Compilation of a 100m Bathymetric Grid for the Arabian Plate: Red Sea, Arabian and Oman Seas, Persian Gulf, and Northern Indian Ocean

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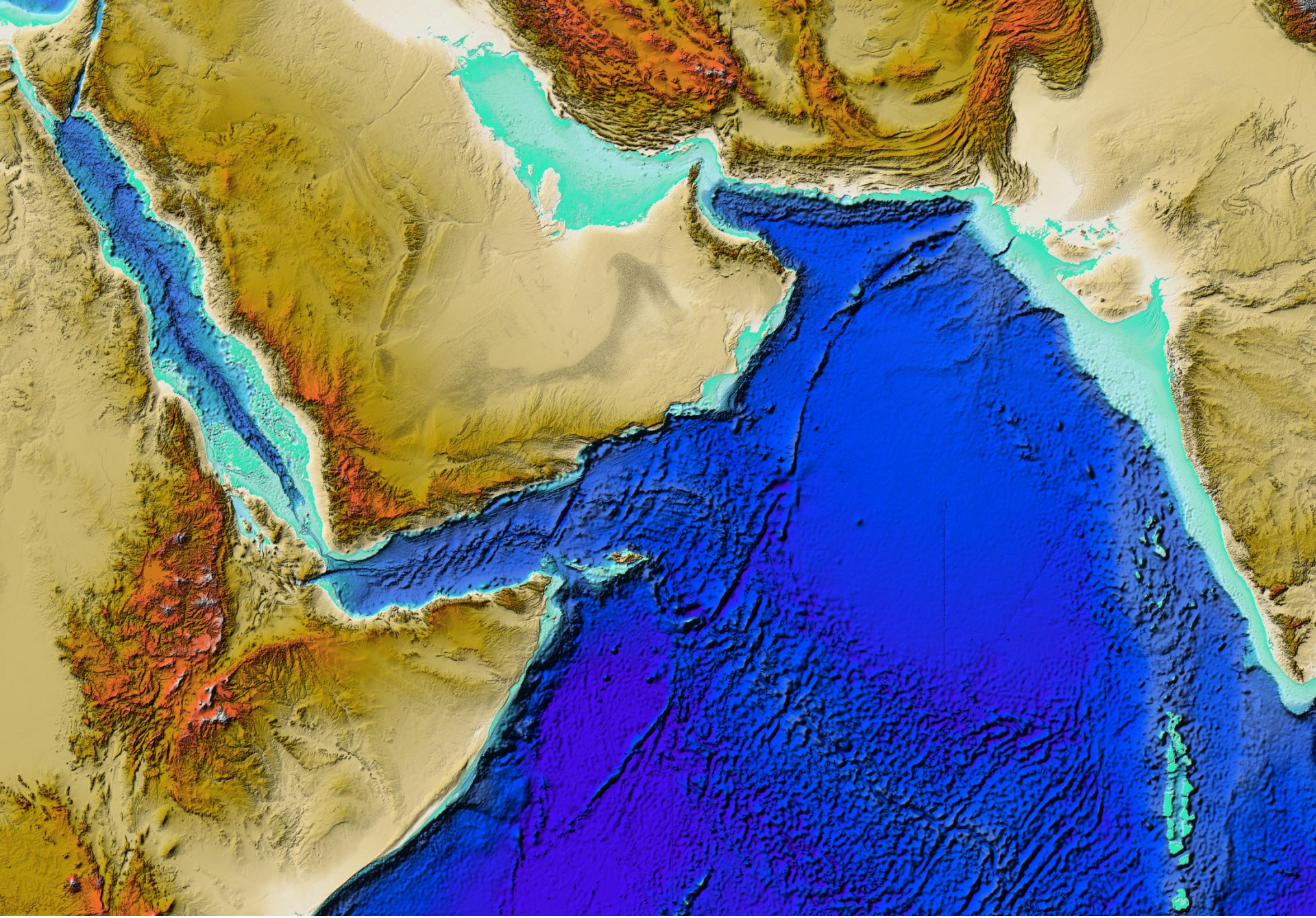
SB2030-Atlantic/Indian RDA&CC
LDEO Palisades, NY
Week of October 29th, 2018



The GEBCO 2014 30sec Compilation: 32°N-0°N and 32°E to 78°E

19 CIA Coastline lengths involved in this 100m grid compilation

Bahrain	161 km	Maldives	644 km
Djibouti	314 km	Oman	2,092 km
Egypt	2,333 km*	Pakistan	1,046 km
Eritrea	2,234 km	Qatar	563 km
India	7,635 km*	Saudi Arabia	2,640 km
Iran	2,440 km	Somalia	3,025 km
Iraq	58 km	Sudan	853 km
Israel	12 km	UAE	1,318 km
Jordan	26 km	Yemen	1,906 km
Kuwait	499 km	**Total**	**29,799** km

From *digitized* OpenStreetMap Coastline, without Islands **~41,300** km

* *Determined from OpenStreetMap Global Digitized Coastline*

This Project contributes to the goals of SEABED 2030

We accept that:

There is no substitute for MULTIBEAM below 150m. And little time or budget can realistically be allocated for mapping the shallows (deeper than 150m for broad margins and likely deeper than 50m for these reef margins).

Therefore what can be gleaned from existing surveys, and available bathymetric data?

The ANSWER, is a LOT.

Available hydrographic spot soundings and contours haven't been exhausted. For example there are today: UKHO 7290 charts, Russian 5938, NGA 4514, Canada 1628, France 1520, Japan 1057, Peru 1053, Australia 780, Chile 587, China 566, Spain 447, Norway 447, Greece 423, India 364, New Zealand 327, Germany 248, Argentina 234, Mexico 195, Vietnam 170, Iran 133

Of the almost 28,000 charts above; ~583 are represented in this work (>2%).

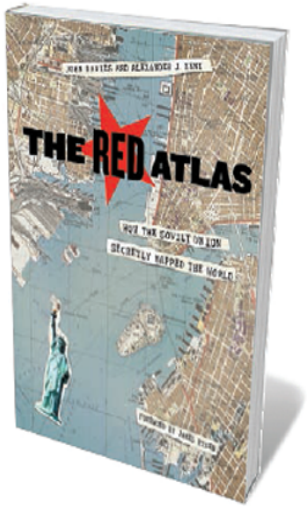
Hydrographic offices do not put all their holdings on their charts. GEBCO should encourage them to release more (especially the Russian Federation, UKHO. And NGA).

Hydrographic Chart Sources

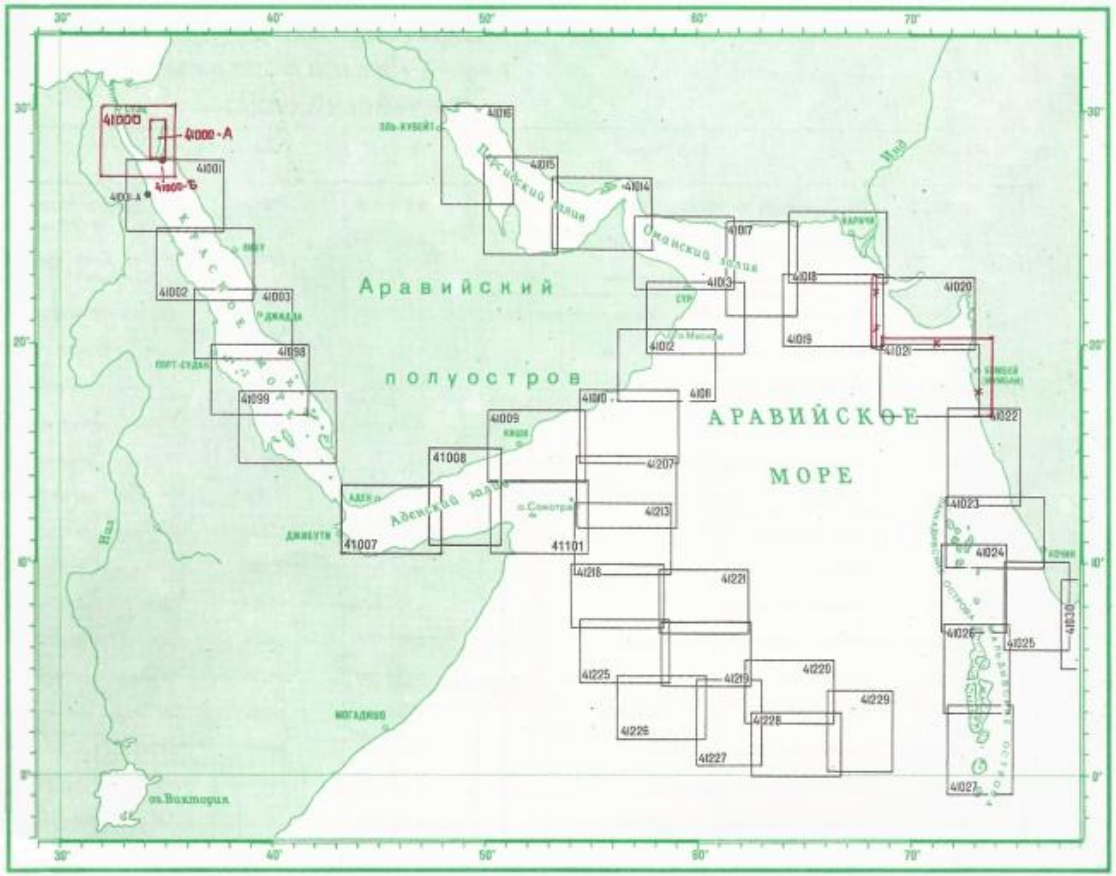
Russian-HDNO Nautical Charts

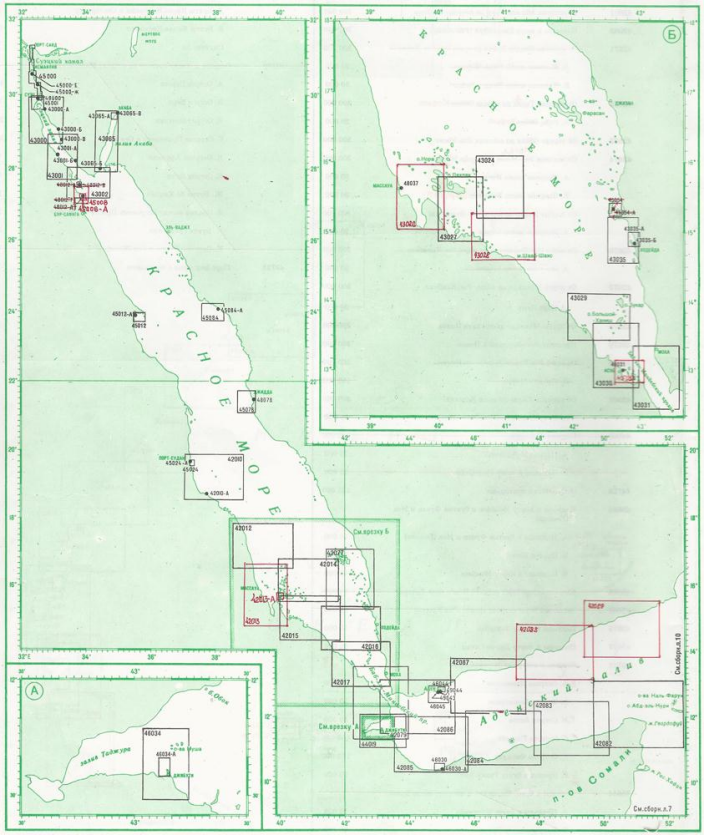
Available in the US from:

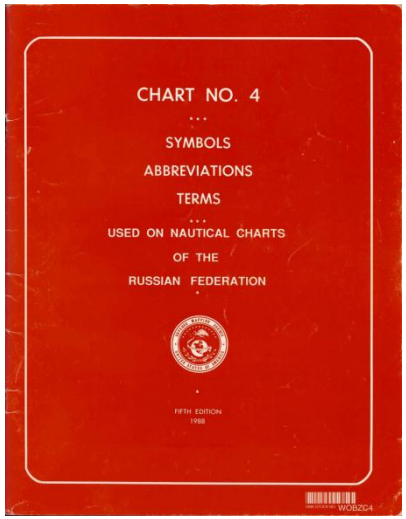
East View Geospatial,
Minneapolis, MN, USA



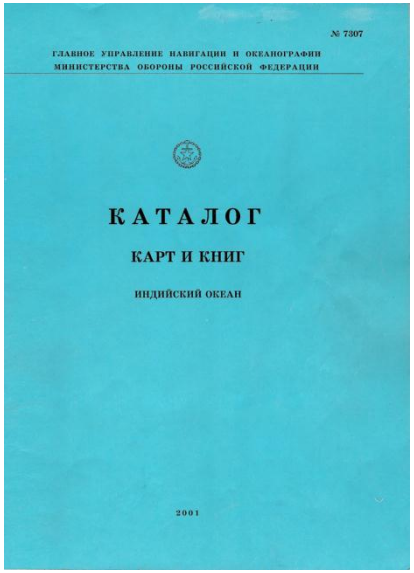
The Red Atlas: How the Soviet Union Secretly Mapped the World
John Davies and Alexander J. Kent UNIVERSITY OF CHICAGO PRESS *(2017)*
It stands as one of the most astounding feats of twentieth-century cartography. From 1950 to 1990, Soviet spies and satellites surveyed most of the planet to create what may be more than one million military maps, so detailed they show the composition of bridges and species of trees. As John Davies and Alexander Kent reveal in this glorious homage embellished with 350 map extracts, the gargantuan project might have been groundwork for a cold-war coup. Ironically, its near-comprehensive coverage has proved a boon for Western surveyors working in otherwise uncharted territory.

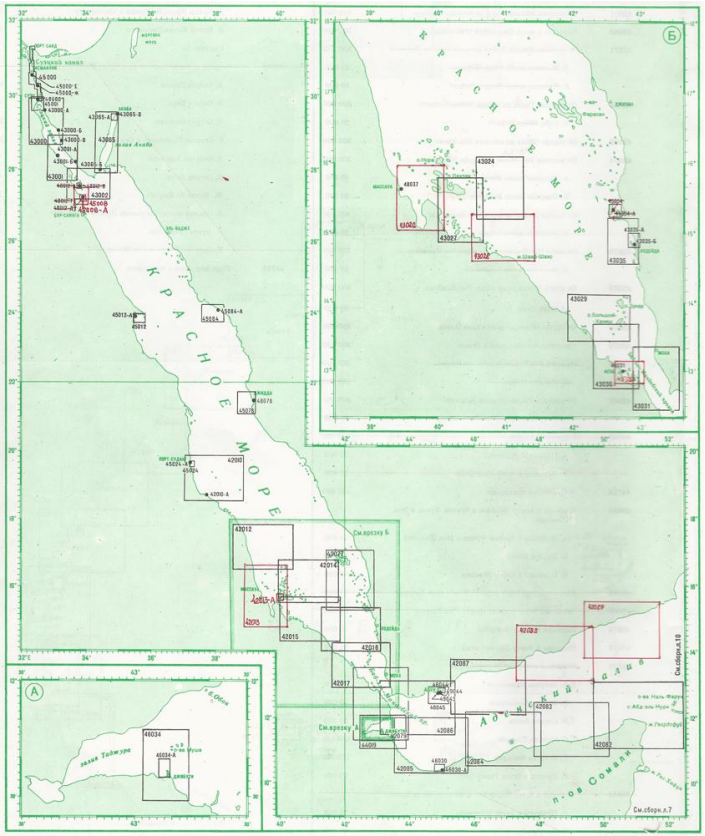


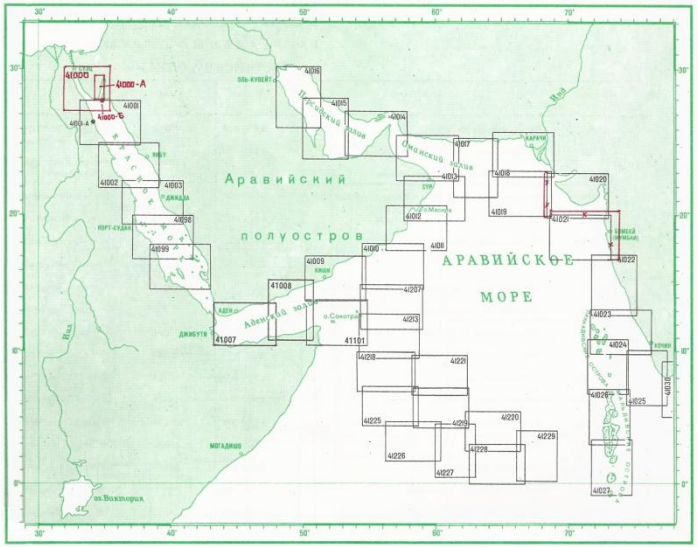


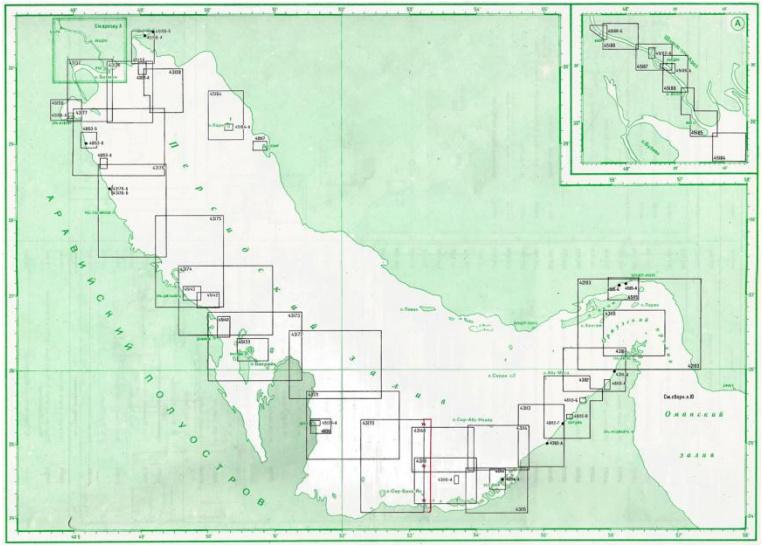


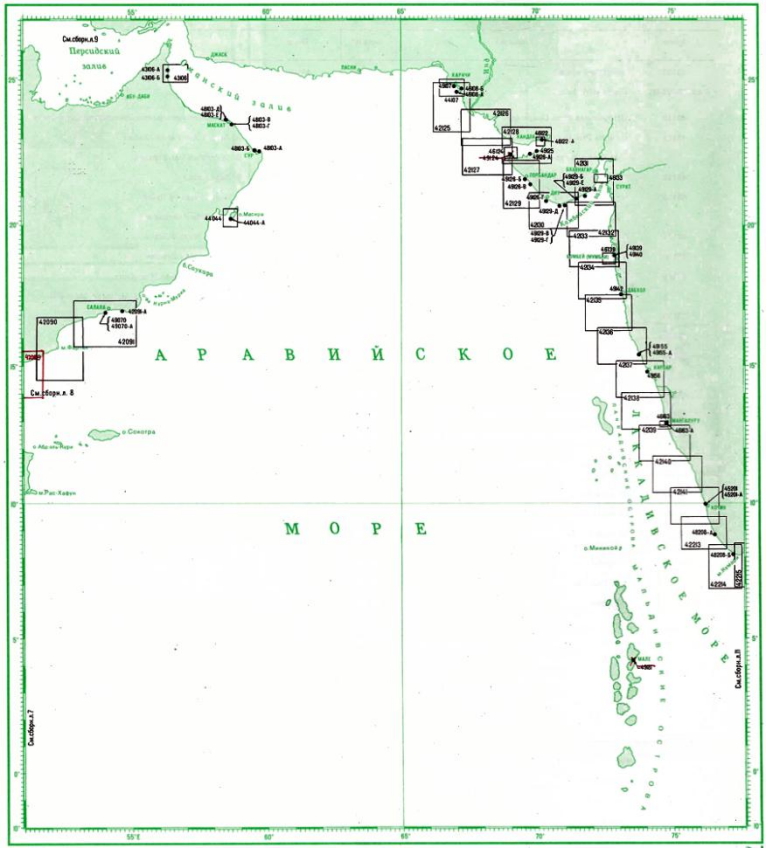
Useful document and up-to-date chart catalogs obtained decades ago when the first 700+ charts were ordered through a friend at NRL in Washington.

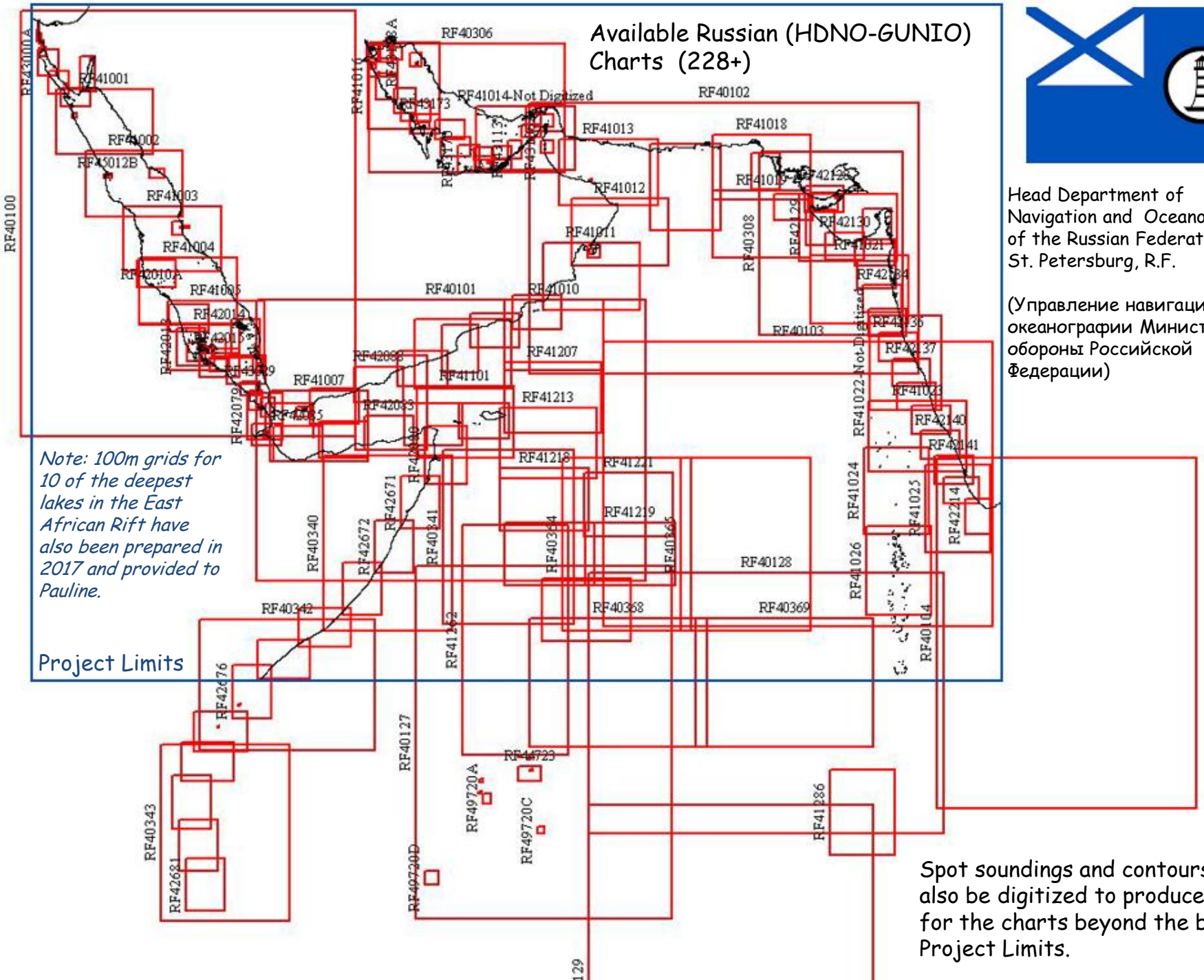












Head Department of Navigation and Oceanography of the Russian Federation. St. Petersburg, R.F.

(Управление навигации и океанографии Министерства обороны Российской Федерации)

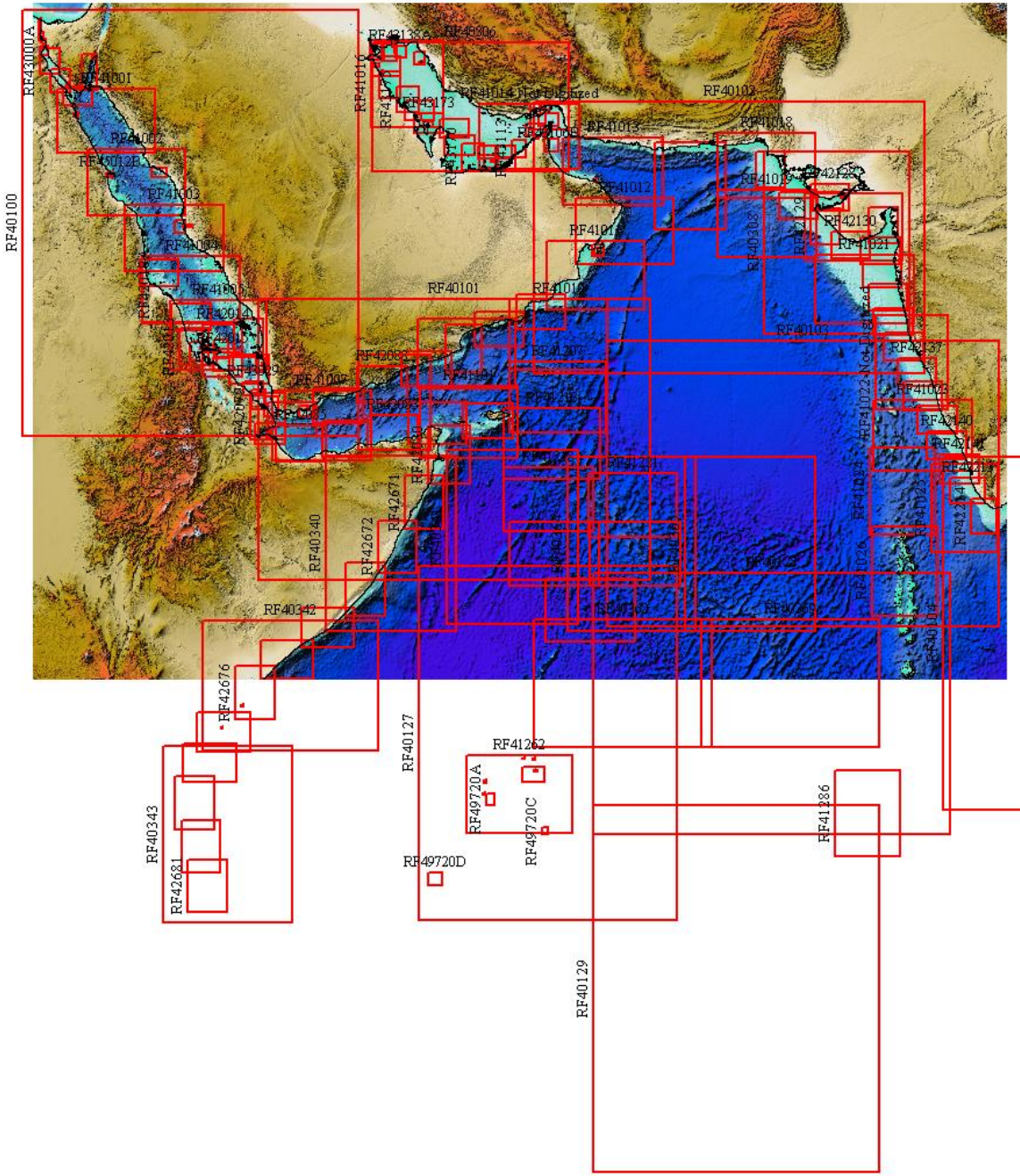
Spot soundings and contours will also be digitized to produce grids for the charts beyond the blue Project Limits.

Hydrographic Chart Source
Russian Nautical Charts

East View Geospatial
Minneapolis, MN, USA

In the late 1990s, some 700 charts were purchased via Norm Cherkis in the US. These were for the Med, Black, Red, Arabian, and Caspian Seas, and Lake Baikal. Soundings from the Black and Caspian Seas provided the grids in the GEBCO editions after 2000.

For this project the 228 charts shown include over 100 new sheets purchased from East View Geospatial.



Hydrographic Chart Sources

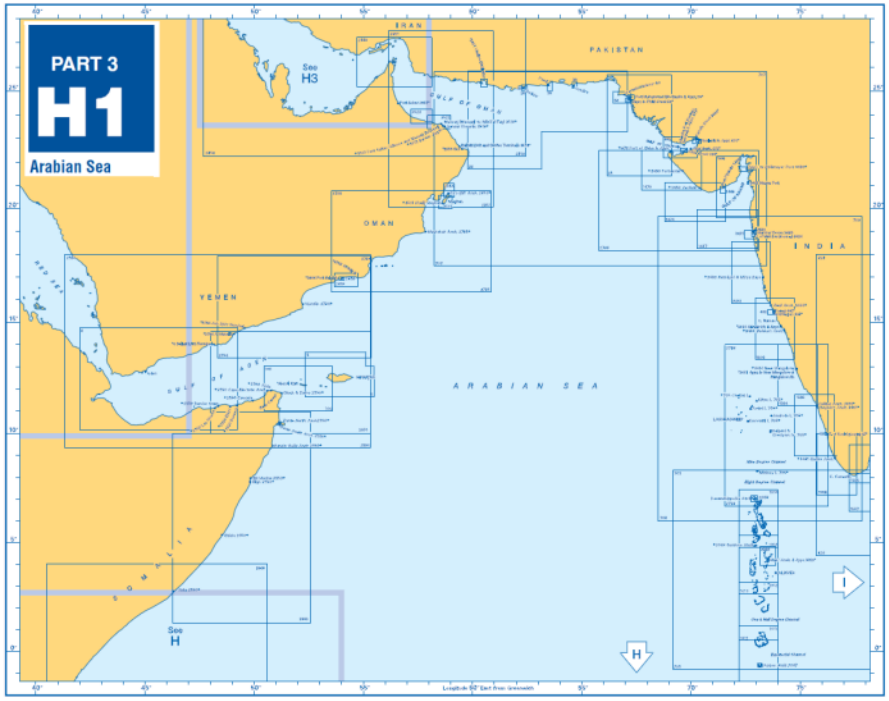
UKHO Admiralty Nautical Charts

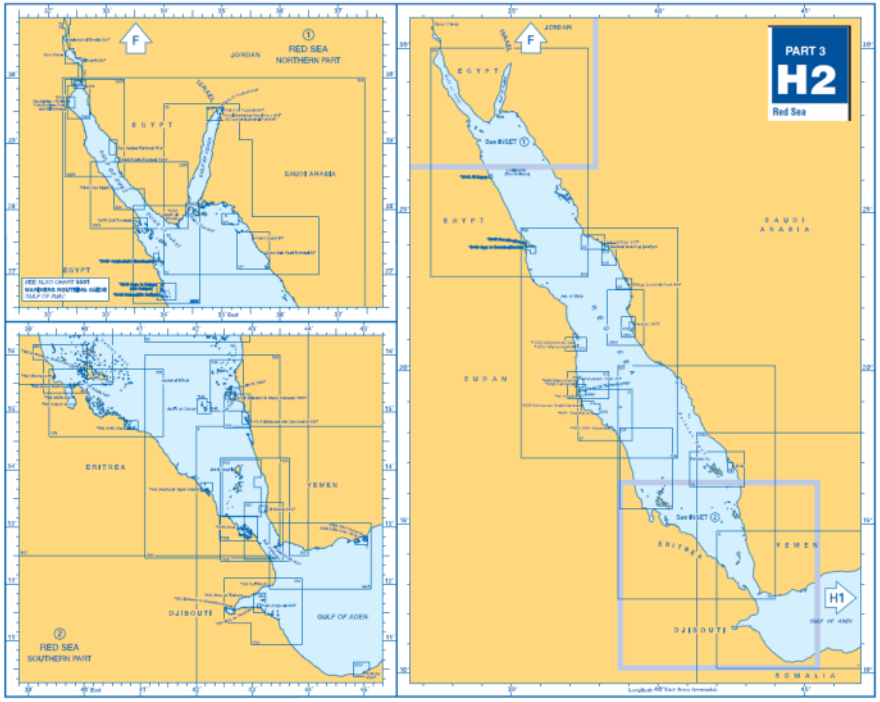
American Nautical Services,
Ft. Lauderdale FL, USA

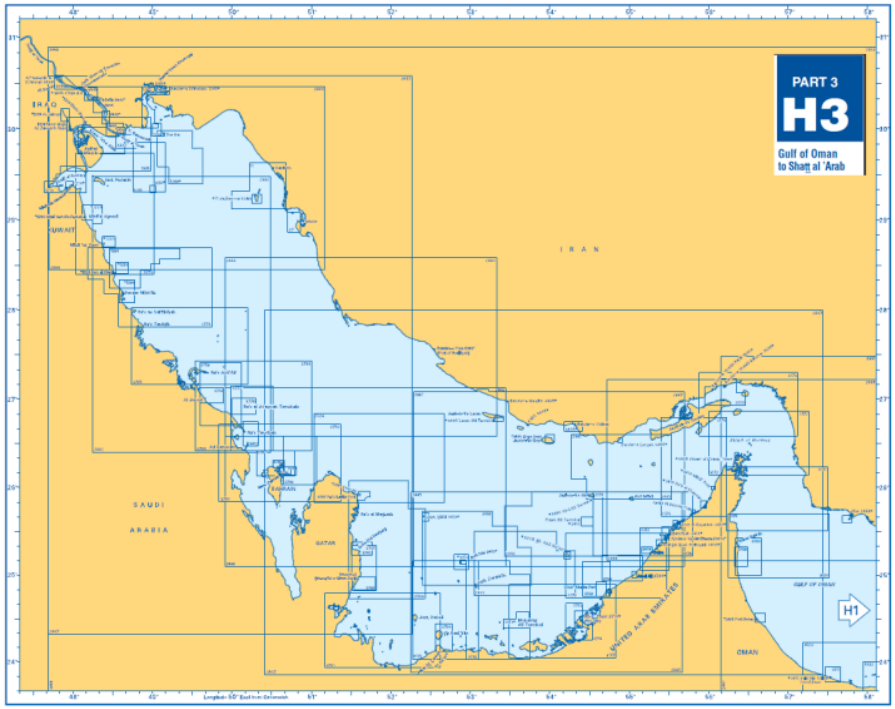
East View Geospatial,
Minneapolis, MN, USA

Maryland Nautical,
Baltimore, MD, USA

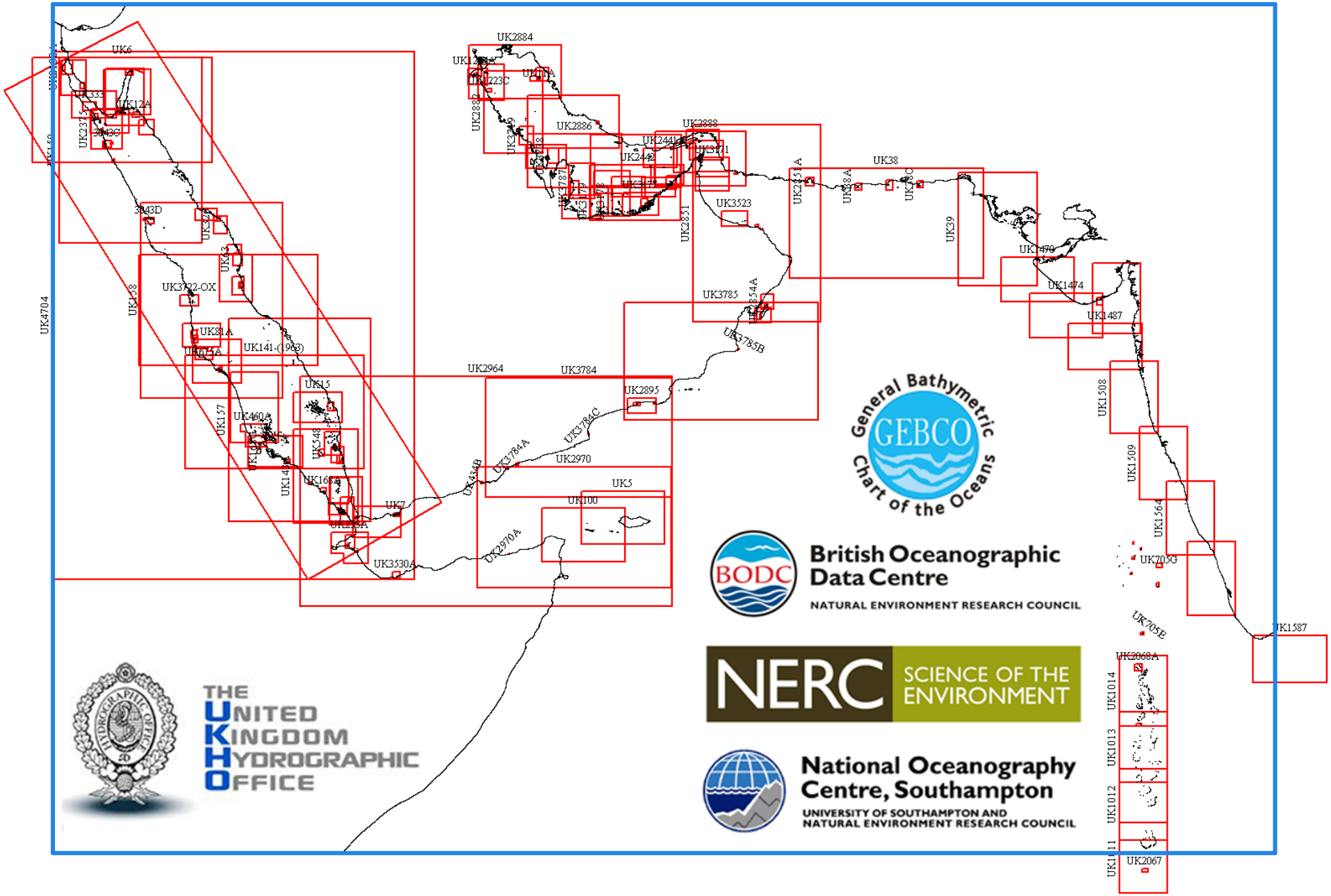
Most of these charts, plus old legacy charts, are in use





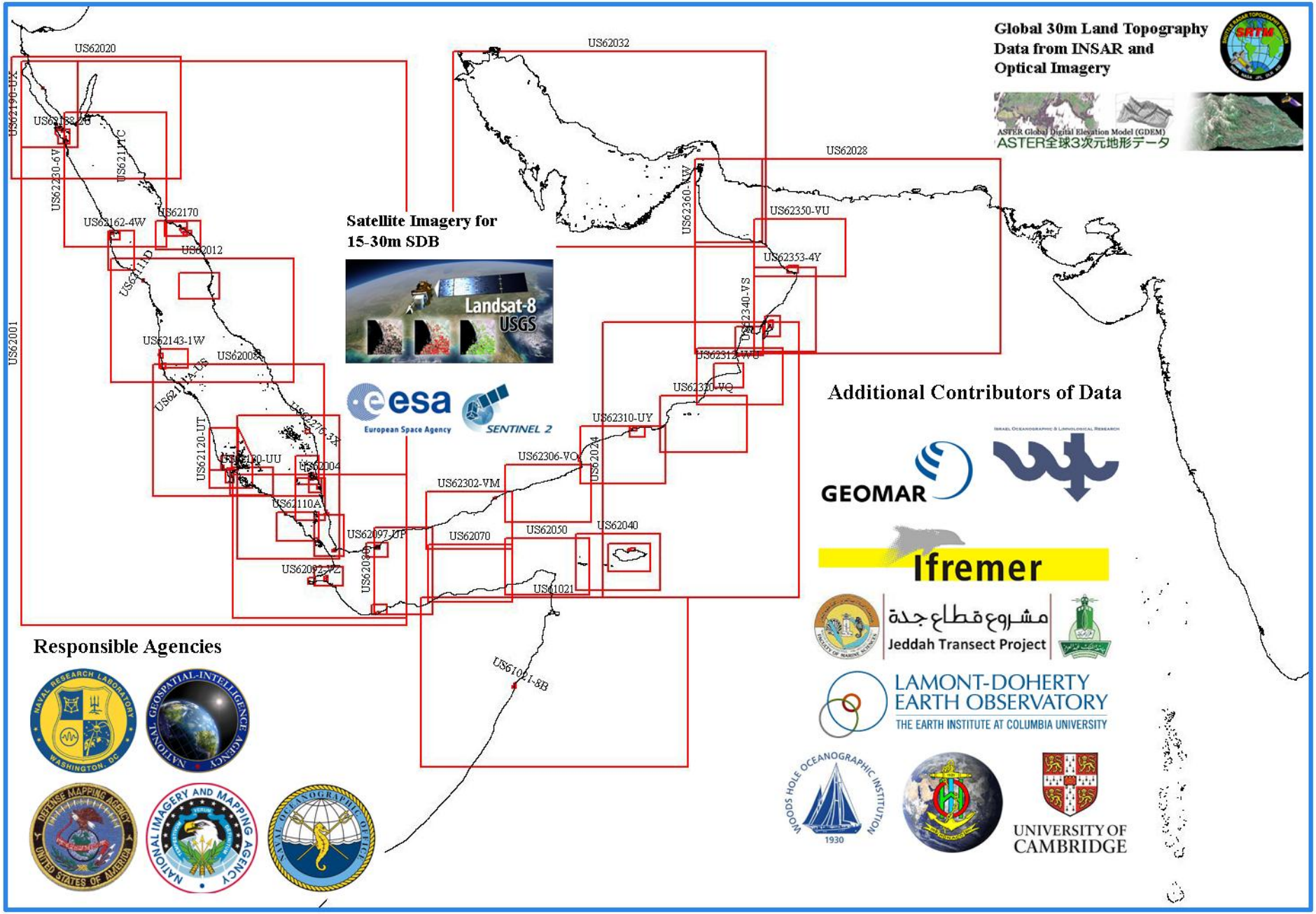


Available British UKHO Charts (227 - 140 added since 2015)



US Nautical Charts Available to the Project (88)

Note: These charts date from the 1970s to 1990s. No new charts were available to this project as NGA took over non-USA charts, and these were generally unavailable in print.

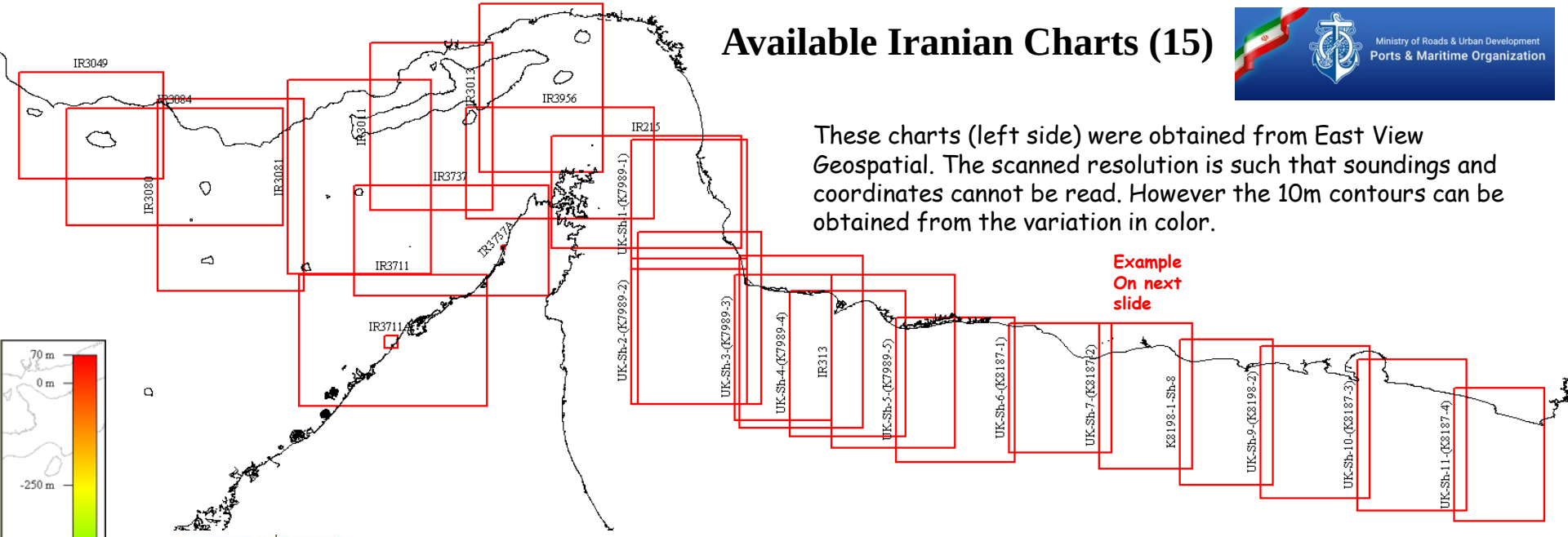


Available Iranian Charts (15)

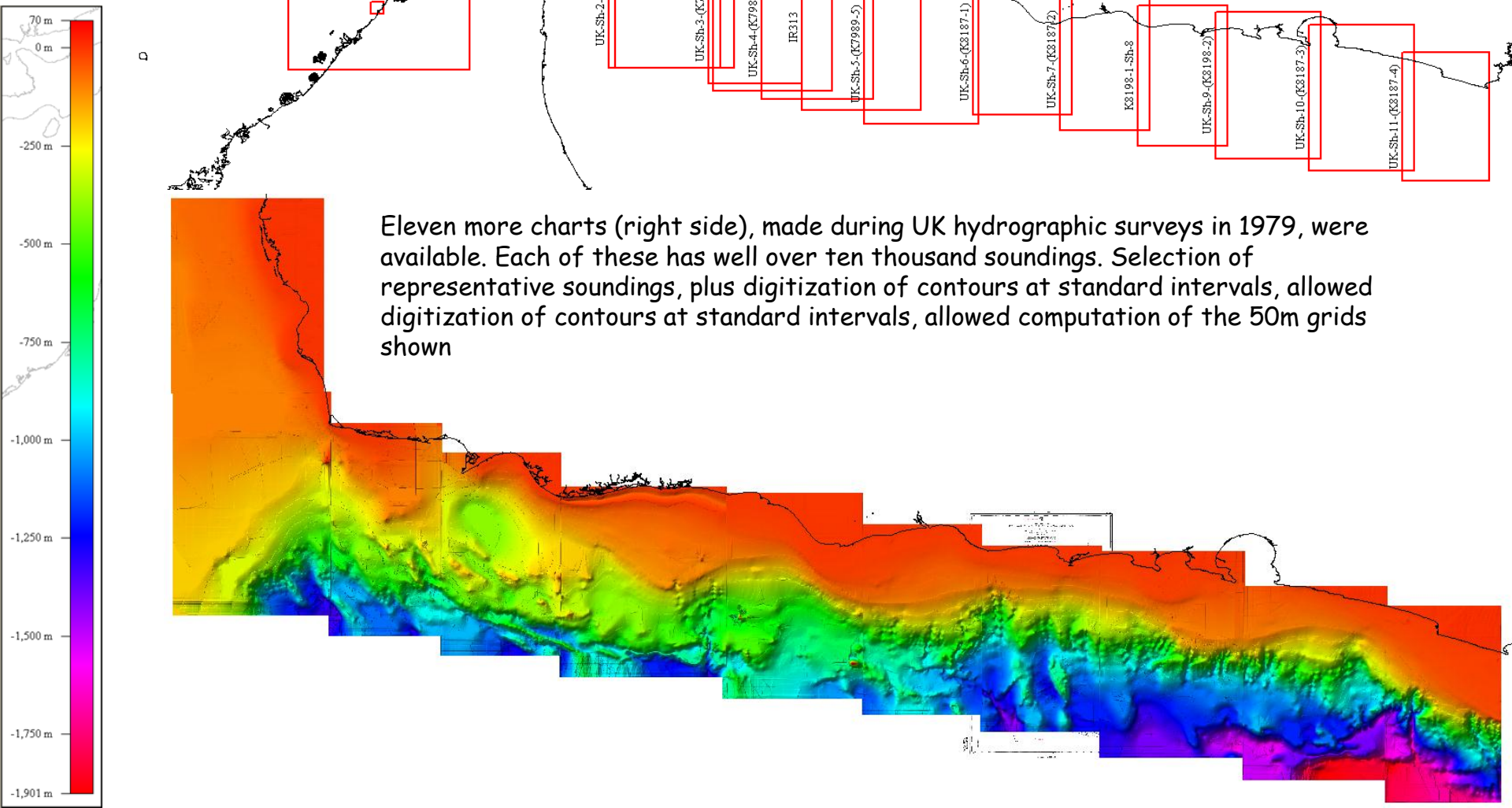
Ministry of Roads & Urban Development
Ports & Maritime Organization

These charts (left side) were obtained from East View Geospatial. The scanned resolution is such that soundings and coordinates cannot be read. However the 10m contours can be obtained from the variation in color.

Example On next slide



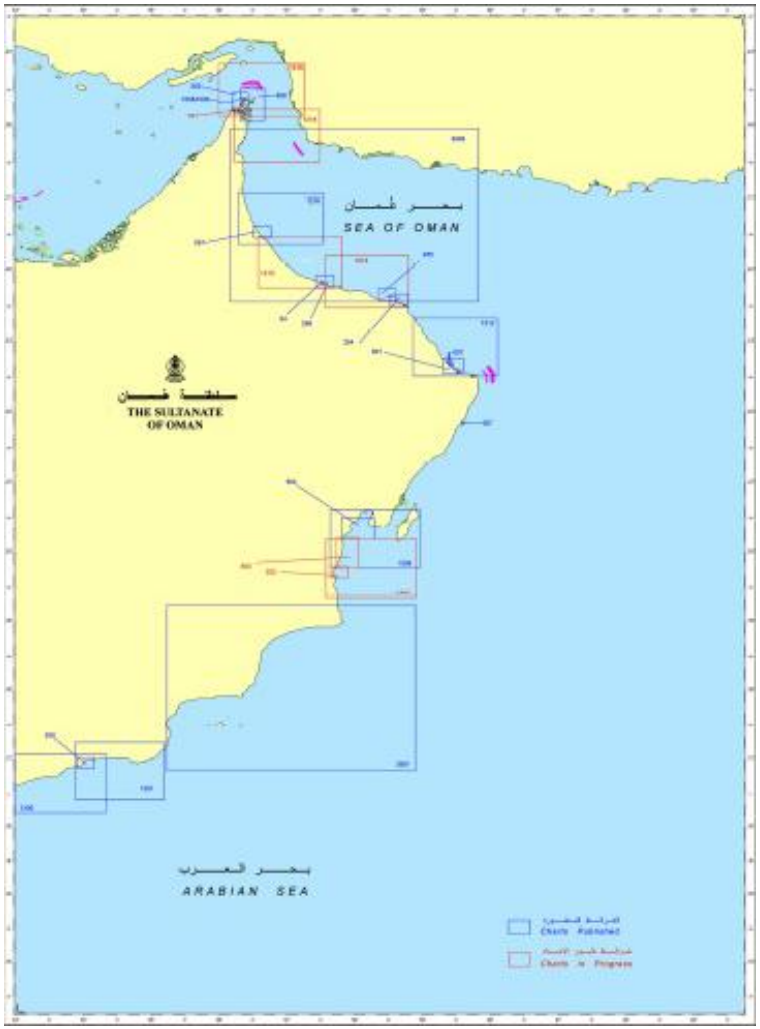
Eleven more charts (right side), made during UK hydrographic surveys in 1979, were available. Each of these has well over ten thousand soundings. Selection of representative soundings, plus digitization of contours at standard intervals, allowed digitization of contours at standard intervals, allowed computation of the 50m grids shown

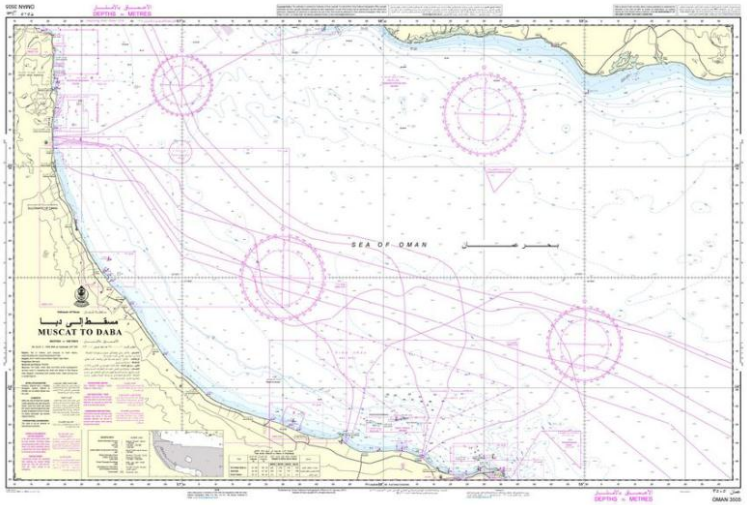


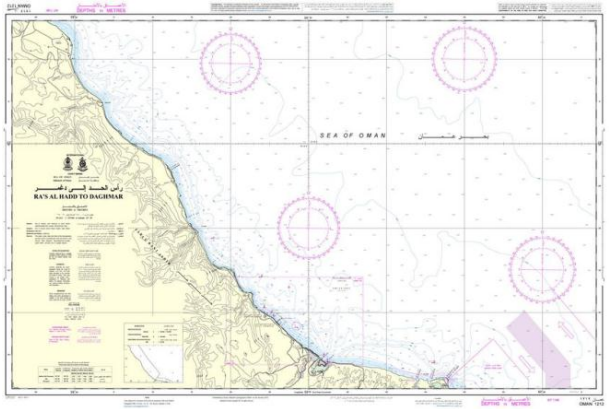
Oman National Hydrographic Office

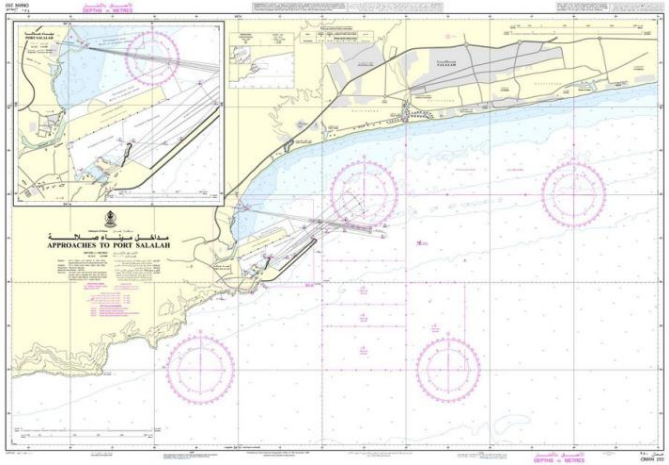
20 Charts/Insets are indicated in their website

East View Geospatial notes that 60 charts may be available. It is likely that some Omani coastal and port charts will be acquired and included.







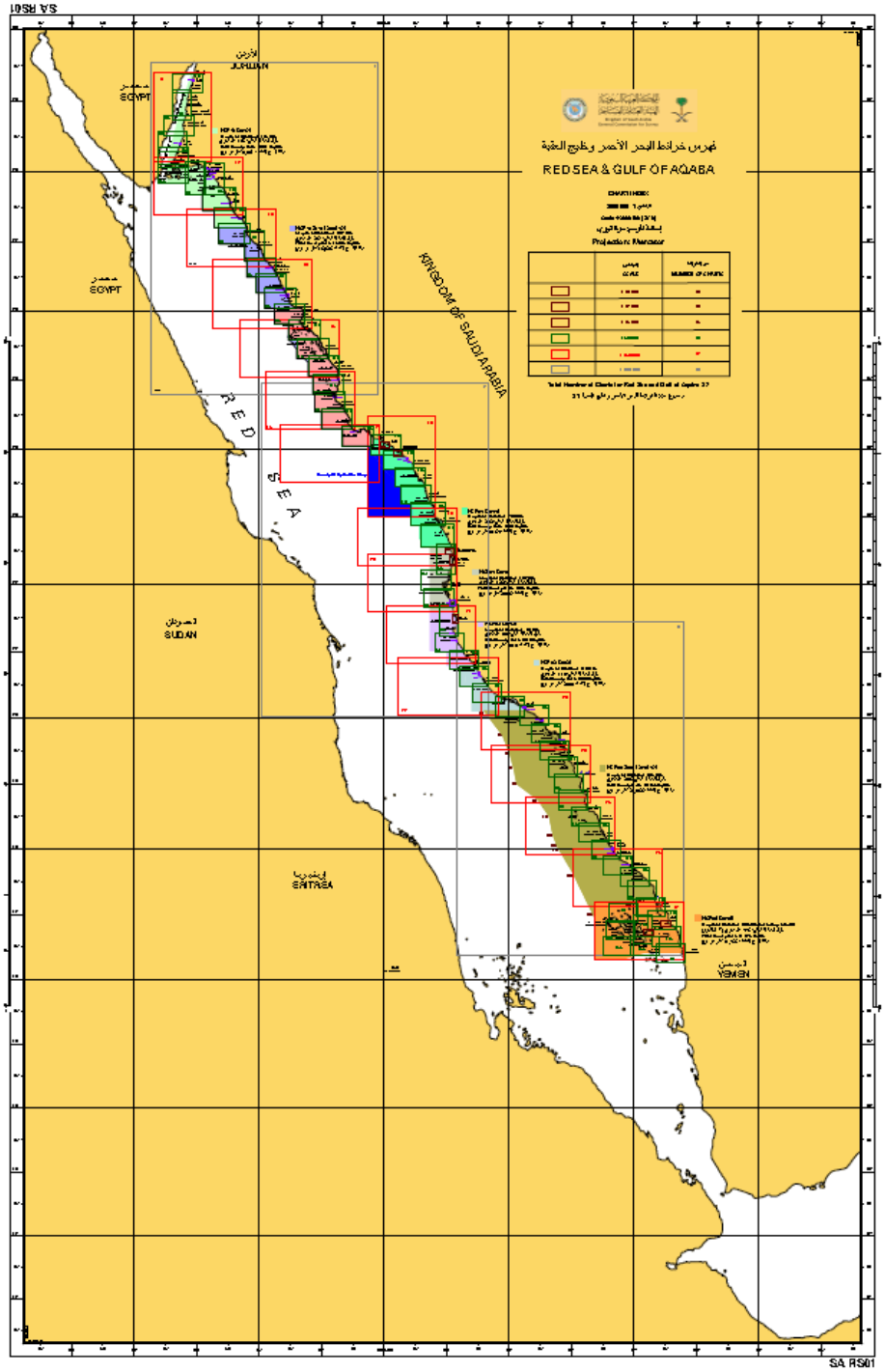


Saudi-Arabia Hydrographic Mapping

Saudi Arabia has extensive coast on the Red Sea and the Persian Gulf.

Since the mid-1960s, when WHOI discovered the Atlantis II Deep, Saudi Arabia has done at least three hydrographic mapping campaigns. The first, with single beam by the Sonne and Valdivia, mapped the brine pools. A second, called MARAD, apparently produced some 1600 charts and used LANDSAT to do SDB to depths of around 20m. The third was between 2013 and 2015 when FUGRO's $80m H-11 Hydrographic Survey mapped some 110,000 km².

The Index chart shows the layout of planned charts for the Red Sea coasts. In late 2016 a friend was able to download 10 1:50,000 scale charts from the country's Geoportal. These are shown on the next slide.



Red Sea Bathymetry Chart

Compiled by the N.A.T.O. Research Centre, La Spezia, **1964**

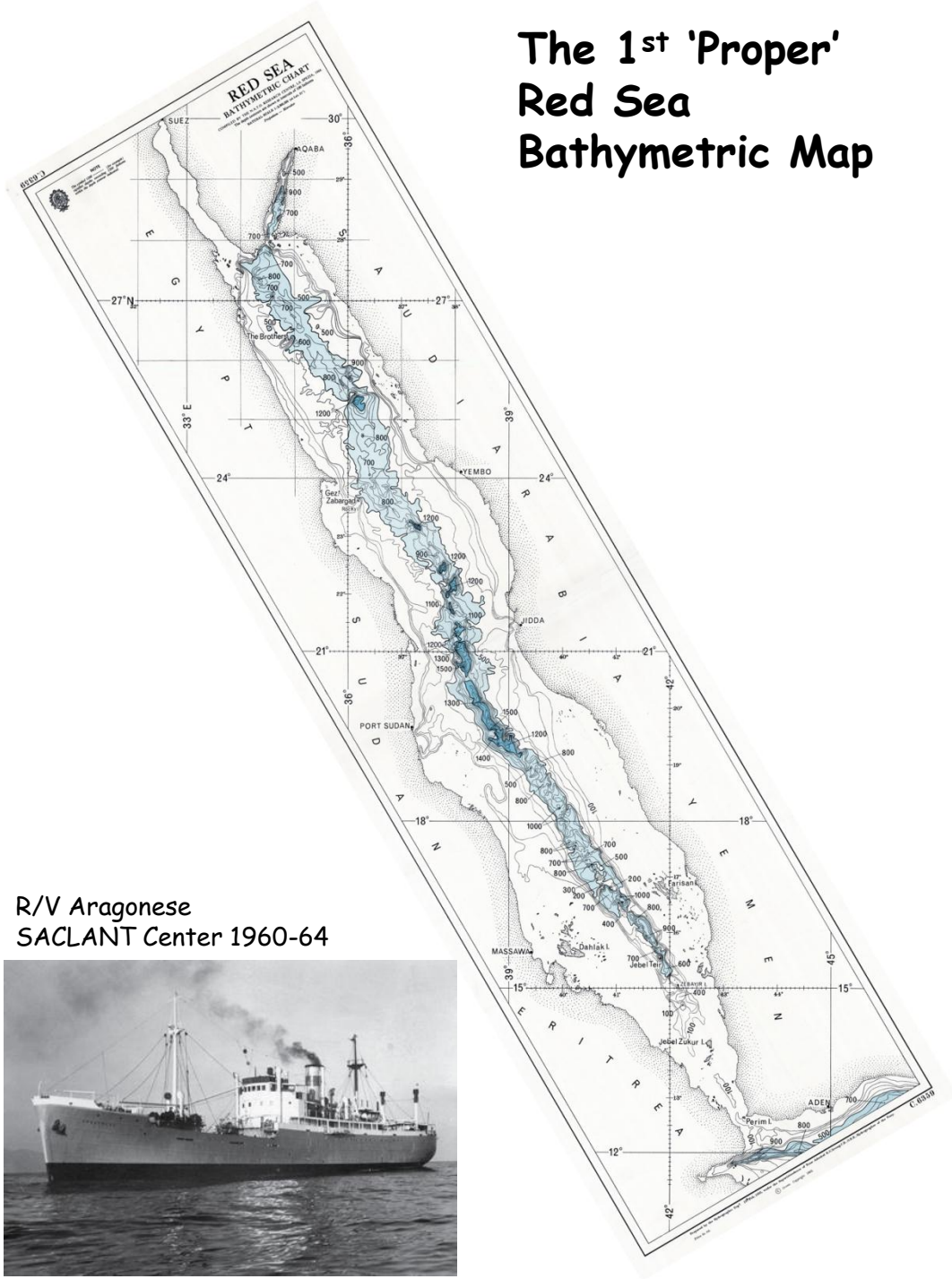
100 fathom contours
Scale 1:2,300,000 at 21°N

Based on the 1961 Cruise Concrete of the R/V ARAGONESE using Loran C navigation.

During the 1995 GEBCO Meeting at La Spezia the original PDR records for the CONCRETE Cruise were located in a remote store-room.

The records were sent to Israel and digitized (81,188 soundings) as an early part of this project.

The 1st 'Proper' Red Sea Bathymetric Map



R/V Aragonese
SACLANT Center 1960-64

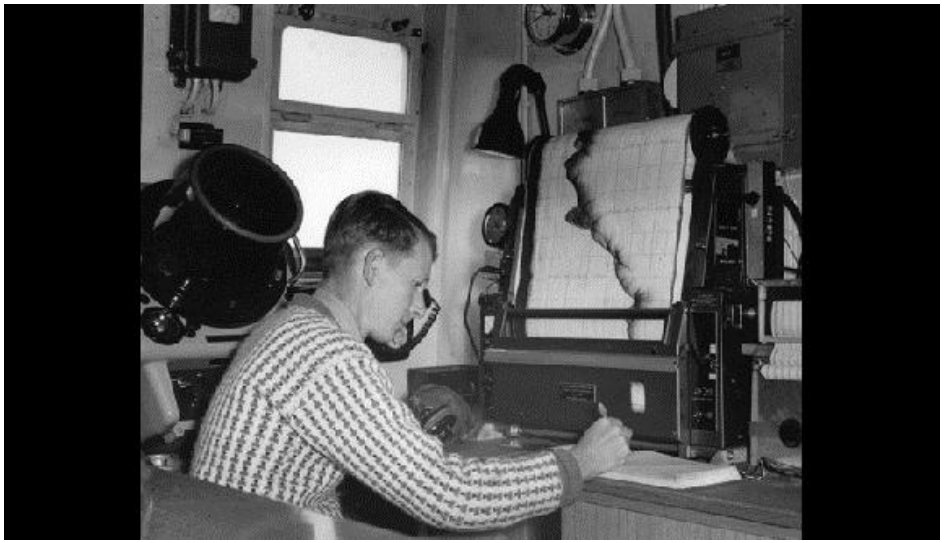
Laughton, A. S., **1970**. A New Bathymetric Chart of the Red Sea. Phil. Trans Roy. Soc. Lond., 267(1181), p. 21-22.

Scale 1:2,000,000 at 33°N, Mercator

100 fathom contours

Matthews Tables Corrections (1939)

Collected Soundings from British Admiralty Hydrographic Department up to May 1968.



Tony Laughton at the RRS Discovery PDR

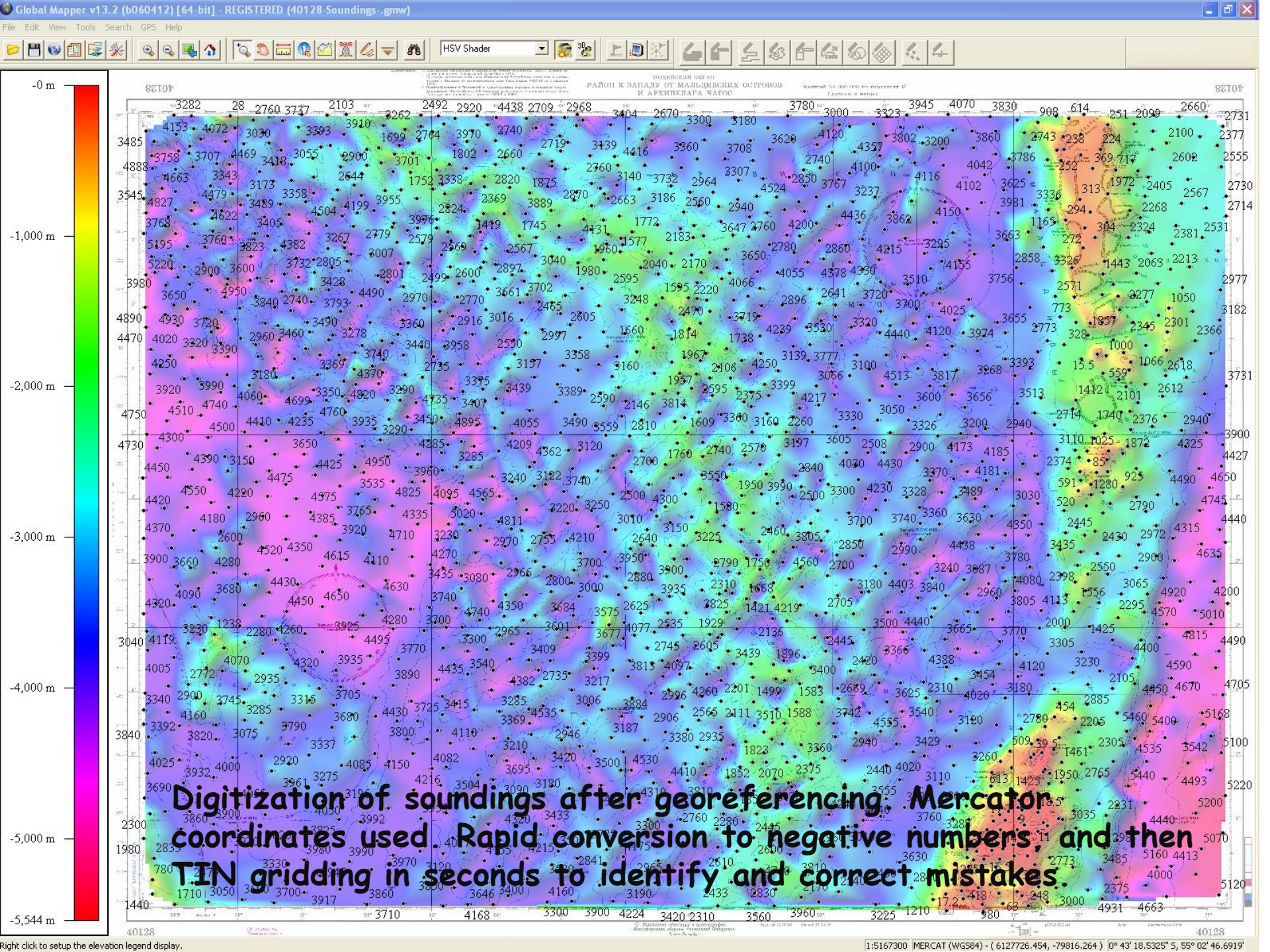
The Tools Used:

Global Mapper v. 12-14 (higher not recommended)

Blue Marble Geographics, Hallowell, ME, USA

1. ***Georeferencing*** scanned materials (projection used is Mercator)
2. ***Soundings***
   - Digitizing,
   - Correcting ,
   - Converting (fm & ft to m, changing sign),
   - Quickly visualize using TIN
3. ***Display*** of charts, soundings, contours, grids, land topography, coastlines, SDB
4. Projection, Location shifting, Scaling, Offsets of Raster and Scalar Data
5. ***Manipulation*** of grids, 3D visualization, palettes
6. Keep important record of operations, digitization and identification of soundings, contours, shallow features etc.
7. Comparison of datasets

Almost all slides above and below generated with Global Mapper 13.2



Digitization of soundings after georeferencing. Mercator coordinates used. Rapid conversion to negative numbers, and then TIN gridding in seconds to identify and correct mistakes.

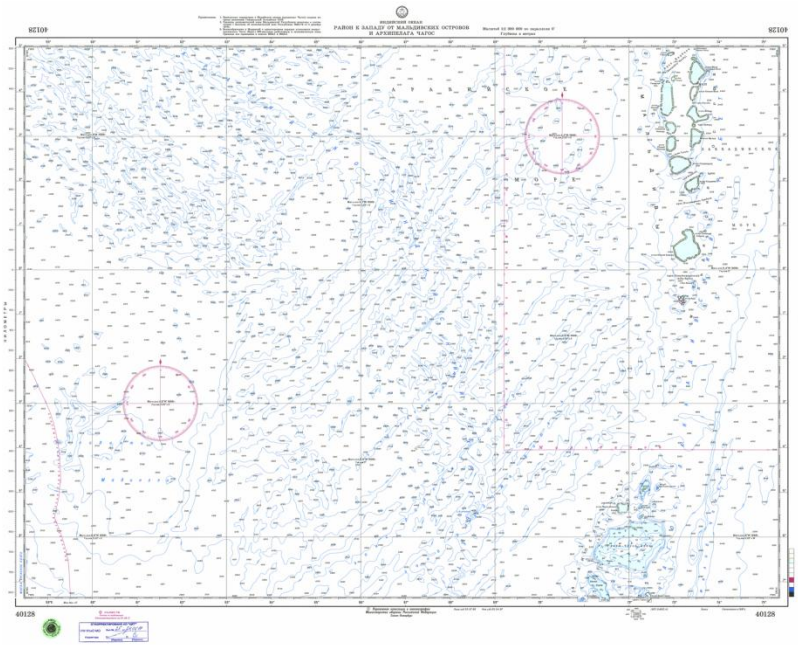
The Tools – Contour Digitizing

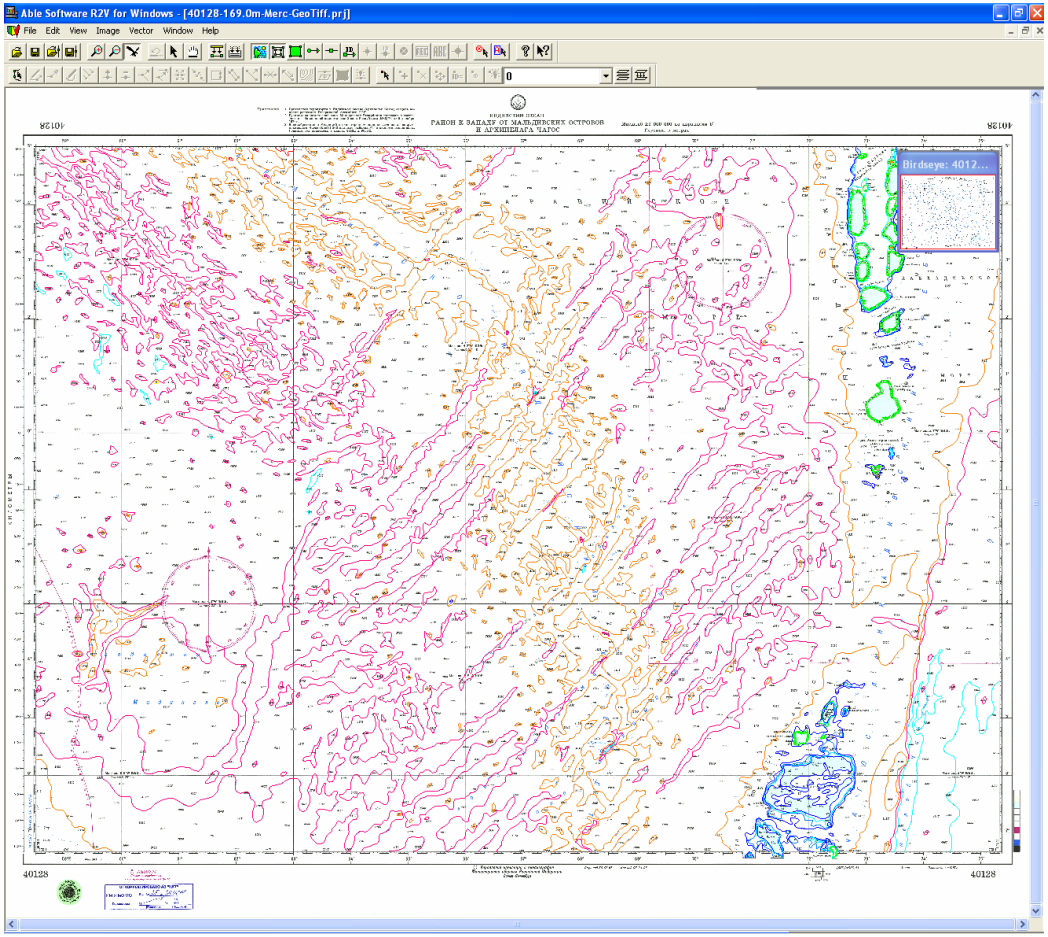
R2V (Raster to Vector)

Able Software Corp, Lexington, MA, USA

Automated Contour and Coastline digitizing (projection primarily Mercator)

1. Color coding of Contours
2. Digitization of contours (best for repetitive values)





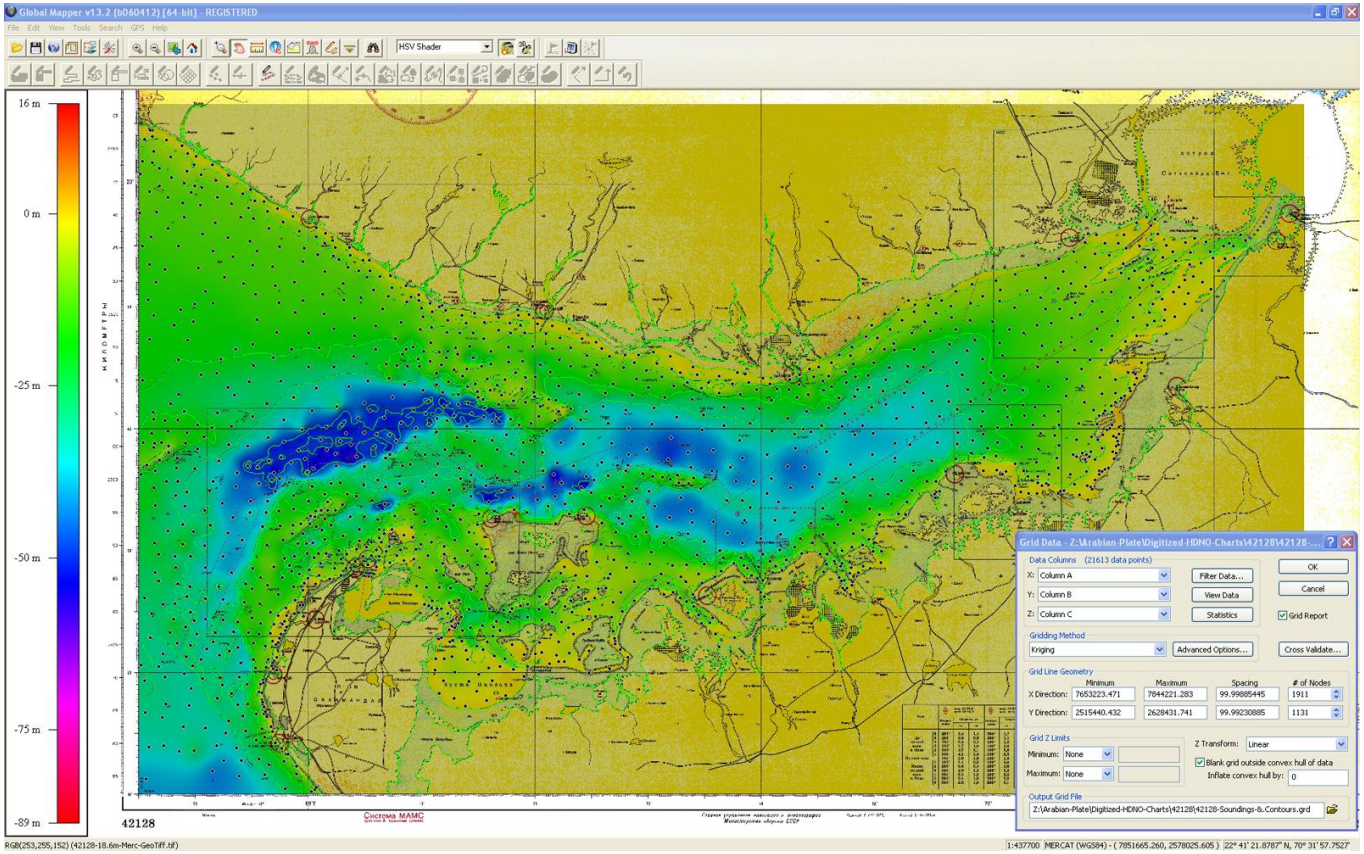
Example of the R2V digitization of the 1000m contours of the 1:2 million scale HDNO Chart 40128 (169m pixels) in the southern Indian Ocean. Time ~8 hours, 52,280 points, 1,280 closed contours.

The Tools – Grid Generation

Surfer v.13

Golden Software, Golden, CO, USA

1. Gridding algorithms – Kriging primarily used (Mercator meters)
2. Grid visualizations, and manipulations, blanking
3. Grid calculus (not needed)

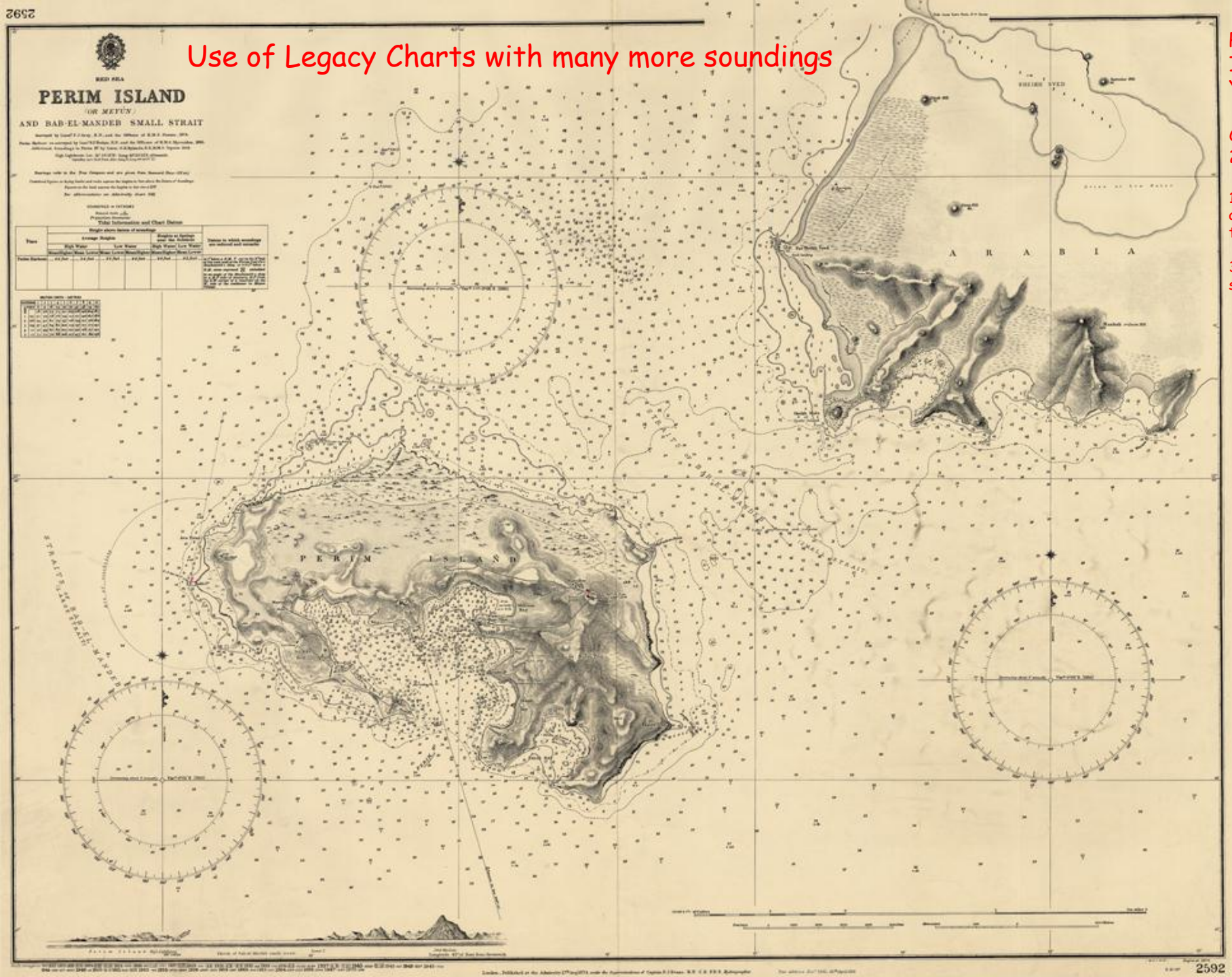


Surfer 13 100m Krig interpolation grid of the Gulf of Kutch in northern India from Russian HDNO Chart 42128.

Global Mapper 13 plot of this grid. Includes 1,372 spot soundings, and 352 digitized contour segments, made up of 20,241 points.

This Krig interpolation at 100m required 383 sec.

Use of Legacy Charts with many more soundings



Perim Island Yemen

Chart 2592

1874 with additions to 1975

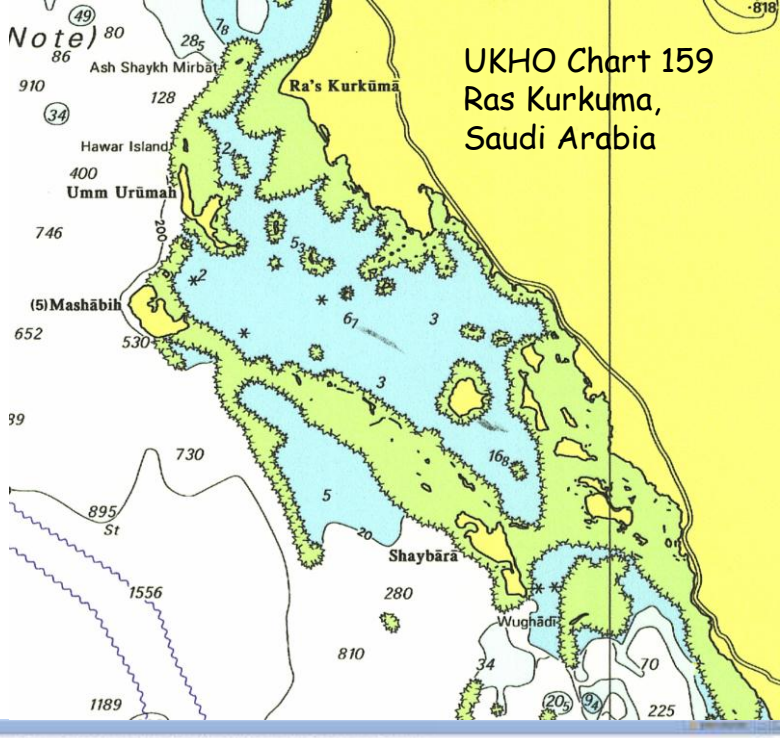
3130 soundings

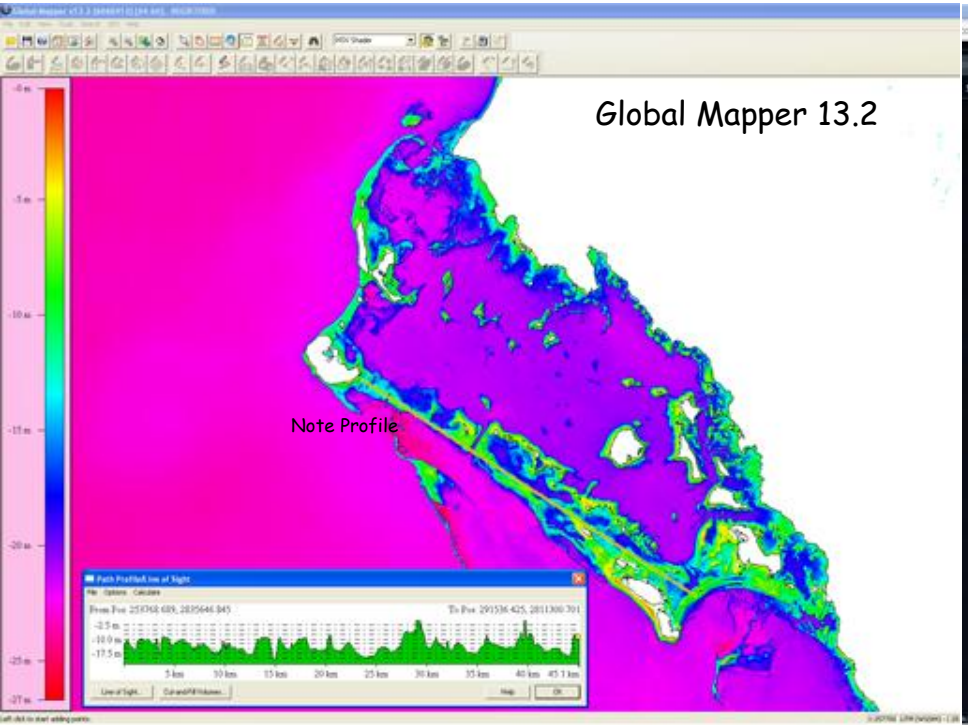
Shallow Water Bathymetry

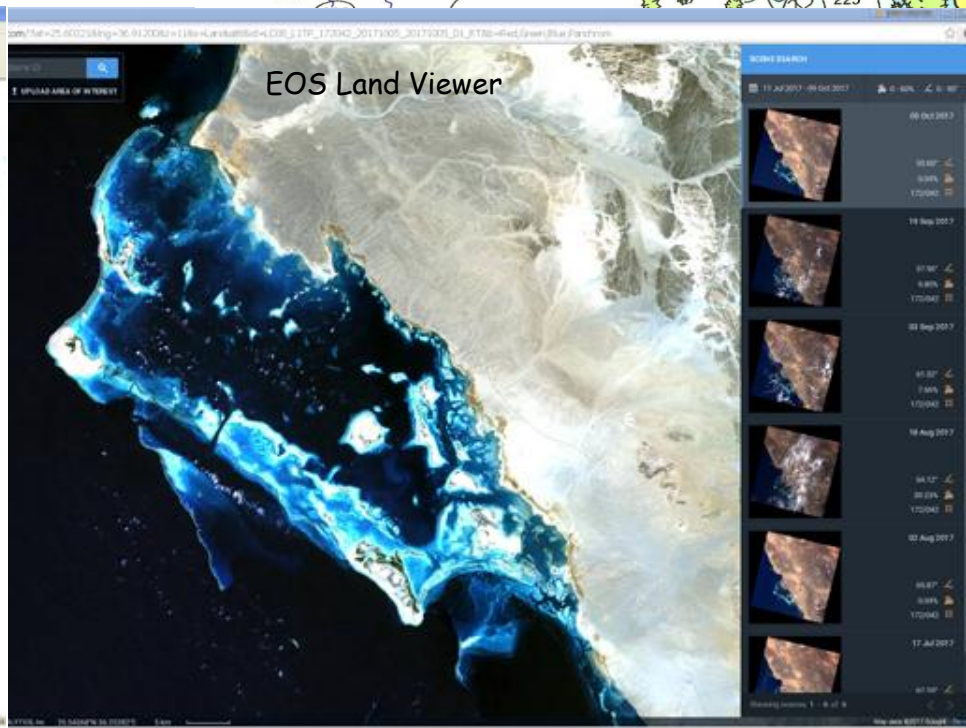
This is done with Satellite Derived Bathymetry (SDB). For this project it is part of the MSc thesis of Shahar Levenson at the Hebrew University of Jerusalem.

Using EOS Land Viewer, LANDSAT 8 scenes are selected for their lack of waves, suspended sediments, and slicks, as well as low to absent cloud and dust in the atmosphere.

By using Bands 3, 4, and 8, and various manipulations using Python scripts, some ground truth, and ArcGIS, the shallow bathymetry is extracted. These methods must be refined to pick up shallow soundings and 2 and 5 m contours for calibration.





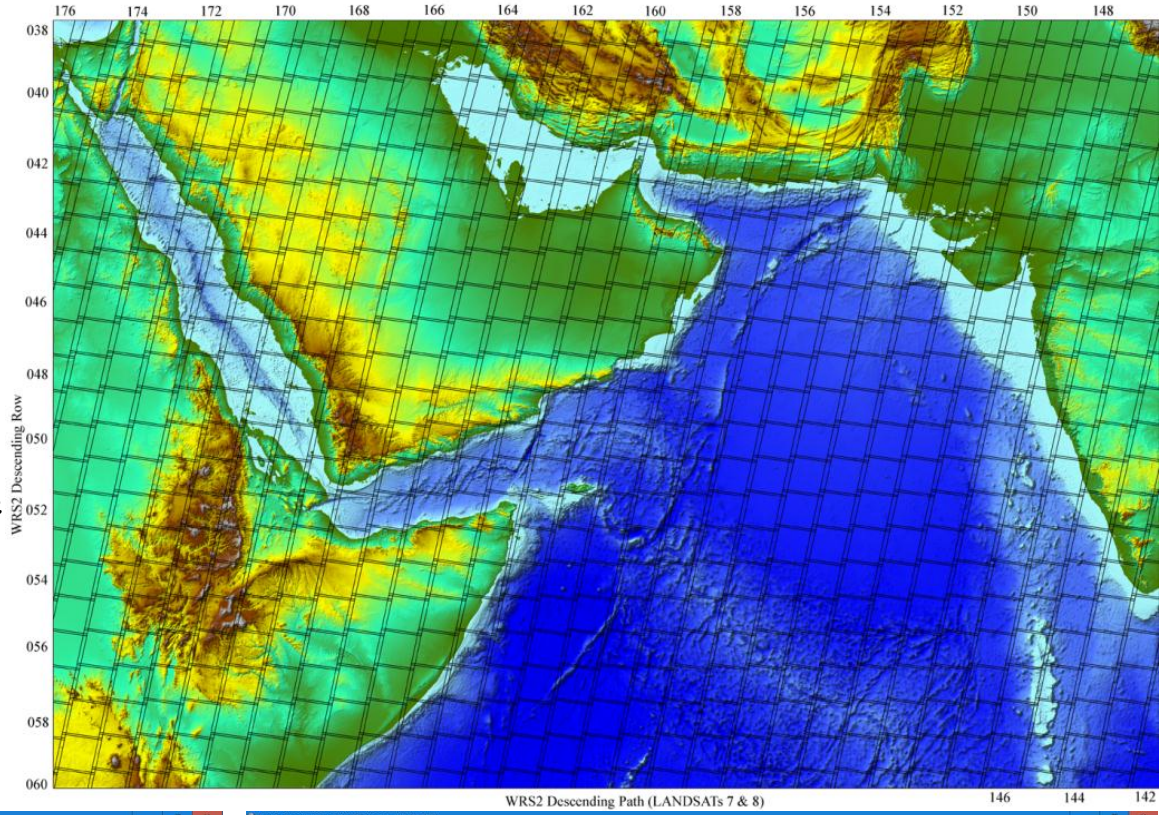


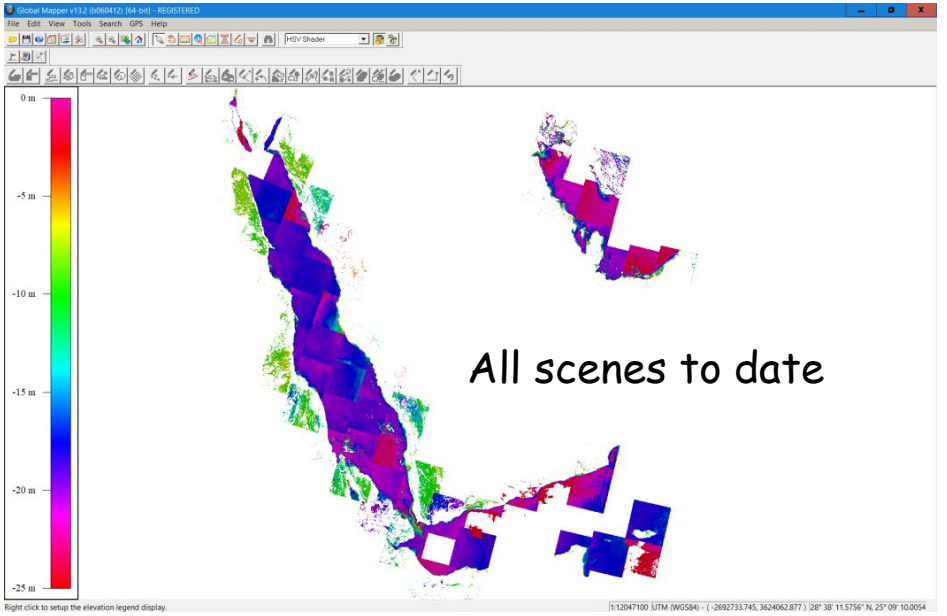
Layout of the LANDSAT 8 World Reference System 2 (WRS-2) Path/Row coverage.

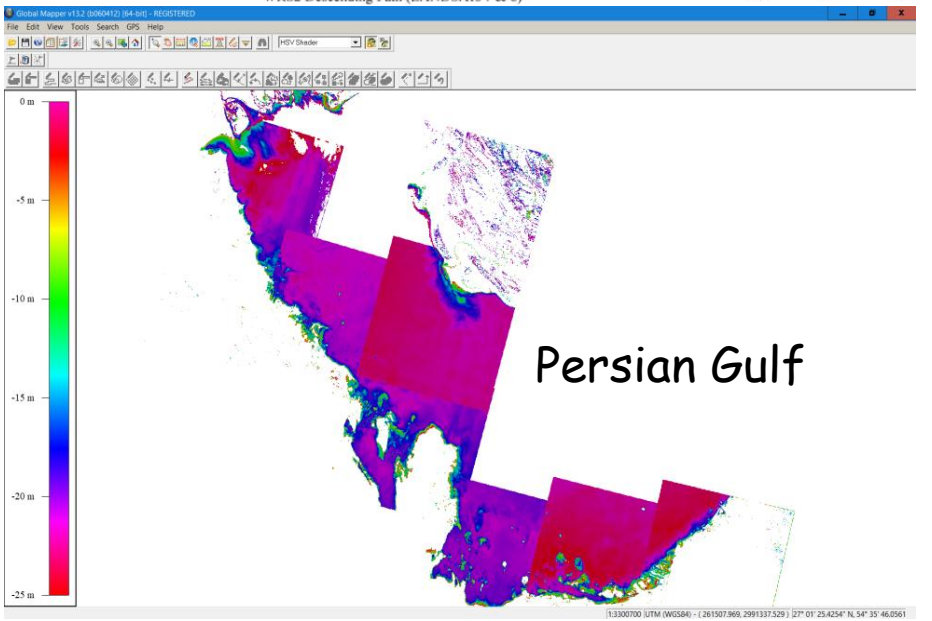
Approximately 167 LANDSAT-8 scenes cover the islands, reefs, and shallow coastal margins.

About a quarter have been analyzed to date to produce the 30m grids of the shallows shown below.

The results validate the approach but with completion of analysis of the most up-to-date coastal charts, only then can the grids be calibrated using shallow soundings and the common 2 and 5 m contours.







Israel's Contribution to GEBCO Appreciates your Attention