Continental Slopes.
  - UNCLOS Article 76 requirement to map the Foot of the Slope and the 2500 meter contour.
  - Presence of methane hydrates in the sediments of the slope
  - These data may or may not enter the public domain
- Tsunami effected area (and other emergencies)
  - We will see a debate over which is more important, the shallow water run-up zone, or the deep water path
- In areas of specialized interest
  - E.g. The Ridge Program
- "Random" tracks that collect data will decrease
  - shift from the "expeditionary" style of at-sea data collection to repetitive measurements of the same point or small area to collect time series

- Unfortunately, the net result will be…



"You call that mowin' the lawn? . . . Bad dog! . . . No biscuit! . . . Bad dog!"

- Gary Larson, The Far Side

Making maps from this data set

- Not the same as making maps or charts from single data sets
- Requires interpretation and consideration of other types of data
- Can be treated as numerical exercise (algorithm) only up to a point

Technical Issues

- 1 Ensonification/ coverage
  - a) Do you really need to mow the lawn
  - b) Is there information in the existing single beam coverage that can be used to plan / orient the MBES survey?
  - c) Is there information in the existing single beam bottom traces that could help select the most appropriate MB system for that area?
- 2. Portrayal of results
  - a) How do you show adjacent/ overlapping areas that have been surveyed by MBES, by single beam, or by both?
  - b) Can you do this on bathymetry maps and navigation charts the same way?
  - c) How to express uncertainty for a map made from two types of data? d) How do you select a publication scale appropriate to both data types?
- 3. Prediction of the bottom.
  - a) can you extrapolate the convolution / texture of the seafloor captured by MBES into the areas not surveyed by MBES

Using new MBES data in combination with legacy single beam data in areas of sparse sounding coverage.

- That's what we will have to do in GEBCO for some time
- This is not unique to deep water: there are many areas of shallow water that will not be covered by complete MBES data for some time, yet they have to be charted for navigation purposes.
- Don't forget side-scan

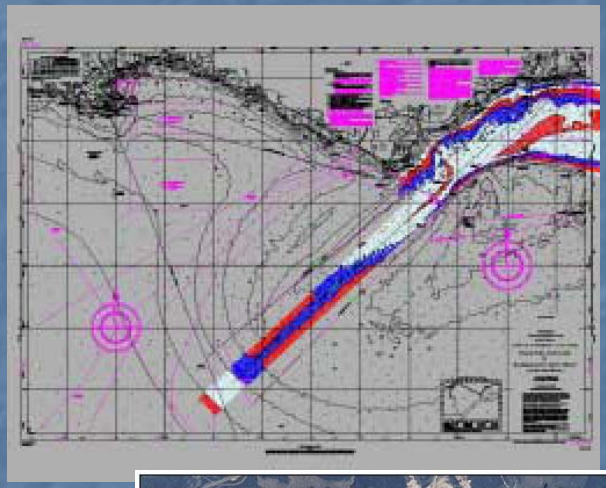
Patch test, we don't do no stinkin' patch test!

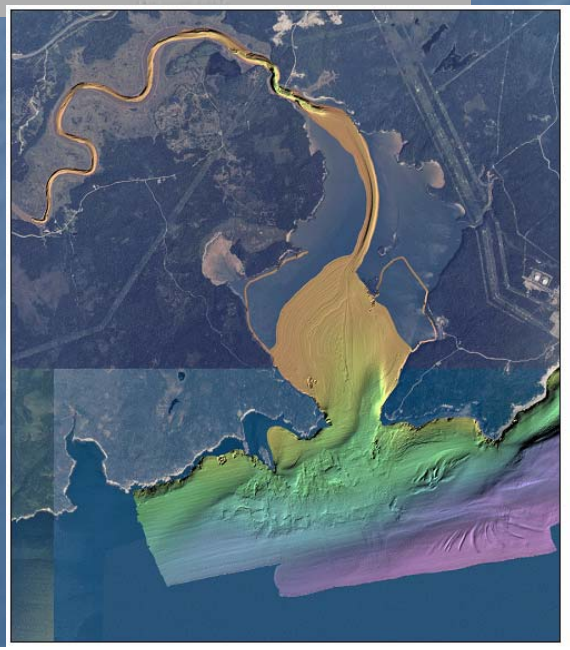
- Use the patch test early on in a survey to calibrate the system
- Without one, the data can contain artifacts created by systematic errors
- A patch test creates a data set that is free of systematic errors.
- It is a mistake to believe that this data set is free from error. All the patch test can do is help render the data internally consistent.
- When trying to combine two MBES data sets, its possible that their patch tests offset them from each other.
- In the real world of disparate data sets, different data sets will have either had different patch tests or had no patch test at all.
- Since you wouldn't accept a single line of your own survey without a patch test, how can you accept a line from a different survey without one?

To use different types of data together, we:

- 1. Must understand how they are collected
- 2. Must have an estimate of each piece of data's uncertainty
- 3. Must have a means of comparing them
- 4. May have to adjust one to match the other
- 5. May have to down-grade to lowest common denominator
- 6. Understand scale implications
- 7. Have a means of interpretation that works on different types of data
- most MBES work is done in the interior of one survey, aimed at making it internally consistent, but two data sets are more complicated

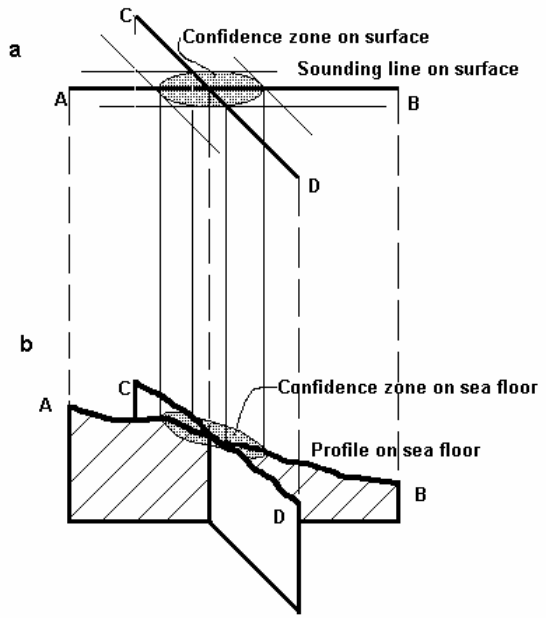
How have data been combined in the past?





- Easy answer is that they haven't.
- Draping one over the other is not combining them, its just producing a picture and perhaps an illusion of combination.
- Often usually just replace chart with MBES image without trying to match the two eg Shep Smith navigation surface "rules were established for superseding one survey with another"
  http://www.ccom.unh.edu/nav_creation.htm#A

Comparing single beam and single beam



- Cross-over
- Comparing two similar if not identical things

Comparing MBES and MBES swaths at cross-overs

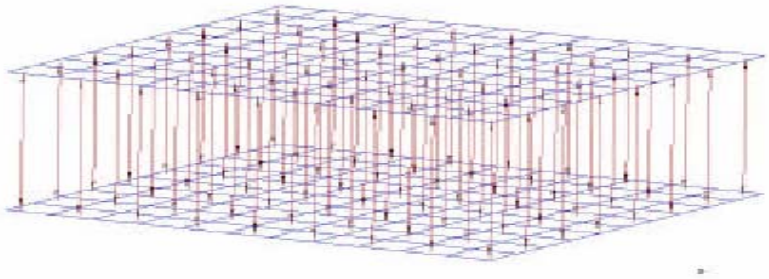


Figure 2. Area comparison approach. Each red arrow is a residual value. A single quality statistic is calculated from the residuals of collocated grid cells.

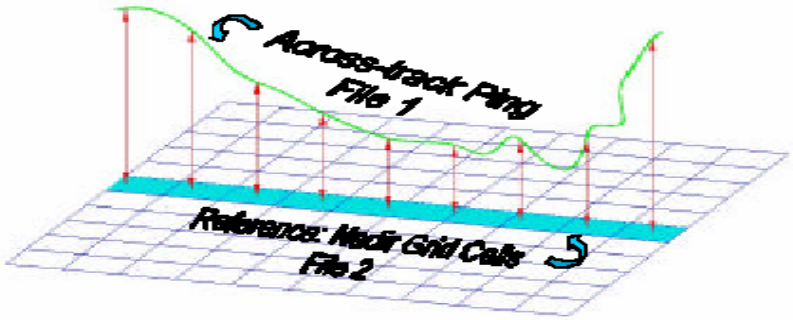
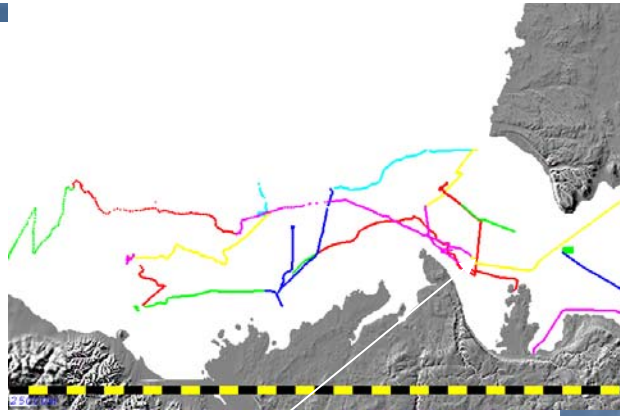


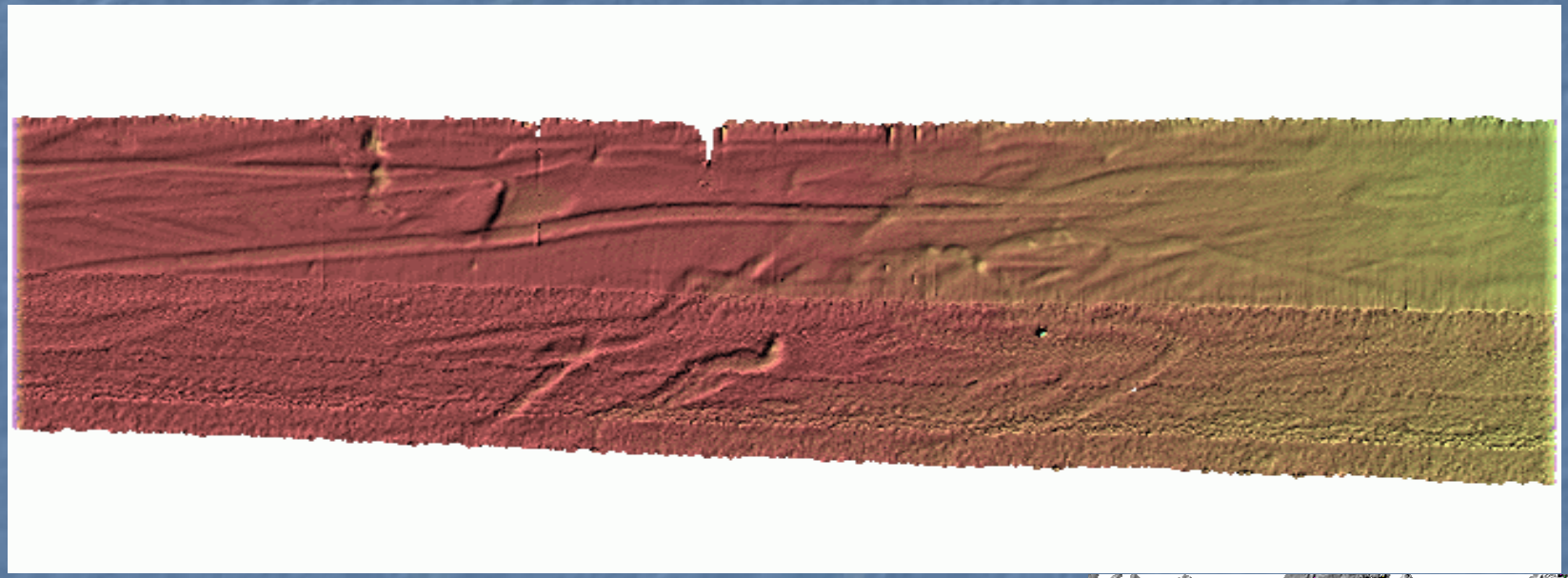
Figure 3. Ping comparison approach. A residual is found between an actual ping and nadir grid cells.

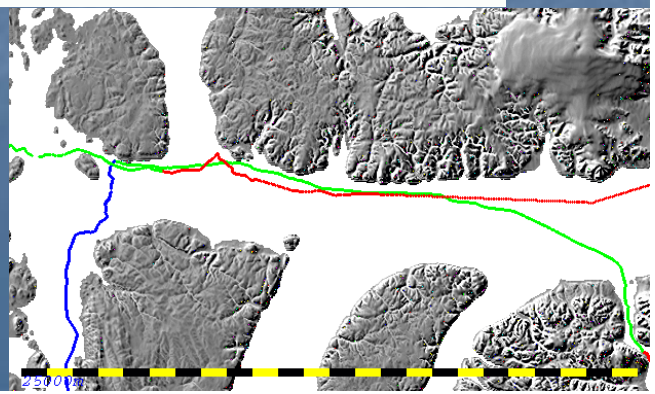
- As a precursor to comparing MBES and single beam
- Sebastian, S. and D. Wells (2003). Analysis of Multibeam Crosschecks Using Automated Methods. US Hydro Conf 2003, Biloxi, Mississippi. http://www.thsoa.org/hy03/6_3.pdf



Area in Amundsen Gulf.
Approximately 200 m depth.
The EM300 is the data that is vertical.
You can notice a seafloor feature
Passing through each data set.

Results as seen on the MBES

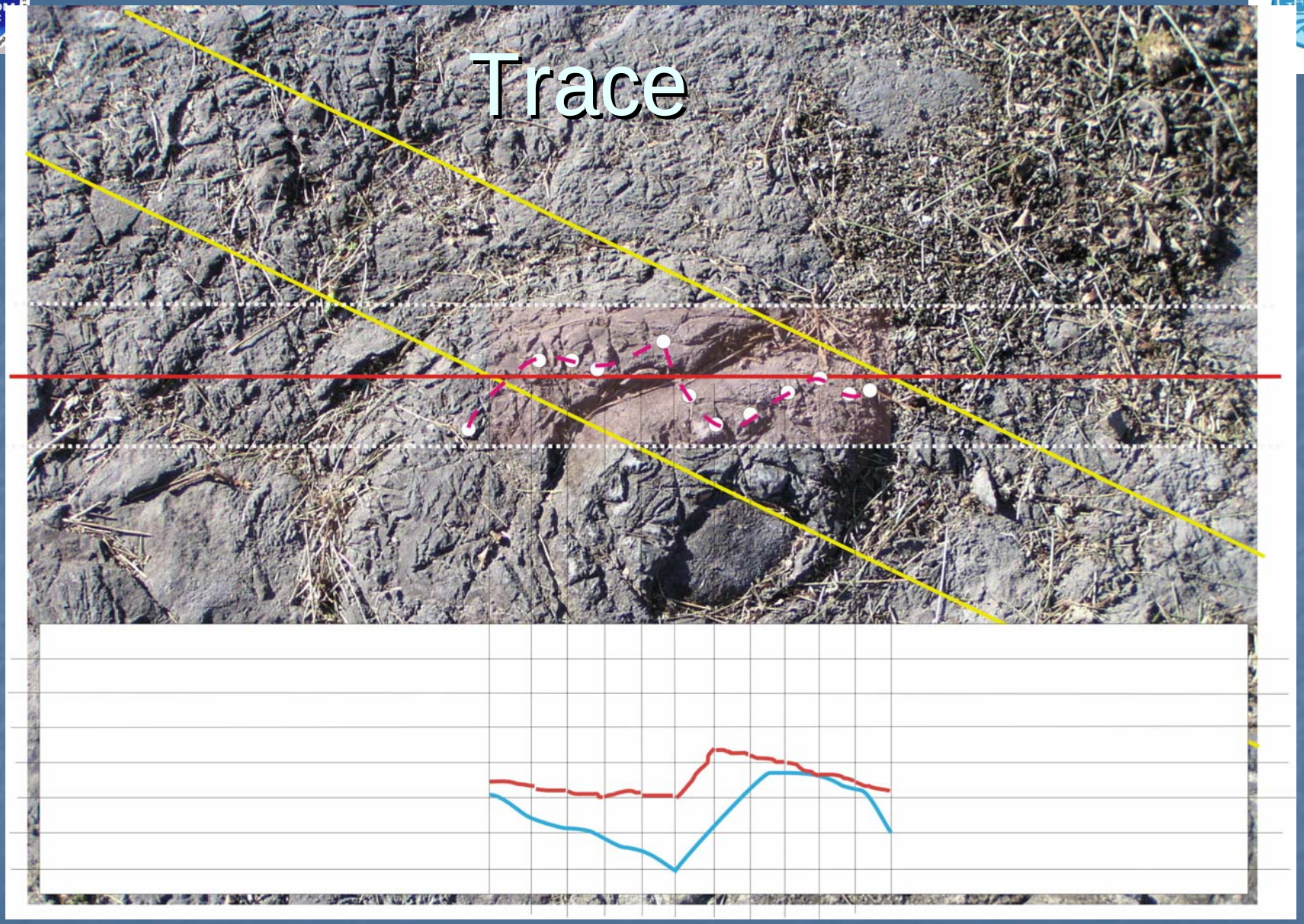




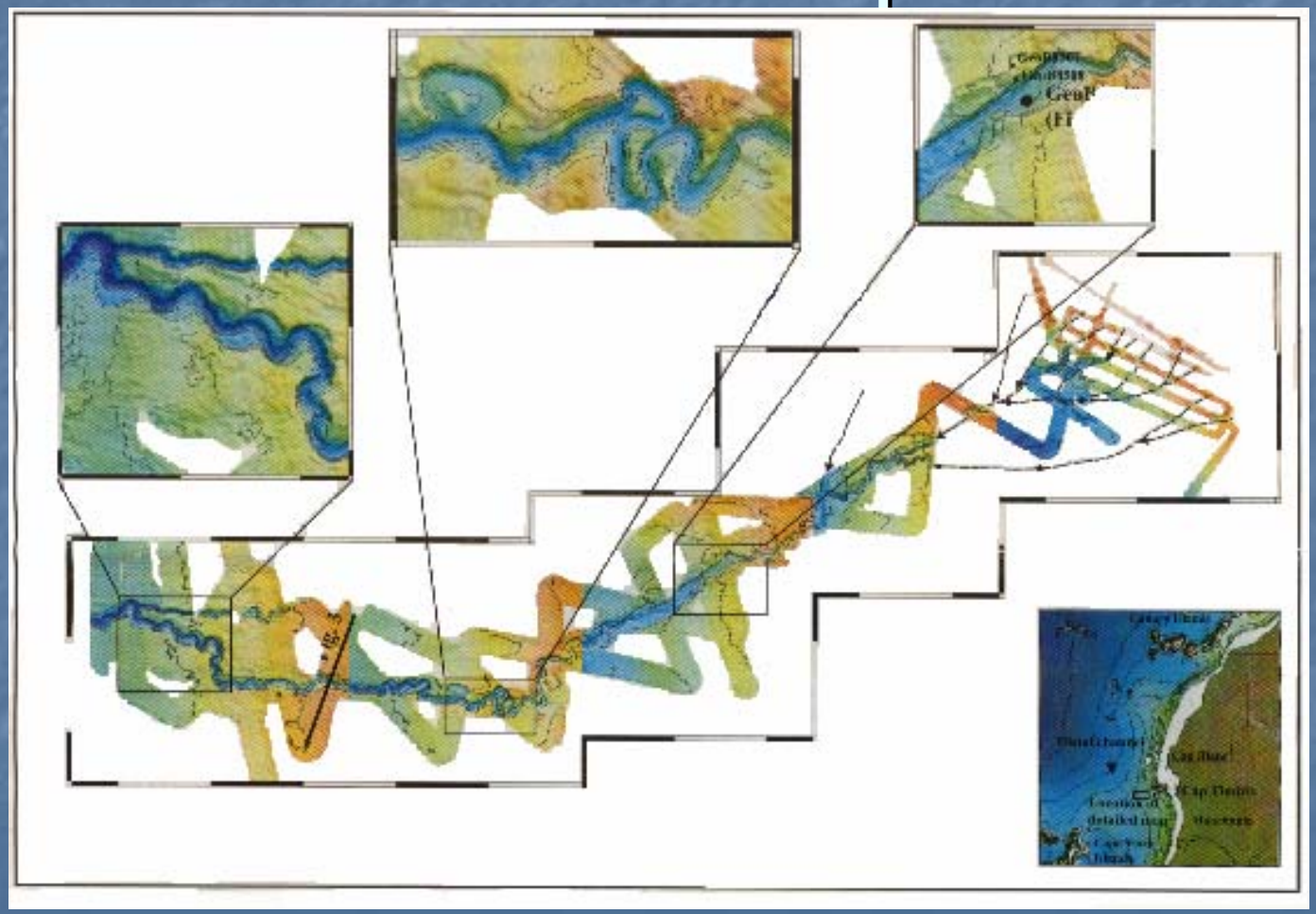
Try to compare a sbes and MBES

- Say there is an area that has a MBES swath and a single track crossing it
- Where they cross, what constitutes agreement?
- What would agreement look like?
- SBES is probably broad beam, so: a) rough parts on bottom are smoothed and b) reported bottom is along track but first return might be a wiggly line

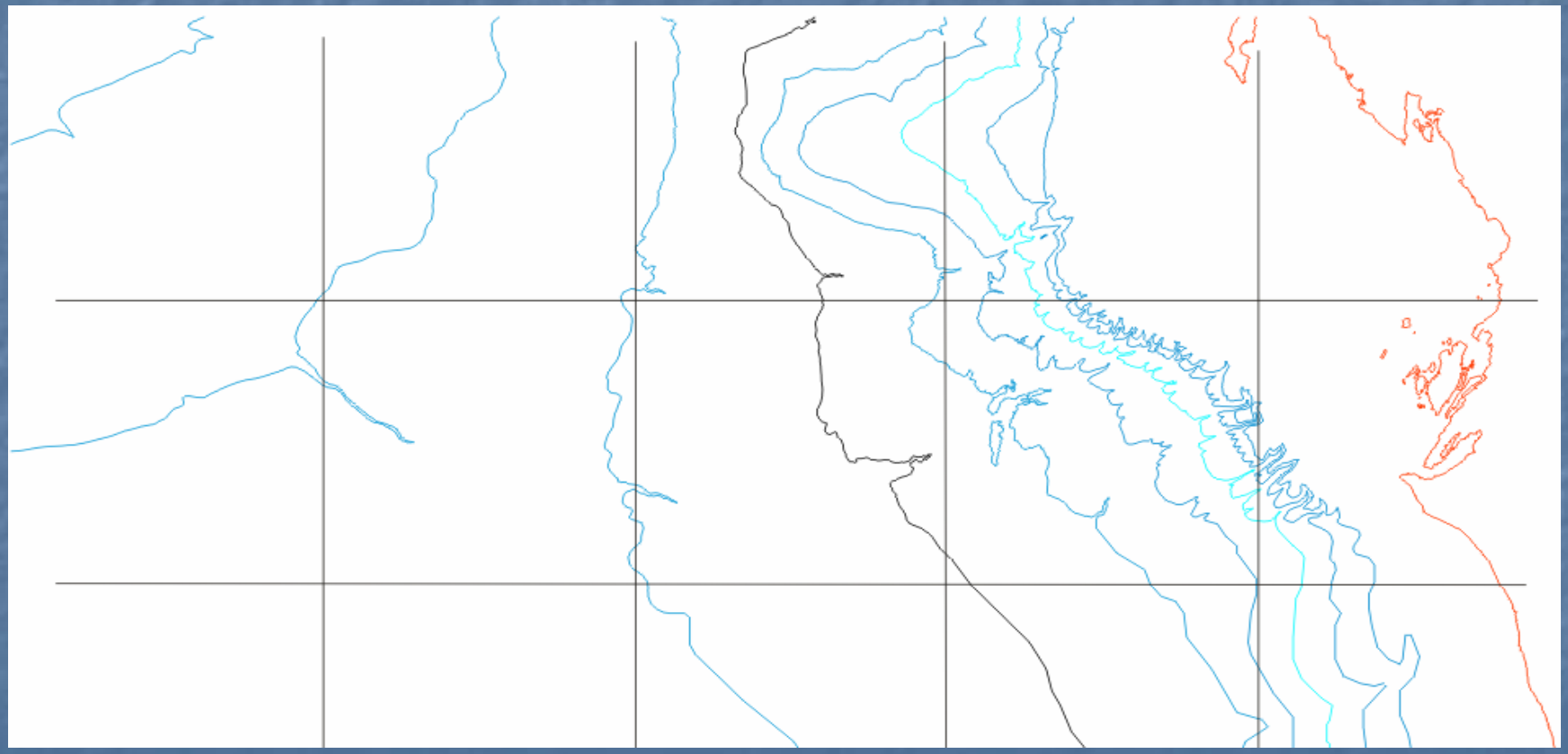
Trace



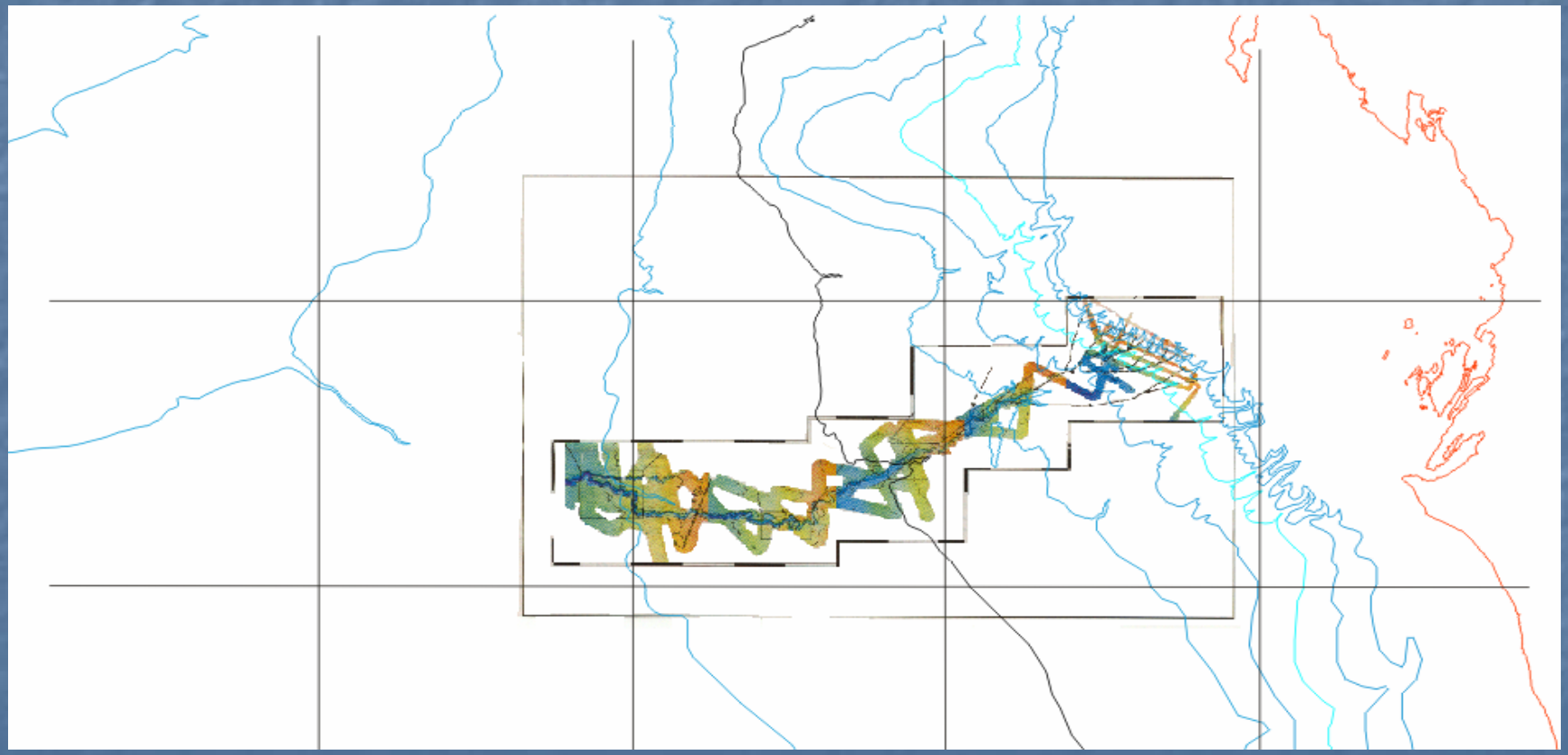
Compare MBES with existing contour map 1



Compare MBES with existing contour map 2



Compare MBES with existing contour map 3



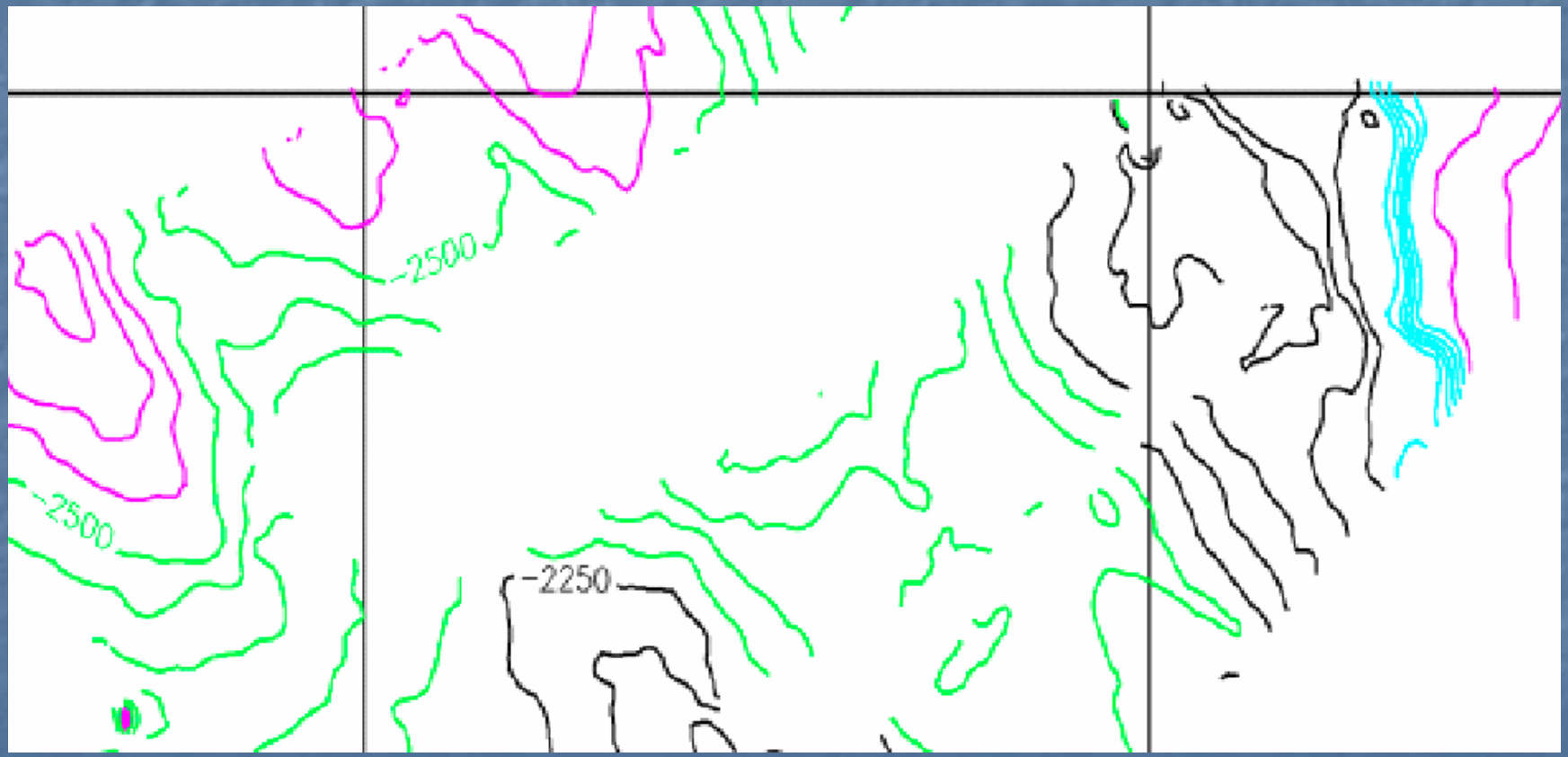
Combining with altimetry

- At the opposite end of the scale, altimetry provides long wavelength information. While combining altimetry and single beam has been made operational (Smith and Sandwell, 1994), interpreting the three data types together awaits development (Walter, is this still true?)

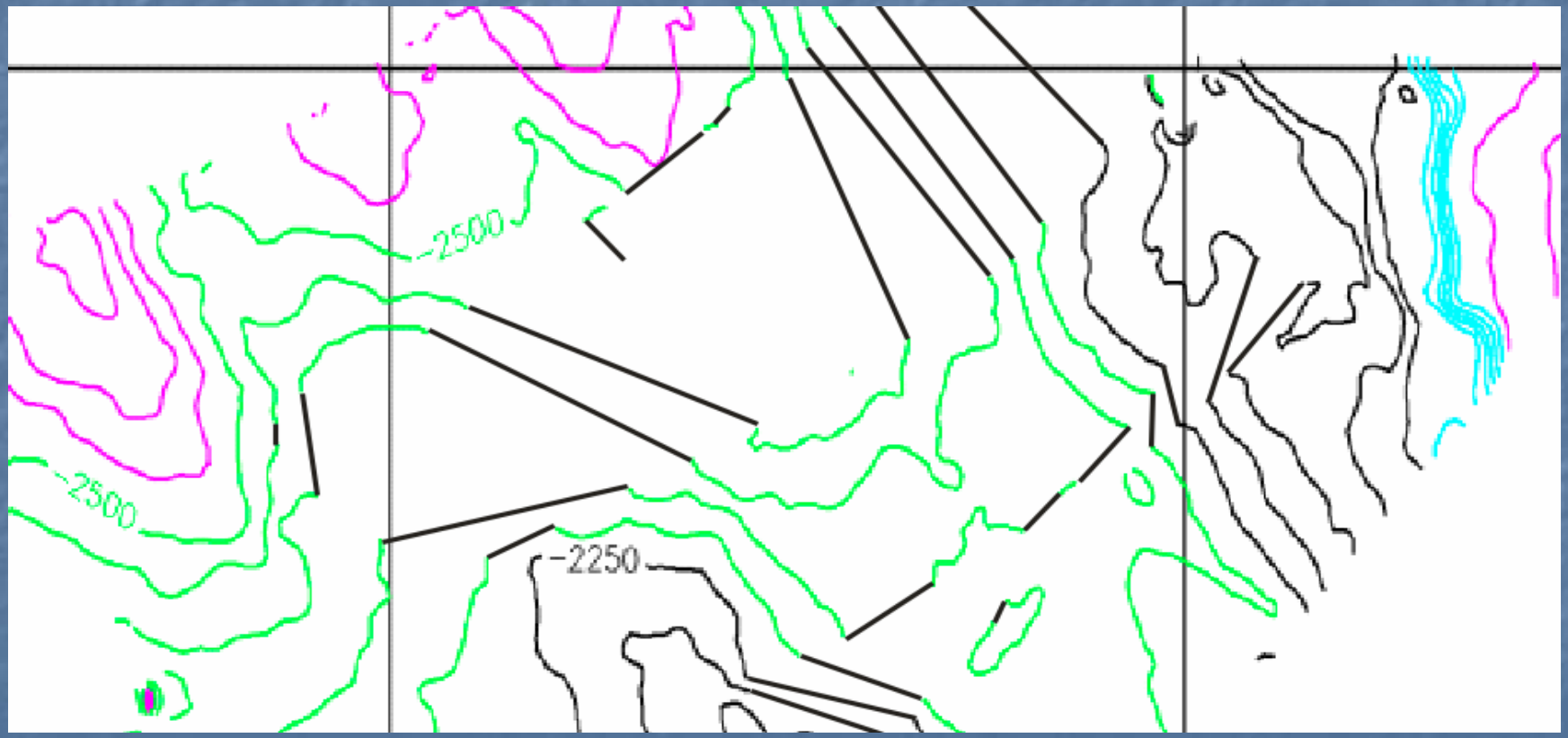
Extracting characteristics from the MBES areas and predicting the seafloor in white areas to have similar characteristics

- Can the convolution / texture of the seafloor captured by MBES be extrapolated into the areas not surveyed by MBES, anchoring the predicted surface to the single beam profiles?
- Fractals— been tried and died
- All sorts of curve fitting to the MBES surface –
- ? wavelets
- Chris Fox—your roughness model?

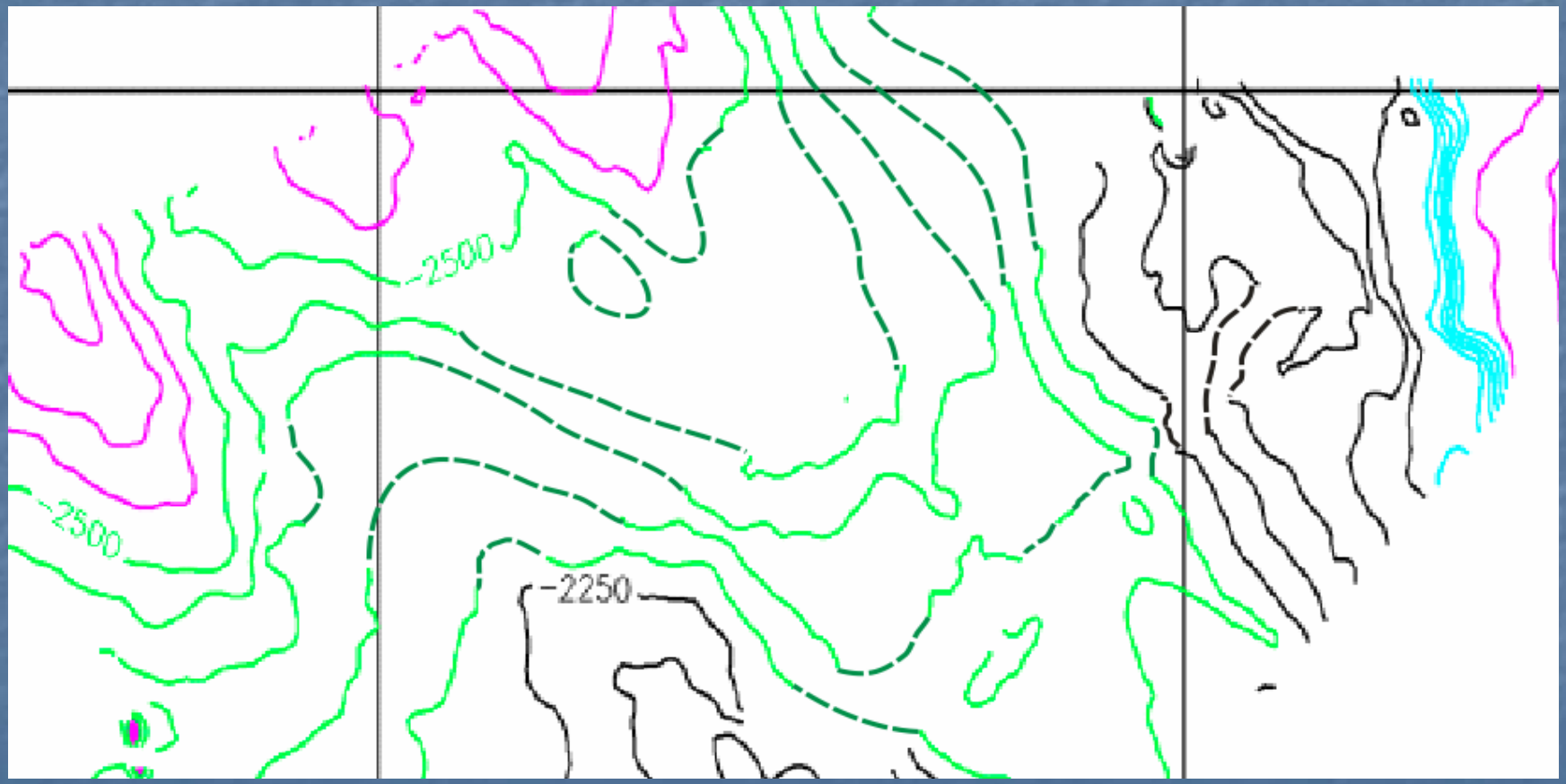
Projecting from MBES coverage to empty white space or almost empty



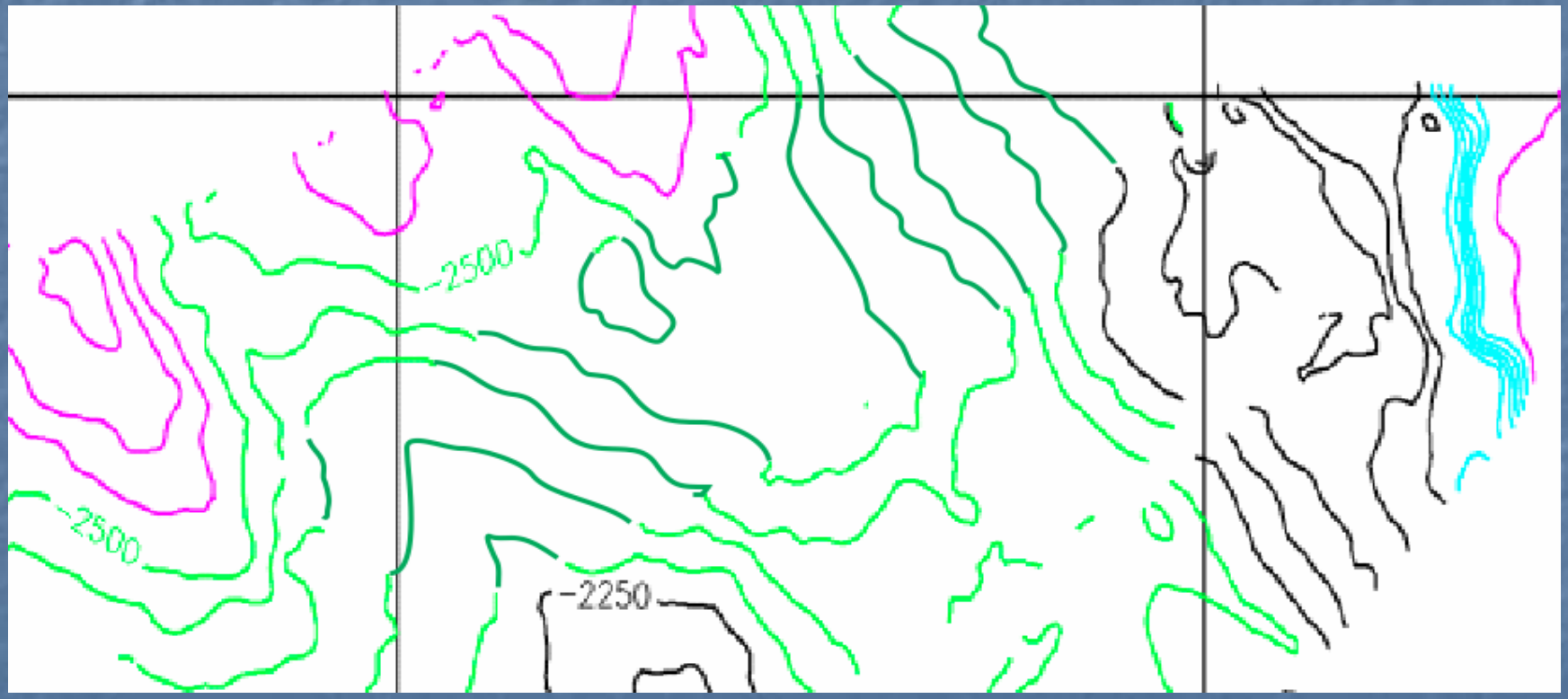
Project 2



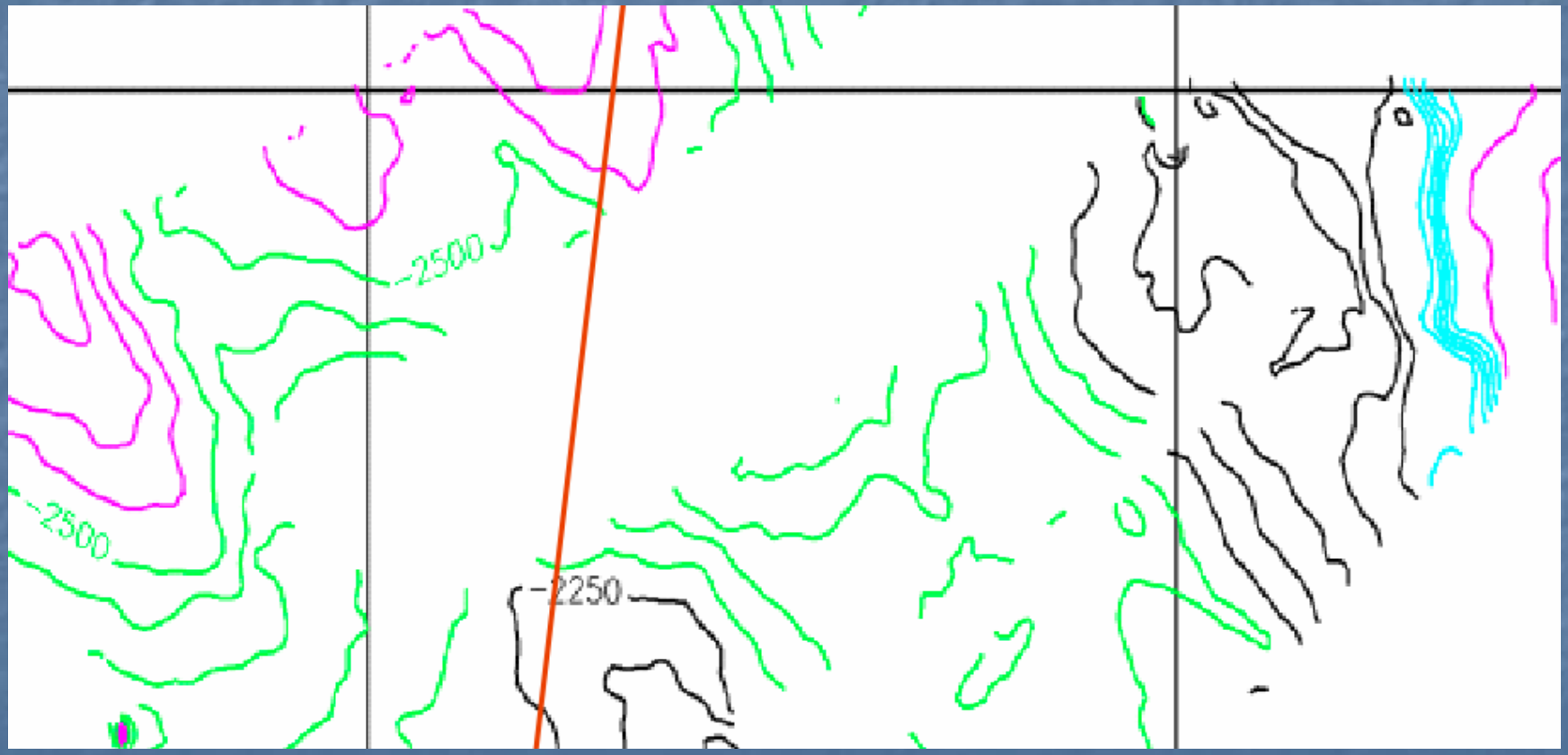
Project 3



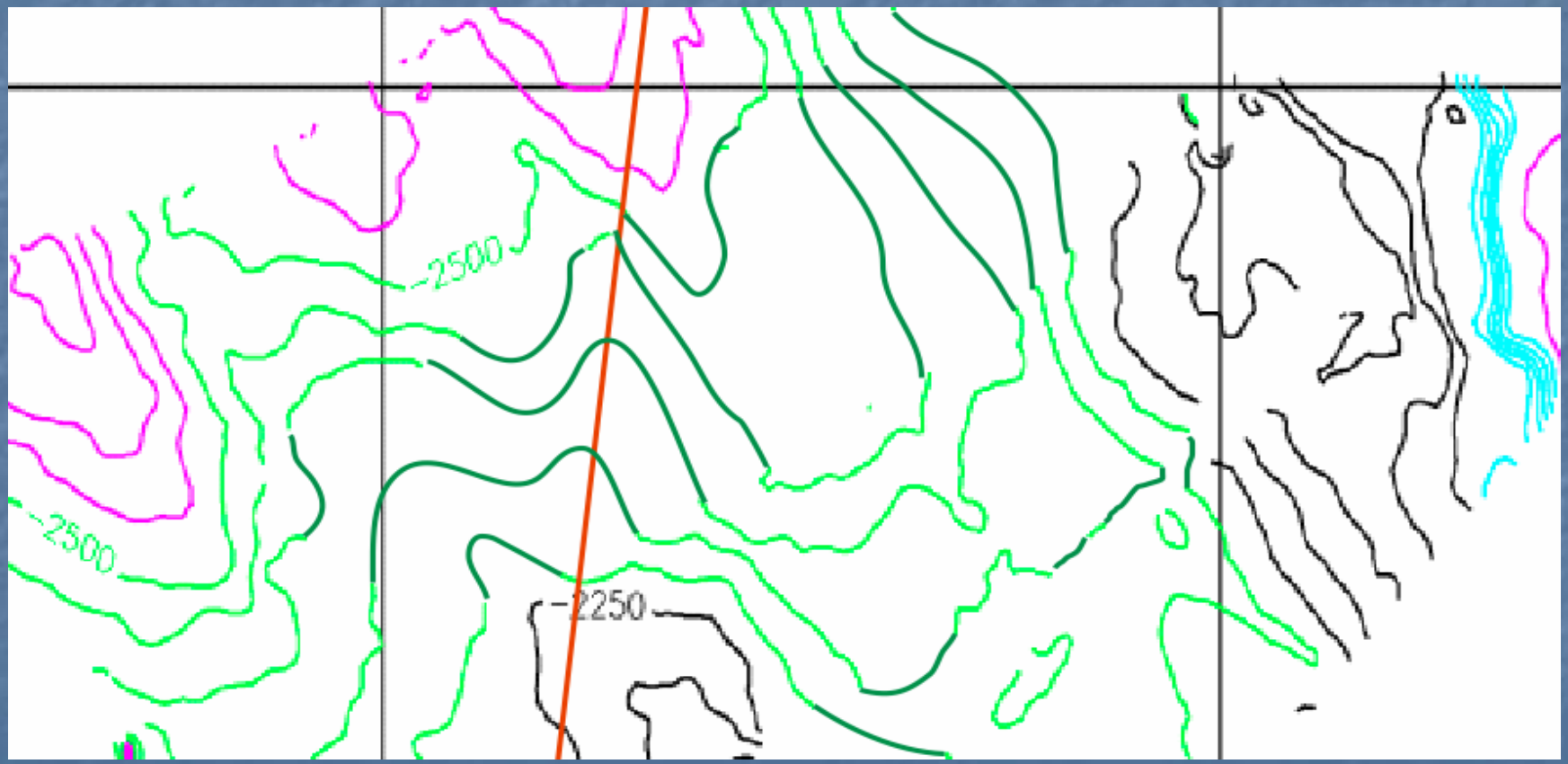
Project 4



Add one single beam line



It may add or change things



Leads to a new role for interpretation

- Within the area ensonified during a multibeam survey, there is no need to interpret the shape of the seafloor
- Between multibeam passes, there is still a need to interpret the seafloor, and ways may be devised to use, in the areas between tracks, the extra information provided by the multibeam.
- These unsounded areas have always been interpreted but we may be entering a new era where interpretation is aided by extracting data from MBES data and projecting it across the white spaces.

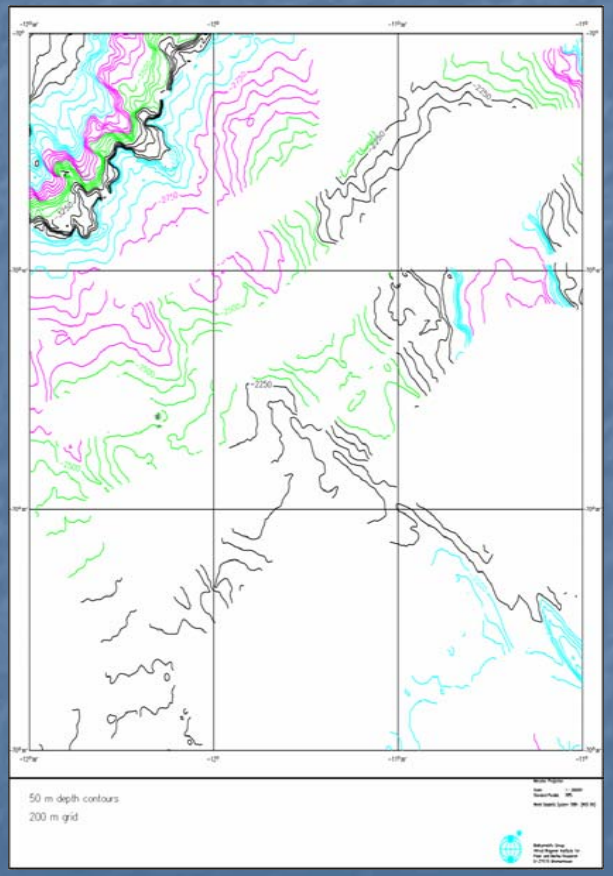
Portrayal of results

- a) How do you show adjacent/ overlapping areas that have been surveyed by MBES, by single beam, or by both?
- c) How to express uncertainty for a map made from two types of data?
- d) How do you select a publication scale appropriate to both data types?
  - relationship between footprint, pixel size, distance between track, dimensions of horizontal features within area ensonified
- Generalization — (smoothing, displacement, caricature, aggregation)
- 2D - 3D visualization –in areas of little data, is this counterproductive?

Single and Multibeam portrayed together

- East Pacific Rise from LDEO RIDGE website

AWI



- Skunk Stripes Good!
- For more than half the surface of the earth, they would be a great improvement

Some ponderables

- A lot of workers in MBES brag / complain about having too much data / vast amounts of data. In the deep sea, we have TOO LITTLE
- The people who have developed wonderful visualization techniques are loath to use visual methods of data interpretation and prefer mathematical approaches
- Lots of graphs show that many, many more data points have been collected in recent years. This does not mean that there has been a proportionate increase in information and knowledge
- In the past have spent a lot of energy on removing artifacts within an ensonified area. In future should look at artifacts OUTSIDE ensonified area –ie the white stripes on the map

Take home message

- GEBCO must develop methods to incorporate multibeam data into its maps and grids
- All welcome to contribute