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Technical Sub-Committee on Ocean Mapping and
interim Sub-Committee for Regional Undersea Mapping

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INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION
(of UNESCO)

INTERNATIONAL HYDROGRAPHIC ORGANIZATION

General Bathymetric Chart of the Oceans (GEBCO)

Technical discussions of the Technical Sub-Committee on Ocean Mapping and the interim Sub-Committee for Regional Undersea Mapping

13th-17th September 2010

at

Direccion de Hidrografia y Navegacion (DHN), Lima, Peru

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ANNEXES

1. OPENING OF THE MEETING

1. The meetings at the Naval Club in Lima, Peru did not involve a strict separation of TSCOM and iSCRUM business but were scheduled according to need and the requirements of the participants as shown in the Agenda (Annex 1).

2. Those present at various times during the meetings were Anastasia Abramova, Christopher Amante, Bob Anderson, James Braud, Juan Brown, Etienne Cailliau, Dave Clark, James Daniell, Ksenia Dobrolyubova, Paul Elmore, Robin Falconer, Vicki Ferrini, Jenifer Foulkes, Chris Fox, Jose Gianella, Bruce Goleby, Hugo Gorziglia, Joko Hartoyo, Colin Jacobs, Martin Jakobsson, Izabel King Jeck, Jiye Jin, Megan Jones, Shao Hua Lin, Paolo Lusiani, Karen Marks, Dave Monahan, Hugo Montoro, George Newton, Inyoung Park, Tony Pharaoh, Walter Reynoso, Hans-Werner Schenke, Shereen Sharma, Walter Smith, Steve Shipman, Vaughan Stagpoole, Hyo Hyun Sung, Shin Tani, Lisa Taylor, Paola Travaglini, Nataliya Turko, Pauline Weatherall, Bob Whitmarsh and Kunio Yashima. The meeting was assisted by a team led by Hugo Montoro and Luz Cano of the DHN.

2. WELCOME

3 Rear Admiral J. Gaviola Tejada extended a warm welcome and special thanks to the attendees for their willingness to come to Peru to participate in an important event that brings together an international group of selected experts in ocean mapping. He said he was very pleased that GEBCO had decided to meet in Lima and hoped that the meeting would encourage and facilitate scientific cooperation between individuals and organizations to enable the exchange and conservation of bathymetric data and related metadata, as well as the development of technical knowledge.

4 Robin Falconer, Chairman of GEBCO, replied. He thanked the hosts for inviting GEBCO to Lima and Hugo Montoro and Luz Cano for being the local organisers of the meeting. He noted that this was possibly the biggest GEBCO meeting ever and the first in South America. The fact that people were present from 21 countries illustrated the global nature of GEBCO and the important opportunity the meeting provided for networking, particularly for the several Nippon Foundation/GEBCO scholars present.

3. SCHOLARS' PRESENTATIONS

5. **3.1 Jo Hartoyo, Indonesia** explained that on his return to Indonesia from Durham, New Hampshire he had been put in charge of the Centre for Marine Surface and latterly had been appointed project manager of the tsunami buoy programme which was supported by Australia, Germany and NOAA/USA. He was responsible for the deployment, recovery and maintenance of the buoys. Also for mapping in the vicinity of the buoys which had been done jointly by an Indonesian ship and NOAA vessels. Mr Hartoyo noted that because he was not the principal investigator for collecting swath data he couldn't show any in Lima. However, he explained that since 2006 he had been working with another Indonesian scholar to load and merge multibeam data on a server and hoped to be able to show this data at the next meeting. The RV *Ocean Explorer* had found six new seamounts and volcanoes. He acknowledged that his ability to carry out mapping was entirely down to everything he had learned at UNH.

6. **3.2 Pryantha Jinadasa, Sri Lanka** described the past, present and future status of ocean mapping in Sri Lanka and the role of the National Aquatic Resources Research and Development Agency (NARA). NARA is the principal National Institute charged with the responsibility of carrying out and coordinating research, development and management activities on Aquatic

Resources. He explained that the EEZ of Sri Lanka was eight times bigger than its land area and the eventual UNCLOS shelf area might be 23 times as large. In the 2004 tsunami Sri Lanka lost its survey vessel, echo sounder and multibeam systems and DGPS navigation system. A ship donated subsequently by the German government had been used to carry out new surveys. Nine tide gauges had been installed around the coast and a large part of the southern and western coasts had been surveyed bathymetrically as well. NARA staff had been trained in various skills at UNH, in India and at the UKHO but further training to PhD/Masters level was being sought. Hydrographic and oceanographic instruments and software had also been donated by the German Federal Maritime and Hydrographic Agency.

7. **3.3 Walter Reynoso Peralta, Argentina** explained that he was currently working on the marine geophysical aspects of hydrographic surveys of the Argentinean EEZ. He was collaborating with the universities of Hawaii and Miami and NOAA. He was trying to begin the creation of a map of the South Atlantic using research ship data from the outer continental shelf. He was able to use data which was part of Argentina's UNCLOS submission. He was also working with a Brazilian geologist and was an advisor to a marine science school in Argentina.

8. **3.4 Hugo Montoro, Peru** explained that he had been involved in national chart production until the end of 2009 but now was based in Peru's second largest town, Iquitos, in the Amazon basin. Here he is head of the branch that maps Peru's rivers. This mapping is being undertaken with a view to using rivers in South America to transport goods from the Pacific to the Atlantic. The work is challenging because the river levels change with the season and their courses may also change from year to year. Surveys have been conducted with multibeam and LIDAR may be used too.

9. **3.5 José Gianella, Peru** stressed the great value of having two NF/GEBCO scholars in one country. He said that he and Hugo Montoro work closely together as a team within the DHN. He contrasted his roles as a manager in Peru and as a student at UNH. He noted that his naval career was actually initially set back by taking a year out to study at UNH. Within DHN he was head of Cartography then head of Hydrography and is now head of Survey and Geomatics.

10. **3.6 Muhammad Bashir, Pakistan** is now Deputy Hydrographer in Pakistan and a member of SCUFN. After he returned from UNH in 2006 he joined the Hydrographic School but discovered there were no students. He designed a programme of basic training leading to the Cat B hydrographers qualification which was approved by IHO and IOC. The most recent course was run in September 2010 with attendees from several countries. His job now involves administration and operations as well as running a project. He has also been involved in the installation of tide gauges provided by IOC and installed with the help of the University of Hawaii. He was involved with bathymetric surveys of Denis and Bird islands on the Seychelles continental plateau which were coordinated by the Pakistan Hydrographic Office. Cmdr Bashir also described other activities of the Pakistan HO in which he was not directly involved. He concluded by saying that he hoped more hydrographers from Pakistan could be trained at UNH and that there was a shortage of ocean researchers in Pakistan.

11. **3.7 Anastasia Abramova, Russia** said that she was based in the Laboratory of Geomorphology in the Geological Institute of the Russian National Academy of Sciences, Moscow. Before coming to UNH she had obtained a degree in geomorphology at Moscow State University where she worked on modelling the axial morphology and segmentation along the ultra-slow spreading Knipovich Ridge. Currently she is working on a Masters degree at CCOM, UNH where she is comparing and evaluating publicly available global bathymetric grids. This is being done by visual assessment and by quantitative comparisons. In particular she is using grids from several cruises on the RV *Academician Nikolai Strakhov* in the Norway-Greenland Sea and south and southwest of Svalbard which covered different topographic provinces.

12. **3.8 James Daniell, Australia** said he had just graduated from Year 6 of the Training Course at UNH. He had previously done a PhD at the University of Sydney on sea-grass habitats. He now works for GeoScience Australia where he is involved in the acquisition and dissemination of multibeam bathymetry. Before coming to UNH he had felt isolated with few resources available but now GeoScience Australia was collecting multibeam data routinely and was considering buying new systems. He had found the course quite tough but he now felt that he was in a good situation to make the most of the training received.

4. OUTREACH WORKING GROUP

13. Paolo Lusiani described the goal of the WG as telling the public what GEBCO is and what it does. He added that even in the scientific/hydrographic community not everyone was familiar with GEBCO so that there was a need to inform them too. Thus the WG aimed to operate at two different levels 1) inform the public and 2) inform colleagues. He continued that in the last two years there hadn't been any opportunities other than working through Google Earth and Google Ocean which helped the public 'see' beneath the sea.

14. However a few months ago he had met someone involved in running aquaria in Italy from which the concept of introducing GEBCO within aquaria had arisen. This was not an ideal situation because people go to aquaria expecting to see living organisms. He planned to work with aquarium staff to create a 'bathymetry' clip for visitors, 1.5 million of whom visit the Italian aquaria each year. The clip would have to be very short (ca. 15 seconds) but would include information about GEBCO, where it can be obtained and possibly a fly-through clip; links to sites with further information might be added too. He noted that the GEBCO web site was only published in English and translations into other languages was needed for maximum outreach.

15. Paolo Lusiani pointed out that IHB had already allocated funds to GEBCO which could be used for creating a short video clip. Steve Shipman confirmed that USD8,000 for education, plus USD10,000 initially allocated for other purposes, remained to be spent before 2012. Colin Jacobs opined that GEBCO was not an exciting subject; he said had tried to create a clip showing what would happen if the oceans were drained. Walter Smith noted that any video clip could be dubbed in multiple languages. He recommended that the clip should not refer only to the vicinity of the aquarium. Dave Monahan was not in favour of involving students at UNH. Juan Brown thought that GEBCO had to decide what resources were needed and then buy in the expertise.

16. Walter Smith described the JASON project which was an American science curriculum project tied to global ocean mapping. The motivation for creating the project was that two-thirds of 11-14 year old students were said to be bored by science. However clips of the Titanic survey carried out by Bob Ballard were said to have stimulated students. This had led to the release of lots of web resources for students and teachers funded by the US government and the creation of the JASON project. Teachers from Puerto Rico and Singapore had also become involved. JASON was now used in 160 countries and 23 percent of users were outside the USA. Although the web material was currently in English it was hoped to translate it into Spanish shortly. The project expected to have reached 3.5 million students by the end of 2010.

17. Bob Anderson described progress with creating a globe with GEBCO bathymetry. He reminded everyone that in 2009 he had obtained a 42-inch globe make in the Isle of Wight (UK) and a 30-inch Chinese globe. The misregistration that had been present in the Chinese globe had now been overcome. The company was now ready to take orders at a cost of $2000 per globe plus shipping costs of a few hundred dollars. Mr Anderson said several people or organisations had expressed interest in buying the globes but the Chinese company wanted payment in advance. Alternatively the Chinese might market and sell the globes themselves. Chris Fox confirmed that there had been huge interest in the globe at the Fall AGU meeting in 2009. **Robin Falconer concluded that the**

globes were a potentially important part of GEBCO's outreach and deserved further discussion in the coming week.

18. Martin Jakobsson reported on progress with the World Map and showed a glossy prototype with much improved colours. The World Map web site, from which a pdf copy can be downloaded, has sustained over 68,500 hits. The question was what to do next, e.g. a new print run for the next Fall AGU meeting? He suggested that distribution costs could be reduced by printing at a number of print shops spread around the globe; although offset printing is expensive to set up, once done the price per copy is low. He also suggested printing a smaller version for schools. It was established that printing in Australia would not be a problem and copies could be distributed at the IUGG, Melbourne meeting in July 2011 and at IGC, Brisbane in 2012. It was also suggested that copies could be used in the JASON project.

5. METADATA AND DATA EXCHANGE

19. Tony Pharaoh began by describing the multitude of metadata standards, including various ISO Geographic information standards, and described the typical component parts, for example, quite detailed data could be recorded about the distribution of data. He described in more detail how the draft metadata rules of the EU project INSPIRE operated. They consist of Discovery data, which contains keywords to allow search engines to locate the data, and Evaluation metadata that allows a potential user to decide if the data are fit for purpose e.g. resolution, precision, accuracy, access restrictions etc. Finally there is Use metadata that provides information required to make use of the data in a tool or application. He illustrated the point using data from offshore Peru. Finally he described how controlled vocabularies could be created and used. These could consist of lists of Flat terms, which contain non-overlapping terms, and Hierarchical terms.

20. Lisa Taylor showed a presentation from D. Schaap and Eric Moussat about the EU European Marine Observation and Data Network (EMODNET) hydrography pilot project which had made progress in its first year with partners from ten countries. The overall objective is to create pilots to migrate fragmented and inaccessible marine data into interoperable, continuous and publicly available data streams for complete maritime basins. The pilots include the Greater North Sea, English Channel and Celtic Sea and Western Mediterranean, the Ionian Sea and the Central Mediterranean Sea. EMODNET is setting up a Hydrography portal (www.emodnet-hydrography.eu). The plan is to involve research institutes, monitoring authorities, and HOs, in providing hydrographic data sets for producing Digital Terrain Models (DTM). The portal will include a metadata discovery service based on the SeaDataNet CDI metadata standard. It is intended that the CDI metadata remain public domain and freely available as are various GIS layers such as gridded depth, vector depth, along track depth profiles and multibeam surveys, coastlines and underwater features. QA/QC specifications have been prepared by IFREMER, NERC-NOCS and ATLIS.

21. Lisa Taylor and Juan Brown both noted that it was important to work with others on developing metadata concepts. She continued that quality assurance was the real problem because many entries contain mistakes although software exists that can be used to make checks. She thought that one solution was to limit the number of free text fields. Nevertheless entering data has to be easy to do.

22. Pauline Weatherall mentioned metadata for the GEBCO grids which distinguish between interpolated and non-interpolated data. However it would take time to decide what other information to provide to users and what ISO standards to follow. The NERC Vocabulary Server, a system for serving metadata via the web (http://www.bodc.ac.uk/products/web_services/vocab/), offered one option for delivering the metadata.

23. Bruce Goleby noted that SCUFN has had a problem with defining new vocabularies. He wondered if metadata fields could somehow be populated automatically and asked how different data types should be handled.

24. Walter Smith talked about GEBCO's source identifying grid (SID) which Pauline Weatherall had worked on. He noted that any 30 arcsec x 30 arcsec box might contain several soundings and needed adequate documentation. He concluded by saying that GEBCO needed to be clearer about what it was trying to do.

25. Pauline Weatherall replied that the aim was to attribute contributors and provide quality assurance in the form of basic data. She said that she had drafted some attribute fields but they were non-standard and she was uncertain how to proceed.

26. Martin Jakobsson warned against duplicating efforts at NGDC. Chris Fox replied that NGDC aimed to have metadata for each sounding but this needed a big database engine. Juan Brown said this would require a lot of work to populate the metadata fields.

27. More discussion followed about the aims of the metadata working group and what it was trying to provide for the user. Lisa Taylor thought that the main was to populate the GEBCO grid in a number of clear steps.

28. Walter Smith attempted to describe the big picture as,

1. create products that are well documented
2. to discover and input data
3. to build a grid at a certain scale.

29. Bruce Goleby thought that the aim should be to,

1. produce grids of the ocean floor
2. to enable users to capture data from different sources and merge it using metadata.

30. Chris Fox noted that, with existing standards, it was common for metadata to help in merging data. Walter Smith countered that in many regions 'old' data presented problems because one could not necessarily get back to the original sources.

31. Tony Pharaoh said that metadata profiles had already been created and vocabularies discovered. He thought at the next meeting the group should concentrate on controlled vocabularies and on the SID grids. He proposed creating a test grid to illustrate how the system worked. Finally it was suggested that the IHO or GEBCO web sites should contain links to disparate but relevant resources.

32. Tony Pharaoh then showed a Powerpoint presentation created by Eric Moussat of EMODNET which was an EU project designed to bring hydrographic data together. Twenty three states had provided data and the French and UK Hydrographic Offices were said to have promised to provide grids. The project was driven by the EU INSPIRE directive for collecting spatial environmental information. It is a good example of what to do where resources were limited. Another useful example to consider was the SOPAC project in the SW Pacific which had set up its own network. The island states are digitising their own data which is delivered to a SOPAC portal. Martin Jakobsson added that a lot of high resolution data was being collected in which case the metadata problem was even worse.

6. NIPPON/GEBCO PROJECTS

33. Robin Falconer introduced the discussion by saying that the Nippon Foundation (NF) had been talking for a while about how to keep up the education of the scholars. As a result a new proposal had been submitted in early 2010 which the NF had liked. They had agreed to continue funding the

UNH training project for the year 2010-11 at a level of USD535,000 but in addition had awarded GEBCO USD415,000 to develop a number of projects over two years in 2010-2012.

34. The project funds were likely to be spent on the following:

35. 1. developing regional mapping projects for the purpose of global capacity building and not solely for making charts. The scholars have to play key roles in these projects.

36. 2. a GIS project that had already been started at UNH and which would include aspects of outreach and communication.

37. 3. further training at PhD or Masters level which might or might not include scholars. Again the objective here was to develop people, on a global scale, and not simply to develop the subject of ocean mapping. Just as originally in 2003 GEBCO had looked worldwide for a university to run the training course now in 2010 it needed to find a university/universities willing and able to supervise PhDs and run Masters courses which would be paid for by the NF/GEBCO. Discussion followed about the priorities, for a PhD, of identifying a student, a university or the subject of research. Martin Jakobsson believed that every PhD project would be different . He thought that the starting point should be finding a good supervisor. James Daniell said that he had had a 'brilliant year' at UNH and would have liked to follow it with some research. He noted that the structure and time-scale of a PhD in the USA was very different from one pursued in Australia, New Zealand or the UK. Megan Jones opined that PhD students look for the best place to study whatever interests them. Colin Jacobs pointed out that most UNH students were employed and there might be a problem with employers agreeing that they pursue a PhD. Shereen Sharma quoted an example of Fugro allowing a staff member to work part-time on a PhD at a local university.

38. The discussion ended somewhat inconclusively with different views expressed as to what the users of GEBCO products actually want and who these users are. It was thought that the scientific users were well aware of the bathymetric products available from GEBCO but this was not the case with industry. Various suggestions were made for holding a meeting between bathymetric users and GEBCO providers within a larger international meetings such as IGC, IUGG and AGU and for writing an article about GEBCO in EOS.

7. INTRODUCTIONS TO iSCRUM AND TSCOM

39. iSCRUM is not (yet) an official GEBCO Sub-Committee but is described as an interim sub-committee until such time as Terms of Reference and Rules of Procedure have been approved by the IOC and IHO. Martin Jakobsson explained that iSCRUM was set up in 2009 to facilitate,

1. closer collaboration between existing regional mapping efforts. He noted that it had been difficult to contact IBCs and to discover what they were doing. The IOC had been unable to provide such information. Serious budget constraints within IOC had led to most IBCs becoming dormant or inactive.
2. to get new compilations into GEBCO. Currently this works well through personal contacts and networking.
3. to encourage the establishments of new regional mapping projects. He explained that a framework was needed to facilitate new projects even including the provision of seed money. This approach might include, for example, funding scholars' projects.

40. Walter Smith summarised TSCOM's objectives and background philosophy. These had been summarised in a paper circulated earlier entitled 'The Ocean, Mapped and Unmapped' (Annex 2). The gridded datasets would include mapped and unmapped grid squares each with estimates of depth and uncertainty and adequate metadata. The mapped area would be scale independent.

Critically the supporting data should be public and freely available. The tool would allow not simply visualization of the data but also extraction and downloading of the data. There are technical questions in the above for TSCOM, and its Working Groups on Metadata and perhaps other Working Groups, to answer. There are questions for Google. There are policy questions for the Guiding Committee. There are Education/Outreach issues and there is a potential interface with SCUFN.

41. Robin Falconer commented on the IOC situation. He noted that GEBCO is a joint project of the IOC and IHO. It was very important for some people's attendance at GEBCO meetings to acknowledge this fact. It helped them obtain travel funds and even, on occasion, to release data.

42. He continued that GEBCO had tried, and was trying, to integrate with the IBCs. He had attended the IOC Executive Council meetings in Paris in June 2010 and had referred there to GEBCO's work with shallow water bathymetry and ENCs, as requested by the Assembly at its 25th Session (Paris, 2009), as well as to the World Map, data harvesting, capacity building etc. This had persuaded the Executive Committee to make the following remarks,

43. 'The Executive Council recognized the importance of bathymetric data and digital elevation models for the development of inundation models and evacuation maps for mitigating the impact of natural coastal hazards and noted that access to such data is sometimes restricted in nationally sensitive coastal zones on security and commercial grounds.'

44. 'The Executive Council supported capacity-development in bathymetric mapping techniques and thanked the Italian Government and the Nippon Foundation for their support for hydrographic training through the COAST-MAP-IO project and the GEBCO programme.'

45. Robin Falconer continued that people should remember that GEBCO is part of IOC which in turn is part of UNESCO which is a UN body. The UN is keen on supporting Africa and on gender balance. He also revealed that after many years IOC's Consultative Group on Ocean Mapping (CGOM) had ceased to exist in 2008.

46. A recommendation was tabled that IOC member countries be requested to provide extra budgetary support for GEBCO and IOC ocean mapping. However the Executive Council in its decisions did not include this recommendation.

47. Lastly Robin Falconer explained that GEBCO was not asking IOC for funds since money is tight because they want to focus their efforts. Some countries do provide funds for specific programmes but not, so far, for GEBCO.

8. IBC REPORTS

48. **8.1 IBCSEP** (see http://www.ngdc.noaa.gov/mgg/ibcsep/english/index.html). Hugo Montoro reported on the IBC of the Southeast Pacific. He mentioned that it had started in 2003 and had been instrumental in getting hydrographers and cartographers in Hydrographic Offices to work together. This had led to the publication of nautical charts in the GEBCO style with contoured soundings. A lot of effort went into deciding the details of the printed charts. Twelve sheets had been produced but it had not been possible to review the data. There were no scientists on the IBCSEP. After he returned from UNH some consideration had been given to printing further charts but the effort had faltered. There is no common grid between the different sheets so there are likely to be overlap problems. Given funding the remaining sheets could be completed. So far, as shown on the IBCSEP web site, three sheets off Peru have been completed and are under review, as well as a number of sheets off Chile. Sheets 1-06 and 1-12 exist in preliminary form.

49. Martin Jakobsson congratulated Hugo Montoro on what had been achieved. He thought that generating a gridded dataset would provide a good focus for further activity. This would present a good foundation for a regional project.

50. **8.2 South Atlantic Ocean**. Walter Reynoso Peralta described how he had been working to collect data for 4-5 years over the Argentinean continental margin with a view to creating a bathymetric chart of the southwest Atlantic Ocean bounded by the latitudes of Argentina (36°-60°S, 17°-24°W). He said that he wanted to collaborate with others working under the auspices of IHO; he was already working with someone in Brazil and hoped to create a link with Uruguay as well. Although he could access Argentina's UNCLOS data (single and multibeam data and continental shelf data from fishermen) he could not share it with others. He noted that a regional mapping project would help to progress these plans. He said he hoped to present the first version of his bathymetric chart at the 2011 GEBCO meeting. Finally Martin Jakobsson pointed out that, given permission, the *Odin* and BAS ships could collect data too.

51. **8.3 IBCWP** Jin Jiye described the situation of the IBC of the West Pacific. He said that the area had been divided into 6 sub-regions for the purpose of mapping. Russia was the leader in Sub-Region 1 which is planned to contain 14 sheets (1-1 to 1-14). Six sheets have been produced at 1:500,000 scale, three sheets at 1 million scale and two sheets were 'in preparation' in 2006. Japan leads Sub-Region 2 and has produced seven sheets. In addition the PRC has produced seven sheets and Korea two sheets. PRC leads Sub-Region 3 which is planned to have 16 sheets. In addition the Philippines are working on five sheets and Vietnam on three sheets. Sub-Regions 4, 5 and 6 are the responsibilities of Australia, New Zealand and SOPAC, respectively.

52. Jin Jiye referred to some problems with the IBCWP. He said suggestions for metadata made in 2004 had not been implemented well and there were problems with the annotations on the charts (toponomy). He thought that the Executive Board of the IBCWP should meet again soon because it had not met for six years. He hoped that constructive suggestions would be forthcoming to overcome disagreements. He also proposed that data exchange should be promoted after identifying a suitable data format. He ended by saying that the PRC offered to host the Fifth Editorial Board meeting and an associated technical meeting in late 2010 or in the first half of 2011.

53. Chris Fox asked how much data was publicly available and was told that data would be available after the charts were produced although the format had yet to be decided. Walter Smith noted that he had learnt last year that the SE Asia Hydrographic Commission had agreed that data were to be exchanged. Steve Shipman confirmed that this body was cooperating over data for ENCs but he didn't know about the rest of the data. Walter Smith responded by asking whether GEBCO could help financially. Steve Shipman responded that the whole concept behind the Regional Hydrographic Commissions was to get states to work together and it would be better if GEBCO approached the problem from that direction. Nataliya Turko noted the huge area covered by the IBCWP and suggested that more progress might be made if the project was divided into two areas, for example, Sub-Regions 1-3 and 4-6. Robin Falconer responded that a few years ago New Zealand had been invited to be part of the IBCWP but had not considered that the SW Pacific was a very logical part of the project. New Zealand had not been able to get further involved. Bruce Goleby offered to discuss Australia's involvement in the IBCWP informally.

54. **8.4 IBCSO** In the absence of Hans-Werner Schenke, who was in the SCUFN meeting, Martin Jakobsson reported that progress with the IBCSO had been halted because funding for Norbert Ott, who had been working on the project, had been lost.

55. **8.5 IBCAO** Martin Jakobsson said that the last Editorial Board meeting of the IBCAO had been in 2002. Ron Macnab had contacted the IOC since then in an attempt to re-vitalise the project. However progress had been made by the scientists involved who worked independently of the Editorial Board. He reported that a chart had been published in 2004 with a major release in 2008

with an accompanying paper in Geophysical Research Letters. A lot of new data had been acquired from organisations such as the Canadian Hydrographic Service and from cruises on the research ships *Healy, Polar Stern, James Clark Ross, Oden* etc. Additional data had come from Italy, US submarines, Olex and ENCs. All these data are being compiled and used to update the chart.

56. He concluded that he had tried without success to persuade the IOC to set up a new Editorial Board. So, he asked, was the IBCAO now a scientific or an IOC project? Further discussions would take place during an Arctic/Antarctic mapping meeting to be held in Stockholm in May 2011.

57. In discussion Dave Monahan asked about the quality of the Olex data. Martin Jakobsson replied that it was good for grid sizes down to 500 m. It complements deep-sea data mainly on the continental shelves.

9. TEST OF A MODEL FOR GEBCO'S EDITORIAL FUNCTION

58. Pauline Weatherall reported on a test of GEBCO's editorial function based on a review and incorporation of new bathymetric grids of the Black Sea, Weddell Sea and Caspian Sea into the GEBCO_08 Grid. She affirmed that GEBCO needs a review process because its aim is to provide the most authoritative, publicly available global gridded bathymetric data sets for the world's oceans. Thus, an editorial process to review and check data supplied for updating GEBCO's products will help to provide quality assurance to users of the data sets.

59. She presented an overview of the steps in the review process as follows,

60. 1. is the new grid an improvement on the existing GEBCO grid and other datasets?

61. 2. Does the data set itself contain any artefacts.

62. 3. Are there problems with edge matching the data to the existing GEBCO grid, e.g. along coastlines?

63. 4. Work with data originators by providing feedback and discussing the outcome of the review with them.

64. 5. Finally, obtain feedback from iSCRUM and TSCOM colleagues on new data sets before they are released as part of the GEBCO grid.

65. Pauline Weatherall then showed graphical examples from the Caspian Sea (new grid from John Hall), Weddell Sea (Alfred Wegener Institute), Australian Bathymetry and Topography Grid, 2009 (Geoscience Australia), Amundsen Sea (Frank Nitsche, LDEO) and Black Sea (John Hall). She compared in more detail aspects of the Black Sea grid e.g. the coverage of soundings (including the SID grid), a grid of the differences in depths. Specifically, she showed how overlaying the source data used to generate the grid can help to identify the information/data source that a feature is based on and how 'difference' grids, comparison with other data sets and track control coverage can help to identify potential 'spikes' in a data set caused by anomalous soundings. Finally she suggested some points for further discussion which included,

66. 1. Should GEBCO ask that any new grids are accompanied by supporting control data/information?

67. 2. Should a minimum level of metadata be provided with the data set?

68. 3. Should the inclusion of relevant land data be a requirement and, if so, should GEBCO specify what data sets to use?

69. 4. Does GEBCO need a network of local experts/regional reviewers? Should iSCRUM (and other GEBCO groups) undertake this review?

70. 5. Over what timescales should a review be carried out? (see later discussion below)

10. GLOBAL MULTI-RESOLUTION TOPOGRAPHY SYNTHESIS

71. Vicki Ferrini described the GMRT system developed at LDEO. It enables the user to experience a seamless transition, between nine grid resolutions of 100 m or more, based on the chosen zoom level. GMRT outputs are in the form of grids or images provided by a variety of software packages.

72. Historically the project started as the Ridge Multibeam Synthesis Project in 1992. Eventually the area covered expanded to encompass the whole world ocean. The first version of GeoMapApp appeared in 2004. By 2010 GMRT version 2.0 was released which offers a revised tiling scheme, new data preparation tools, improved quality, improved land resolution and extended swath coverage.

73. She showed the, mainly Pacific Ocean, coverage of 100m swath data; 125 cruises had been added in 2008/09 and 100 cruises in 2010. Using image dumps from the web site she showed how the user could attribute data to its source and even access the original data source. Next Vicki Ferrini discussed the problems with ingesting data; these included bad navigation, noisy outer beams, attitude problems, bad soundings, instrument problems, bad weather, sound velocity and turns at slow speed. She then related the workflow of multibeam data as it was ingested. This included a number of tools for quality assessment.

74. In the second half of her presentation she presented a proposal for how the LDEO group could contribute to GEBCO. This centred on a new GEBCO 100m synthesis. LDEO would contribute its existing 100m compilation to the GEBCO 100m synthesis. LDEO would serve as Data Assembly Centre for new 100m data sets contributed by the international community. LDEO would provide the GEBCO Editorial Board with tools to evaluate new data sets. After data sets were corrected/approved, they would be merged with the existing GEBCO 100m synthesis and provided to BODC for incorporation into the GEBCO 30 arcsec synthesis. LDEO would also provide the Editorial Board with tools for viewing grids that would dynamically adjust colours and sun illumination and display depths as profiles, compare new data with existing data in a region and review the data at different resolutions (e.g. from 100m to 30 arcsec).

75. It was proposed that the new 100m dataset would be dynamically maintained so that a new version would become available as new approved datasets were merged into the synthesis. The dataset would provide full tracking and attribution to the contributing data source(s) along with the data synthesis and a mask to highlight the areas of 100-m resolution coverage.

76. Karen Marks pointed out that a common grid would be required. Vicki Ferrini confirmed that the LDEO grid was already compatible with Google technology. Participants were very impressed with what had been achieved but it was stressed that there was still a place for GEBCO in that GEBCO provided a global base and bridged the gap between scientists and the international HOs. Walter Smith and Martin Jakobsson noted that although LDEO had achieved a lot of what GEBCO was planning the LDEO grid largely depended on data acquired by US research vessels and thus GEBCO still held a lot of data that was not in the LDEO grid.

77. Jim Braud gave a reaction from a US Navy perspective. He noted that the navy was not so open with its data, e.g. from overseas EEZs, although the US EEZ surveys were in the public domain. The US Navy has six ships with a top of the line EM122 multibeam system. Although the navy had been gridding bathymetry for 30 years it began to use high resolution data only around 15 years ago. Metadata were used simply to distinguish between real and interpolated depths. He described

how the Naval Oceanographic Office developed the Digital Bathymetric Data Base which was followed by the Smith & Sandwell 2 arcmin grid soon to incorporate the 30 arcsec GEBCO grid. Only recently even higher resolutions, e.g. 1 or 2 m, were being envisaged. Finally he stressed that the Navy's interest was in producing navigational charts which had an uncertainty value associated with each grid point in deep water. Lately there was also interest in shallow water bathymetry and a data file format called a Bathymetric Attributed Grid which includes metadata.

78. In discussion Jim Braud made it clear that the US Navy was not about to release data or even metadata indicating depth uncertainties. He said that most of the Navy data remained unattributed.

11. REPORT ON COLLECTION AND USE OF OLEX DATA

79. Tony Pharaoh described how ships of opportunity had collected data around Antarctica. These included cruise ships run by Lindblad Expeditions which operates multibeam systems for the safety of their ships in uncharted waters. They used the Norwegian Olex system, which was essentially a black box designed primarily for fishing vessels with links to the ship's echo-sounder and GPS systems. There are over 2500 users which increasingly include scientific and research institutions as well as fishermen. Olex are in partnership with a New Zealand company that makes multibeam systems for small vessels.

80. The collected data are sent to Olex and added to the Olex database. Olex users, who contribute data to the Olex global database, get access to the database which includes the data from other Olex users all over the world. All incoming data are quality checked, merged into the database and the depth values are adjusted to get the best mean result. The database divides the world into 5 x 5 m cells. Horizontal datum is WGS84; vertical reference is equinoctial spring low water. Users have contributed some 2 billion soundings over the past 8 years. An updated version of the database is released every six months (on 20 compressed CDs).

81. Tony Pharaoh showed the data coverage over the continental shelves of the North Atlantic, North Pacific and South Atlantic Oceans.

82. He then asked whether data collected by ships of opportunity using the Olex system could be used for charting purposes worldwide. He suggested that in future IHB could purchase the Olex software and that cruise ships (and other vessels) using the Olex system and operating in the Antarctic Region, could send their data to the IHB (via CD, USB stick, or FTP link). Then the IHB would check the data for possible "urgent dangers" (e.g. uncharted shoals) and forward this information to the relevant charting authority for further action. The IHB would also forward the data to Olex for harmonization and integration into the Olex global database and include the relevant metadata (and track-lines) into the HCA web server. IHB would also check every new (6 monthly) release of the Olex database and forward all new data to the relevant charting authority. He illustrated the potential for this new scheme by showing the dense coverage of vessels using AMVER in January and June 2010 (mainly between 70°N and 50°S). For example, 12,000 ships from over 140 nations participate in AMVER (http://www.amver.com/). An average of over 2,800 ships are on the AMVER plot each day and the AMVER Centre computer tracks over 100,000 voyages annually.

83. Chris Fox asked whether there was any constraint on accessing the Olex data. Tony Pharaoh replied that it was available only to contributors but Olex were very helpful. He noted that there was a problem to persuade more fishing boats to join the scheme. Martin Jakobsson offered to become the GEBCO contact with Olex. Colin Jacobs said that initially the data had been provided free but there was now a charge because the scheme had become so popular. It was agreed that the Olex data would be useful for regional mapping. Robin Falconer pointed out that some New Zealand bottom trawlers tow down to 1800 m so the data were not restricted to shelf depths.

12. GEBCO'S REVIEW PROCESS

84. Robin Falconer opened a round table discussion by asking how GEBCO was going to carry out quality assurance of gridded data that it acquired. Martin Jakobsson thought that it was important to have regional experts familiar with the morphology and marine geology of an area who could conduct an iterative dialogue with the data provider. Natalya Turko wanted to see GEBCO draw on people listed in the Personality List. It was asked to what extent should data from a Data Centre be quality assured? Chris Fox asserted that NGDC did some quality assurance but it was unlikely to be perfect. Martin Jakobsson agreed it was reasonable to assume grids were 'clean' even though a review might find additional errors. Chris Fox said that what was needed was digital data, both information and depths, and whether they were soundings or grids. Walter Smith pointed out that there were vast areas where there was insufficient data to build a grid and here there was a need to continuously update from x,y,z information. Robin Falconer made an operational distinction between the gridded data that Pauline Weatherall worked with and the data that scientists acquired and used for their research.

85. Martin Jakobsson affirmed that he needed a list of regional experts to review a new compilation but also some criteria for how to compare different data sets. He thought that there would also have to be some flexibility to work on a case by case basis. Pauline Weatherall agreed. Walter Smith said it would be good to publicise the review process but he was worried if only one person was allocated to review a new grid and preferred to imagine that an Editorial Board would do it. It was suggested that Regional Hydrographic Commissions should be asked to supply experts but Hugo Montoro pointed out that some HOs, e.g. Peru, just assumed that supplied data were good. This led to a consensus that GEBCO should in effect be the 'Editorial Board'. In conclusion, Pauline Weatherall and Colin Jacobs were expected to lead the editorial function and recruit people on a regional basis as and when required and whether from within or without GEBCO.

86. Nastia Abramova asked whether emails were received about errors in the data. Colin Jacobs admitted that there were a lot of emails and this was not very flattering. Pauline Weatherall said that in reply she was often able to refer people to the SID file. Colin Jacobs pointed out that errors were compiled and listed on the web site but unfortunately commercial companies did not contribute to this process.

87. Robin Falconer summarised the discussion so far. **It was clear that GEBCO needed a network of regional experts to help 'review', authenticate or approve new grids. The procedure needed to be publicised. It was up to Pauline Weatherall and Colin Jacobs to seek experts who would be expected to respond within a given deadline. The criteria to be used had to be simple and doable.** For example, metadata about the gridding method and procedures was essential.

88. Regarding coastlines, Pauline Weatherall pointed out that grids that included land, but without coastlines, involved extra work. Perhaps one criterion should be that, if appropriate, a coastline should be supplied. This was a particular problem in the Antarctic where local expertise was needed. **It was agreed to let Pauline Weatherall and Colin Jacobs negotiate over coastlines with a regional expert**.

89. Martin Jakobsson quoted the example of the new bathymetric grid being created by the Baltic Hydrographic Commission as a good example of a regional project. Sweden was likely to take the lead. Users initially wanted a resolution of 1 m but this was deemed to be too sensitive and a compromise of 20-50 m was reached. Robin Falconer pointed out that RHCs tended to meet only every two years and Paolo Lusiani pointed out that in some cases there were a lot of disagreements.

90. Robin Falconer then summarised the main features of the previous discussion which were,

91. 1. It was vital that the IOC remains one of GEBCO's parent organisations

92. 2. Pauline Weatherall would continue to update grids received and would set up an editorial function

93. 3. The US Navy was not about to give data to GEBCO

94. 4. Vicki Ferrini (LDEO) had made a very valuable offer to share LDEO's GMRT system with GEBCO

95. 5. Pauline Weatherall and Colin Jacobs will work together to find regional experts in an appropriate time frame

96. 6. Regional programmes that are set up could use the Baltic Sea mapping project as an example

97. 7. Olex data are a valuable resource particularly in Antarctic waters

98. 8. There needs to be a discussion of Tools for Gridding.

13. HOW TO INITIATE REGIONAL MAPPING PROJECTS

99. Robin Falconer began a discussion on how to initiate a regional mapping project(s) given that the NF had provided funds for this purpose in the period 2010-2012. It was understood that any new chart should go from the beach to the deepest offshore. Although GEBCO would 'service' such projects it was up to the regional community to identify and provide one or two leaders for each project.

100. Hugo Montoro responded that it was difficult to make decisions on behalf of people who were absent. It would be better for someone from GEBCO to attend a meeting of regional activists or for such activists to be invited to the next GEBCO meeting. Jim Braud wondered what should be the 'message' to regional groups because sharing data didn't work. Hugo Montoro replied that it was important for GEBCO to demonstrate the advantage of working with grids and digital metadata. Martin Jakobsson agreed that GEBCO wanted to update and improve grids.

101. Walter Smith gave a short presentation to demonstrate how the SE Pacific could be used as a test area for gap filling algorithms. The GEBCO_08 grid has a lot of bad track lines and a lot of satellite texture. If one computes what the controls are on the grid one finds that in some areas there are gaps of more than 100 km between measurements. In a study of NGDC data from the area, by plotting power spectral density against wavelength, he established that there is no optimal way to interpolate values. The root mean square uncertainty on an interpolated depth, when there is a gap of 100 km between measurements, is over 300 m.

102. After a break, Robin Falconer stated that, after a long gestation, GEBCO will initiate a northern Indian Ocean regional mapping programme. GEBCO will write to key organisations in the area saying that local NF/GEBCO scholars are keen to take part. This would involve, at the least, Pakistan, Sri Lanka and Indonesia.

14. ANTARCTIC AND ARCTIC MAPPING ACTIVITIES

103. Martin Jakobsson led a discussion on Antarctic and Arctic mapping. He began by asking where data needed to be collected and how this could be coordinated.

104. **14.1 Bathymetry of the Ross Sea region.** Vaughan Stagpoole noted that New Zealand scientists had been studying Antarctica, including its on-land geology and offshore bathymetry, for

many years. He recalled that in 2004 a 1:5 million chart of the Ross Dependency and adjacent Southern Ocean and a 1:2 million chart of the Ross Sea had been published. The Rossmap project, part of the Circum-Antarctic Stratigraphy and Paleobathymetry (CASP) project due to end in June 2011, is designed to update and improve these charts taking account of the rapidly growing data coverage, the availability of new swath data and more refined techniques to 'clean' the data and to process gravity data. The new grid and map are expected to be available in January 2011. The mapped area lies south of 60°S between 140°E and 120°W. A second objective is to interpret seismic data over the Coulman High. Data will be made available to Land Information New Zealand (LINZ), an organisation that provides charts to tourist ships in the area, and the IBCSO.

105. Dr Stagpoole noted that there are gaps of 100 km or more between depths. He described an interactive 'cleaning' algorithm that ensured that the maximum depth difference between each bathymetry value and its 29 neighbours is less than 30 m. Satellite gravity data are used in an inversion scheme employing all available data to aid interpolation between tracks.

106. **14.2 Australian bathymetry in Antarctic waters.** Bruce Goleby began by describing the current mapping scene in Australia. Two multibeam capable ships were available, one for shallow-water and one for deep water (being commissioned in 2012). Offshore mapping is dominated by the need to map the very large area, occupying 70% of the land area, being claimed under Law of the Sea which includes the Antarctic coast. He gave examples of surveys conducted on the Australian margin by Geoscience Australia. A 250 m grid had been produced in 2009 giving unprecedented detail of features within the Australian EEZ. He noted that GA works both onshore and offshore in the Antarctic; the latter studies include benthic habitat mapping on the continental shelf and the bathymetry around anchorages. New grids are being produced for the George V margin and the Davis Base margin. Dr Goleby confirmed that data from 30°E-180° and south of 40°S would be made available to GEBCO eventually.

107. **14.3 The International Bathymetric Chart of the Southern Ocean.** Hans-Werner Schenke described how the idea of the IBCSO began around 1990; it became established in 2000-2003 when the Alfred Wegener Institut became the lead organisation. The IBCSO includes both bathymetry and coastlines (from satellite images). In 2007 the IBCSO was formally adopted as an International Bathymetric Chart by the IOC to complement the IBCAO. For three years Norbert Ott worked on the project and collected data from all available sources. Although tracks had been collected as far north as 50°S not all the data on these tracks had been made available. He noted that data exchange was not always very easy; he recognised scientists need to publish their data but hoped that eventually all data would be released. He quoted one example of being given a 2 km gridded dataset which was next to useless.

108. Dr Schenke said he had been optimistic that agreement on a digital grid would be obtained at a SCAR meeting held in Buenos Aires in 2010. However this had not happened because of an administrative problem with Norbert Ott's employment and a problem with the grid format, of which there appeared to be some 20-30 in existence. Dr Schenke continued that he was trying to find funding to continue the work at AWI and had put a proposal to SCAR in August 2010 for the next three years. AWI are reluctant to continue supporting the project because they expected quicker results. He said that he would welcome any support from GEBCO, IOC or IHO.

109. Chris Fox and Lisa Taylor said that NGDC recognised there was a problem with multiple formats and they hadn't found a solution yet. NGDC are working on archiving data in a single format. Martin Jakobsson commented the he hadn't cleaned the Arctic grids but there were more data sources in the Antarctic and some of the data were quite old.

110. **14.4 Swedish plans in polar regions.** Martin Jakobsson related that the *Oden* had been able to collect data in thick ice in the Arctic between 2007 and 2010. He hoped that in future it would be possible to carry out one expedition every year. There were 29 proposals for Arctic cruises in the

pipeline, not all of which were related to earth sciences. Therefore he was planning a meeting in Stockholm in May 2011 to increase scientific collaboration and to coordinate planning.

111. In the Antarctic, a cruise had been carried out in 2008, 2009 and 2010. It had been agreed to collect multibeam data on all cruises even if the cruise was not an earth science cruise. He said that he was constructing a special web site to make such data available to all. Usually he was provided with grids but it would be possible to accept raw data too. In Sweden the data has to be out in the public domain within two years of being collected.

112. Dr Jakobsson stressed the need for better track planning to avoid duplication and to fill in gaps. He said he would like to see a facility on the GEBCO web site that displayed all tracks with bathymetry.

113. Hugo Gorziglia drew attention to the newly formed Arctic Regional Hydrographic Commission which was going to meet in Ottawa for the first time 4-6 October 2010. This forum would provide GEBCO with opportunities to coordinate with Hydrographic Offices in the area.

14.5 Declassifying Arctic Bathymetry Data collected by US Navy Nuclear Submarines 1957-2005

114. George Newton gave the background to the decision by the US Navy in 1958, following deployment of the Russian sputnik satellite in the preceding year, to begin exploring the Arctic Ocean with nuclear submarines. Initially all oceanic data were classified. The first signs of unlocking the data came when tracks for 1957-1982 were revealed by Waldo Lyon, founder of the US Navy's Arctic submarine lab, in an acceptance speech at a medal award banquet in Paris in 1984. This encouraged George Newton in 1996 to work at getting the soundings declassified. A significant problem was locating the data which potentially was spread among a number of US Navy offices and US (and Canadian) government agencies and departments. The project was announced at a press conference on 21 August 1997 but even so funds had to be found to run it. The first data came from SCICEX (Scientific Ice Expeditions) which collected data on six unclassified, and a number of classified, cruises in 1993-1999. Between 2000 and 2005 the release of data from an agreed area was requested with a 5-year post-cruise moratorium. Data were released except for data acquired within non-US EEZs.

115. Mr Newton continued that SCICEX was entering Phase 2 with a 2010 Science Plan which provides a detailed and prioritized list of sampling recommendations to measure sea ice thickness (i.e., draft profiling), ocean hydrography and bathymetry, and to measure and sample ocean biology and chemistry during "science accommodation missions." In summary, he noted that the US submarines had traversed around 300,000 n.m. in the Arctic during some 70 deployments. The Royal Navy has also contributed.

116. Martin Jakobsson asked whether any US submarines were fitted with multibeam systems. George Newton replied that at the moment they supplied only single-beam data. However he noted that more data was now being collected by surface ships as the extent of ice reached a minimum within historical times.

117. **14.6 Activities in the Antarctic (Italy).** Paolo Lusiani described how the Italian Antarctic programme had begun in 1986 and had continued every year since then. Italy maintained a base on the coast of the Ross Sea. Two bathymetric charts at 1:50,000 and 1;250,000 scales had been produced. However in the last three to four years funds had been cut back and no bathymetric data had been collected. Very recently a meeting had been held to try and re-start the work and although the President of Italy had backed the plan no funds had been forthcoming so far. He concluded that a multibeam system had been installed on the OGS ship *Explorer* but it had never been used.

118. **14.7 Activities in the Antarctic (PRC).** Professor Lin described how a Chinese programme had started in the Antarctic in 1984 with the ice-breaker class research cum supply ship the *Xue*

Long which also conducts research en route to Antarctica (http://www.pric.gov.cn/enindex.asp?sortid=18). Prof. Lin finished by saying that she would like to be involved in the IBCSO and would investigate how China might contribute to GEBCO in the future.

119. **14.8 Activities in the Antarctic (Brazil).** Izabel King described the activities at Brazil's Comandante Ferraz base in the South Shetland Islands under the PROANTAR (Programa Antártico Brasileiro) project of an inter-ministerial programme of the Inter-Ministerial Commission for Marine Resources and its Executive Office (SECIRM). Two ships are involved, the *Almirante Maximiano* (1983), fitted with multibeam, HDCP, gravimeter and magnetometer, and the *Ary Rongel*, which is mainly used for logistical support and is fitted with a single-beam echo-sounder.

120. Izabel King continued that six charts have been produced of the South Atlantic near Elephant Island and King George Island. High resolution multibeam bathymetry acquired near the base shows ice retreat features. Hans-Werner Schenke asked if biologists had access to the data because German biologists found such data very useful in a near-by area. The answer was Yes. Izabel King concluded by saying that she expected there to be two cruises a year in future. She said she hoped to send any new bathymetric data to GEBCO plus some older data as well.

121. **14.9 Activities in the Antarctic (South Korea).** Hyun-Chul Han recounted how Korean activities in the Antarctic had begun in 1978. The Korean Polar Research Institute had been set up in 1988. In 2009 an icebreaker had been launched which was fitted with multibeam. The ship was still undergoing trials but she hoped to be able to present data from the new ship at the next GEBCO meeting.

122. **14.10 Activities in the Antarctic (Peru).** José Gianella said that Peru's activities in the Antarctic had started in 1988 since when there had been 13 expeditions to the region. Peru maintains a base called Machu Piccu on King George Island, the largest of the South Shetland Islands. The first bathymetric survey had been carried out in 1998 which contributed to nautical chart 9125 produced jointly with Brazil. There were plans to conduct a 10-day survey but not until the research ship *Humboldt* had undergone a refit during which a multibeam system would be installed.

123. **14.11 Activities in the Antarctic and Arctic (Russian Federation).** Natalya Turko recounted how the *Akademik Nikolai Strakhov* was the only Russian ship that had worked in the Antarctic region in recent years. She stated that it was hoped to start building possibly four new research ships starting in 2011. This would include one shallow-water and one deep-water multibeam system. There were also plans for a joint cruise with Italian scientists.

124. In the Arctic, swath bathymetry had been acquired from 2006 to 2009 in the Norwegian Sea and around Svalbard and also over the Knipovich Ridge.

125. There was also a plan called 'Meridian' in which small groups of scientists would acquire data from on board tourist ships traversing the Atlantic Ocean longitudinally.

126. **14.12 Activities in the Antarctic and Arctic (Japan).** Shin Tani said that Japan's Polar Institute works from an ice-breaker in both the Arctic and the Antarctic because JAMSTEC's ships are not suited to work in ice. There are plans to use autonomous underwater vehicles with a range of 3000 km (subject to batteries; the current limit is 300 km) to obtain data for climate research. He showed a short film of an ice-breaker that uses water jets to assist its passage through the ice. He concluded by asking for advice on which areas to survey next.

15. MID-LATITUDE MAPPING ACTIVITIES

127. **15.1 Bruce Goleby** summarised mapping activities in Australia which were conducted by Geoscience Australia (EEZ and shelf), the Australian Hydrographic Office (coastal waters), AIMS and CSIRO. Academic mapping included efforts by James Cook University, Townsville and Sydney University. Other mapping is done by IOMS (Integrated Ocean Mapping System) which is a distributed set of equipment and data-information services which collectively contribute to meeting the needs of marine climate research in Australia.

128. Australia runs a marine national facility which operates the *RV Southern Surveyor*. Other ships are *RV Solander* (operated by AIMS) *and RV James Kirby* (operated by JCU). A new vessel which will include a multibeam system as well as a single beam echo-sounder, gravimeter and magnetometer, is being planned.

129. There is a high density of tracks around the Australian margins. A 250 m bathymetric grid was produced in 2009 based on a large bathymetric database. Geoscience Australia scientists recently worked on the west Australia margin and on the Wallaby Plateau transform margin. A pilot study of the Joseph Bonaparte Gulf on the north coast revealed sand waves.

130. Dr Goleby confirmed that Geoscience Australia's bathymetric data would be made available to GEBCO and to the IBCSO in particular.

131. **15.2 Vaughan Stagpoole** explained the various mapping bodies which operate in New Zealand. LINZ (Land Information New Zealand) operates both onshore and offshore, where it carries out hydrographic surveys in New Zealand and Antarctica and publishes charts. NIWA (National Institute of Water and Atmospheric Research) conducts research and operates the ice-strengthened *RV Tangaroa*, which carries a multibeam system, as well as a number of smaller vessels. Research is also conducted by GNS Science (Institute of Geological and Nuclear Sciences). The RNZN (Royal New Zealand Navy) is another body that collects bathymetric data. Finally, Dr Stagpoole mentioned the fishing industry, in which many vessels are fitted with swath bathymetry, as a source of bathymetric data.

132. Dr Stagpoole continued that all the above four organisations maintained databases of bathymetric data although data availability was variable. GNS and NIWA were funded specifically to put their data in the public domain. Plans are afoot to set up a single web-based server with links to all data sources. Swath tracks will be stored as KML files. It will not be possible to supply uncertainties to individual soundings.

133. **15.3 Hans-Werner Schenke** described mid-latitude activities that fell within the remit of the IBCSO. He referred people to the IBCSO web site for its history. He explained that several GIS data sets had been created which were combinations of bathymetry, land topography, grounding lines etc. He said that SCAR wanted the IBCSO to expand its coverage north to 50°S and this would double the chart area. Efforts were also in train to harmonise the SCAR and GEBCO gazetteers.

16. GOOGLE: AN UPDATE

134. Jenifer Foulkes described the current status of Google Earth. She said it is an educational tool in which Google Earth has an ocean layer which provides information within bubbles and balloons from around 1400 sites worldwide. These information boxes can include links to other sites. There are also associated video clips which will display given a fast enough link. She continued that Google Earth also has a showcase of tours, for example about the work being done at MBARI. In future it is planned to include Youtube videos. She described how it also possible to use Google Earth to make a map and annotate it. She suggested that Google Earth might also be used as a

source of ship tracks. For example, data could be entered via the content management site www.thedeepness.org once a user has created an account. The same site will accept blogs.

135. Martin Jakobsson added that it might be possible to display the tracks of all multibeam vessels when they are at sea using marine traffic information from http://www.marinetraffic.com/ais/.

136. Robin Falconer asked how often the Google Earth bathymetry was updated. Walter Smith replied that there were still some technical matters to sort out but GEBCO would create the updates and pass them to Google.

137. Paolo Lusiani asked how many hits had been made on the Google Ocean site. Jenifer Foulkes said she didn't know but there was someone at MIT who would know.

138. Robin Falconer concluded by saying that GEBCO would create a structure whereby data could be entered into Google Earth.

17. REPORT FROM THE DIGITAL ATLAS MANAGER

139. Pauline Weatherall began her report (Annex 3) by listing the new grid releases during the past year. These included an updated version of the GEBCO_08 Grid which contains version 2.23 of the International Bathymetric Chart of the Arctic Ocean (IBCAO), north of 64°N. The Source Identifier (SID) Grid which identifies which cells in the GEBCO_08 Grid are based on soundings or existing grids and which have been interpolated, was also released.

140. Work in progress includes a new version of the GEBCO_08 Grid which will be released shortly. This contains updated grids from the Black Sea (provided by John Hall), Caspian Sea (provided by John Hall) and Weddell Sea (provided by the Alfred Wegener Institut). Work was also in progress on the Australian Bathymetry and Topography Grid (June 2009), which was focused mainly on the Australian coast, shelf and margins, supplied by Geoscience Australia. The new grid showed less satellite 'speckled texture' than the current GEBCO grid. A grid from the Amundsen Sea area had been supplied by Frank Nitsche of the Lamont-Doherty Earth Observatory of Columbia University.

141. She said that bathymetric depths had been submitted from a variety of sources. These included multi-beam surveys in the South Atlantic, for the region around the Vitoria-Trinadade Ridge had been provided by Dr. Nataliya Turko, Geological Institute, Russian Academy of Sciences, and 111,906 soundings, taken from 55 ENCs for the waters around Chile, which had been provided by SHOA (Servicio Hidrográfico y Oceanográfico de la Armada, Chile). Pauline Weatherall noted that, since the initiative to request shallower water data from ENCs began in 2006, data have been received from 19 organisations around the world.

142. Next, she alluded to how GEBCO data sets were being made available either by the internet or via the GEBCO Digital Atlas or by providing user support. Since the release of the GEBCO_08 Grid in January 2009 there had been over 2,122 downloads of the complete global data set and over 4,028 downloads of user-defined areas. Since the release of the GEBCO Source Identifier Grid in November 2009 there had been over 385 downloads of the complete grid and over 304 downloads of user-defined areas. Since January 2009 there had been over 2,1044 downloads of the GEBCO 1 arc minute Grid and over 1,792 downloads of user-defined areas.

143. The GEBCO Digital Atlas (GDA) contains GEBCO's global grid files and bathymetric contour, coastline and track line control data sets. It is accompanied by a software interface for viewing and accessing the data sets and is distributed on DVD. Since 1 September 2009, 108 copies of the GDA had been distributed and £11,580 of royalties had accrued to GEBCO from the sale of the GDA (in calendar year 2009).

144. Since September 2009 user support had dealt with 142 enquiries relating to bathymetry and GEBCO's data sets. These include enquiries relating to the content of the grid and requests to use data (including GEBCO world map and GEBCO's grids) in products.

145. Pauline Weatherall concluded her report by describing development work. First, versions of GEBCO's grids were being developed that use the climate and forecast (CF) metadata conventions. The CF conventions have been designed to promote the processing and sharing of netCDF files. They define metadata that provide a description of what the data in each variable represents, and their spatial properties. CF conventions use a 'standard name' to define the data set variables. This is defined in the 'standard names' table: http://cf-pcmdi.llnl.gov/documents/cf-standard-names/. For GEBCO's gridded bathymetric data sets, it is intended to use the standard name: "sea_floor_depth_below_sea_level". The metadata is included in the netCDF file and so is 'carried' with the data. Second, a demonstration Web Map Service (WMS) is being developed for the GEBCO_08 Grid. A WMS is a means of making maps available over the internet. Users can access the service via the web and include the map in their own application. For example, 'GetCapabilities' requests information about the layers that the service returns and 'GetMap' requests an image using parameters defined by the user.

146. She ended by noting changes to the GEBCO web site which has been maintained and updated at BODC on behalf of GEBCO since July 2008. It now includes information about data set releases and 'news and events' items. A section has been added about iSCRUM and regional mapping (http://www.gebco.net/regional_mapping/). Since its re-launch in June 2008, over 346,000 pages have been viewed. Finally, she asked whether there was a need for more information on a 'General interest' pages.

147. In answer to questions Pauline Weatherall explained that each grid update has a version number that is tabled on the GEBCO web site and that the WMS (Web Map Service) would be available from there when it was released..

18. BATHYMETRIC EDITOR'S REPORT

148. Colin Jacobs presented the Bathymetric Editor's report (Annex 4). He began by stating that NOCS had re-prioritized his work so that he now had less time to devote to GEBCO matters. He said that he has been helping Pauline Weatherall with reviewing grids provided to GEBCO and producing maps for exhibitions and magazine articles.

149. Regarding data, he said he had been in contact with Verizon, a multinational company that owns and operates a large number of submarine cables around the world, with a view to obtaining the bathymetry collected along their cable routes. The situation was complicated because other companies were involved but he saw this as the beginning of a possibly very fruitful future collaboration. He said he had also dealt with a number of individual (and commercial) enquiries as to how to get hold of and use the GEBCO_08 grid.

150. He had also hoped that a NF student would work at NOCS during a lab visit in summer 2010 but the student had encountered visa problems. He regretted that, in spite of his efforts, he had been unable to make contact with any of the NF scholars since the Brest meeting. However, he was now more hopeful since the Indian Ocean Working Group had been set up.

19. REPORT ON THE IHO DATA CENTRE FOR DIGITAL BATHYMETRY

151. Lisa Taylor presented her report (Annex 5) as Director of the IHO Data Centre for Digital Bathymetry. NGDC, in its capacity as the World Data Center for Geophysics and Marine Geology (WDC-GMG), Boulder, promotes excellence in archiving, managing, and exchanging data

obtained from measurements of the seafloor. NGDC works with national and international groups on many projects besides the International Hydrographic Organization Data Center for Digital Bathymetry (IHO DCDB), GEBCO, and the Intergovernmental Oceanographic Commission (IOC) Regional Mapping Projects.

152. Since September 2009, NGDC has responded to 13 international requests for marine geology and geophysics data and 144 total sales requests from 7 countries, all of which are IHO Member States. Hard copy posters used by educators and bathymetric maps used by fisherman continue to be the bulk of products shipped by NGDC, as most of our digital data can be accessed online free of charge.

153. NGDC, in coordination with IHO, is updating and restructuring the IHO DCDB website to allow IHO member states easier access to hydrographic and bathymetric data through interactive graphical display and search capability. Given sufficient resources, the new site will also provide for the submission of data and metadata through a user-friendly custom on-line interface and editor.

154. Over the reporting period, NGDC received 1.9 terabytes of deep-water multibeam bathymetric data from 127 surveys. Significant contributions included surveys from Lamont-Doherty Earth Observatory (38), National Science Foundation Rolling Deck to Repository (11), the Geological Survey of Ireland (10), NOAA (32), the United States Naval Oceanographic Office (31), the United States Geological Survey (2), and the University of New Hampshire (3). The Multibeam Bathymetric Database now provides 4.9 terabytes of data from 1,589 cruises. NGDC offers online access to its multibeam bathymetric data holdings using an interactive mapping tool with query capabilities at http://map.ngdc.noaa.gov/website/mgg/multibeam/. NGDC archived and made publicly available 357 hydrographic surveys and 2,831 Bathymetric Attributed Grid (BAG) files. NGDC continues to archive digital sidescan sonar data. NOS hydrographic survey data is accessible to the public through an interactive map service maintained at http://map.ngdc.noaa.gov/website/mgg/nos_hydro/.

155. The DCDB has also worked with the World Data Center for Geophysics and Marine Geology on Tsunami Research and Training Activities. This includes building high-resolution digital elevation models of U.S. coastal zones, creating an online catalogue of historic and prehistoric tsunami events, cooperating with Canada to create a new bathymetry of the Great Lakes and to develop tsunami propagation and inundation models.

156. Finally Lisa Taylor reported on NGDC Activities in Support of IOC/GEBCO. Following a request from TSCOM, NGDC is participating in a test of various gridding algorithms for compiling sparse and heterogeneous bathymetric data. Related Activities Supporting IOC/GEBCO Programs and Projects include hosting web pages for IOC's international bathymetric chart series and maintaining GEBCO list servers. The IHO is populating a new geospatially enabled Oracle database of the GEBCO Gazetteer of Undersea Feature Names developed by NGDC in collaboration with the British Oceanographic Data Center (BODC). The user interface provides the SCUFN Secretary secure remote access to the database with full administrative privileges and the public with read-only search and retrieval access.

20. PLANS FOR US INTEGRATED MAPPING

157. Chris Fox outlined plans in the USA to achieve greater integration of ocean mapping. He described some 15 likely or possible ECS (extended continental shelf) regions offshore the USA where the government is considering collecting and analyzing data.

158. He listed bathymetry from a number of areas collected by CCOM most of which has already been passed to Pauline Weatherall. The areas include North Alaska, Gulf of Alaska, Bering sea, Marianas, Kingman Reef/Palmyra Atoll, Mendocino Ridge, the US East Coast, Gulf of Mexico,

south of the Aleutians, Johnston Atoll, Necker Ridge and the coasts of the northwest and California.

159. He added that Barry Eakins had also created a 24 arcsec coastal relief model of southern Alaska built from a variety of datasets acquired from the NGDC, NOC, USGS, NASA and other US and international agencies. When it was passed to GEBCO this model might be a good test of the new scheme to review donated data sets.

160. Chris Fox next described the proposed Rolling Deck to Repository (R2R) scheme to be applied to bathymetry collected by US universities. R2R proposes an evolution in data management for US academic research vessels by providing a "direct pipeline" for routine underway cruise data and documentation from operating institutions to a central repository. It was envisaged after it had been mandated that all bathymetry collected with NSF support had to be passed to LDEO. After the bathymetry has been checked at LDEO metadata is added. The earlier scheme worked so well that US universities devised a 'pipeline' (the R2R scheme) whereby data are passed directly to a data assembly centre (LDEO for bathymetry) or a national data centre (NGDC for bathymetry). The goal is to migrate all routine "underway" data to long-term repositories, create a catalogue of cruises and standard products and to assess data quality and provide timely feedback to operators. He described how 22 ships now operate in this way and have contributed data from over 1400 cruises. The catalogue and data can be downloaded from http://www.rvdata.us/catalog.

161. On the US government side a scheme is planned called IOCM, with the by-line 'Map once, use many times', which aims to give easy access and use to the greatest range of users as required by the Ocean and Coastal Mapping Integration Act. This is a new initiative to ensure that NOAA's shipboard mapping investment is protected by capturing, archiving and providing access to data already being collected and "lost". A kick-off meeting was held in July 2010 with representatives from UNH, LDEO, Shipboard Automated Meteorological and Oceanographic System, National Ocean Service, NGDC, NODC, National Coastal Data Development Center, Ocean Explorer, National Marine Fisheries Service, Office of National Marine Sanctuaries, Office of Marine and Aviation Operations, Integrated Ocean Observing System, Office of Oceanic & Atmospheric Research, NOAA's Environmental Data Management Committee and others. A Working Group was formed to develop an engagement plan and track action items. Eventually NOAA plans to base its IOCM processing centre at CCOM, UNH.

162. Chris Fox concluded by saying that the above arrangements should give GEBCO almost immediate access to US bathymetry. In answer to a question he explained that data acquired by US universities was copied to both the PI and the processing centre and that data acquired by a US government agency was immediately available. He added that LDEO perform QA on bathymetry and generally creates 100m grids but NGDC only deals in soundings.

21. UPDATING IHO DOCUMENT B-7

163. Steve Shipman began by recalling that in 2009 the Guiding Committee had requested that the IOC/IHO GEBCO guidelines document, IHB Bathymetric Publication No. B-7, should be withdrawn from the GEBCO web site. This had been done and now only paper copies were available. B-7 was last revised in 2003 since when the Terms of Reference and Rules of Procedure of GEBCO Committees have changed. The focus of B-7 is very much on 5th Edition printed sheets; the GDA and the use of multibeam systems are introduced but are not the main focus. In short B-7 has been overtaken by events.

164. Steve Shipman said that he thought B-7 needed to be revised to set out what GEBCO is, how it operates, who does what and when, how data are ingested, how and by whom it is handled and what products are produced. He described the existing structure of B-7 and proposed a new structure with four parts plus annexes. He then outlined the decisions that he thought needed to be

made. Finally he described the work involved and how it should be shared between the Guiding Committee, the IHB, the DCDB, IOC and TSCOM/iSCRUM.

165. Steve Shipman said he was happy to coordinate the updating of B-7 but he would need technical input from various parts of GEBCO. Walter Smith said that he would seek volunteers to help with technical aspects. However no clear consensus on the way forward was reached (but see Section 14 in Guiding Committee Minutes)

22. GRIDDING COOKBOOK WORKING GROUP

166. Karen Marks noted that the Working Group had been formed in 2009 and had worked via email discussions and by conducting gridding tests since that time. The basic steps involved in gridding are to be released as version 1.0 in a few months time. The aim is to provide free, simple, step-by-step instructions. The cookbook will contain detailed Appendices which include GMT code and other software.

167. She said she had already written a NOAA Technical Memorandum on multibeam data describing how to download raw data, the use of bathymetric models, the use of GMT software and how to grid and test a dataset. The Working Group had decided to include this document in the cookbook. The cookbook will also show examples of tests that have been run and how to estimate uncertainty and handle metadata and data cleaning. She noted that the cookbook will give more sophisticated ways of comparing gridded data than just using the sum of the depth differences at a point.

168. She concluded that the Working Group envisaged the cookbook as a living document which would be loaded onto the GEBCO web site and could grow and change there..

169. In answer to a question she said that eventually the cookbook steps could be followed by someone without access to GMT.

23. COMPARISON OF GRIDDING TECHNIQUES

170. Martin Jakobsson described some work conducted by himself and Benjamin Hell. They had used data from a test area south of Cape Cod (36°-43° N, 64°-73° W). They had created a grid with sparse single beam soundings and another grid using multibeam data. He briefly described the interpolation and gridding methods used. They included splines in tension, a spline pyramid and kriging.

171. The following steps were followed,

i. input the single beam soundings and create a 1000 m grid

ii. create multiple grids with grid spacings from 64 km to hundreds of metres. Sum the results with the best possible gridded value for each point

iii. finally, employ kriging to remove artefacts in the gridded bathymetry.

172. Dr Jakobsson said he preferred to use the spline pyramid over the other methods.

173. In answer to a question about comparing input and output data Martin Jakobsson replied that there would be a high computational cost involved in pyramid gridding. Walter Smith confirmed that a GMT script exists to make the comparison. Chris Fox noted that the same interpolation method was used at each scale and said that other methods were available. Martin Jakobsson replied that they had wanted to keep the test simple and to have a low computational cost compared to running

oceanographic models. Even so, some memory problems occur which have to be overcome by dividing the data into blocks. Finally Walter Smith noted that when using the pyramid spline it was faster to work on depth differences.

24. POSTER PRESENTATIONS (the full images of these and other 5th Science Day posters can be viewed on the GEBCO web site)

174. **24.1 'Comparison of publicly available global bathymetry grids'** Anastasia Abramova presented her poster on 'Comparison of publicly available global bathymetry grids'. The goal of the study was to provide several methods to facilitate the choice of a bathymetric grid for a given purpose. Several recently released publicly available global bathymetric datasets were compared in terms of their data sources, internal consistency, coherency with each other and their accuracy. The six analyzed grids were GEBCO 1 minute grid, GEBCO 30 arcsec gird, Predicted Topography v. 12, ETOPO 1, SRTM30 PLUS and the regional grid IBCAO ver. 2.23. For validation purposes, the gridded datasets were compared with more accurate multibeam data. The Norwegian-Greenland and Barents Seas were chosen for the study. The grids were compared visually and quantitatively. In some grids the predicted bathymetry contained seamounts that were not seen in the GEBCO bathymetry. In other cases the shape of the continental margin was different. She had found some artefacts possibly caused by a problem with the SID file. She demonstrated how histograms of depths revealed the presence of digitised contour in the source data. She also tested the consistency of each data set with regard to the shape of the Svalbard coastline. The work is ongoing.

175. **24.2 'Spline interpolation for sparse data'** Chris Amante explained that this study was related to modelling tsunami inundations. He had experimented with a dense multibeam dataset from off New England. He sub-sampled the depths and then applied GMT and multibeam software, set with varying tensions, to create grids. He found that sometimes spurious oscillations appeared in the gridded depths. This was not a problem over a seamount but, over a submarine canyon, using a higher tension gave a more satisfactory result. In general, surfaces created with GMT software were less sensitive to the tension used.

176. **24.3 'New soundings for SRTM30_Plus v7.0'** Megan Jones said that the SRTM30_Plus v7.0 grid provides the best publicly available bathymetry. Over the past four years tools and methods for editing raw soundings from many sources have been developed at SIO at 500 m resolution. Editing consists of four steps that are applied iteratively until the grid is 'blunder free and visually appealing'. The steps create an SID and remove individual bad points and other outliers. Initially a 1 arcmin grid is generated and finally a 30 arcsec grid. Raw data are converted to a common format. A Seamount Discovery tool has also been developed to help mariners find seamounts and design surveys from information based on satellite altimetry and existing ship tracks.

177. **24.4 'Interpolating across gaps in bathymetric surveys: the value of altimetry'** Karen Marks described how she used single-beam bathymetry to study interpolation schemes at a site at 18°N, 152°E. The resulting interpolated bathymetry was compared with a swath survey and satellite derived depths. A starting point was to calculate and plot the gaps between tracks. She obtained very different results from different gridding routines and the problem is how to quantify the differences. One approach was to compute 'errors', the difference between two sets of depths, and plot them against distance from the nearest ship control point. She established that satellite altimetric depths were better than interpolations based only on ship data.

178. In discussion and in answer to questions about how a new satellite altimetry grid is added to the GEBCO grid and how often such a satellite grid is produced Lisa Taylor said that the fundamental question to address was whether updates of the satellite bathymetry base layer should be considered at all. Chris Fox responded that GEBCO needed to consider the work involved and the flow of data because it was not practical to re-set the GEBCO grid every time the satellite altimetry grid is

updated. Martin Jakobsson thought that there needs to be a review process each time a new base layer is generated; this is what happens in the IBCAO. Walter Smith questioned whether the latest satellite products from SIO were as 'good' as previously. Lisa Taylor replied that GEBCO needed to use LDEO's methodology when creating updates without starting from scratch. Walter Smith concluded that GEBCO should assume that there will be a new altimetric grid eventually based on his work with Karen Marks and others but GEBCO shouldn't wait for that to happen. Martin Jakobsson said that the main improvements were needed where satellite altimetry doesn't work very well such as along coasts, over ice etc. He thought this wasn't a 'big deal' and urged flexibility and pragmatism. Walter Smith agreed.

25. A CONUNDRUM OFF BRAZIL

179. Hans-Werner Schenke described a conundrum that SCUFN had encountered and sought people's advice. SCUFN had received a proposal from Brazil to name a feature at the foot of their continental slope. There was a lot of bathymetric data in support of the proposal, both single-beam and multibeam, some of it from NGDC. The problem is that the plateau to be named, which is 350 x 150 km in size, does not appear in the GEBCO Digital Atlas.

180. Chris Fox suggested that it would be useful to study profiles across the area. Walter Smith suggested that the tracks used in the GDA, and their associated metadata, should be checked. He wondered whether there had been a navigational problem with the GDA data. He advised that satellite altimetry data would probably not be helpful in that particular area.

26. WORKSHOP ON GIS

181. Dave Monahan introduced work that had been done at UNH with students and alumni. He began by stressing that marine GIS differs from land GIS because the marine situation is multidimensional in that it is more dynamic i.e. changes with time. Marine boundaries are often 'fuzzy' so there is a need for spatial data structures that allow for the fact that the relative positions of features change over time. Another difference is that marine data are often collected along profiles, and not over two horizontal dimensions as over land. Consequently marine data often have gaps in them. He concluded by asking whether GEBCO should produce maps of different parameters or just the bathymetric layer for others to use.

182. James Daniell described the MARGO project (MARine Gis for the Oceania region) carried out by six Year 6 students and two scholars. The objective had been to produce charts of a limited area with not only bathymetry. An area in mid-ocean was chosen; 10°N – 35°S, 150°W - 150°E. Each student looked at one non-bathymetric field. They concentrated on data that was easy to obtain and obtained data from 14 databases in addition to bathymetry. Many sources were involved. There were a number of options regarding data formats. Either the format provided by the data supplier could be adopted, or Google Earth and ArcGIS formats could be adopted. The latter solution was preferred. The original aim had been to provide data in raster, KML and/or shape file formats. It was also realised that there was a need to provide adequate metadata.

183. The conclusions from the project were as follows. The project was too vast to finish in a single semester, although it was now approximately three-quarters completed, and Year 7 students may need to continue with it. Although NGDC held much of the data a lot of data were also available from other sources. KML files for many datasets can be exported from Geo MapApp. Potentially there are even more datasets than the fourteen chosen. In some cases, as with Ifremer's multibeam data, individual government organisations would need to be approached for permission.

184. Looking ahead, eventually there will be a problem of maintaining the GIS; who would do it and with which software and hardware? Another problem is that of duplication; other organisations are

already creating some of the layers considered here. So the final question is what can GEBCO add or contribute to such a GIS?

185. Lisa Taylor commented that GEBCO should aim to provide the best possible bathymetric layer; it should not take the focus off bathymetry. Pauline Weatherall agreed and said that it would be easy to create a link to the GIS from the GEBCO web site.

186. In reply to questions, Dave Monahan said that he saw the objective of this student exercise to be both educational and to come up with a useful product. Colin Jacobs commented that the GIS was potentially a great tool but the cost of the software licence would be high. He suggested that Google Earth should be the means of delivery. Even so it would be hard to keep the GIS up to date and he didn't think it would be a good investment on GEBCO's part. Martin Jakobsson added that although GIS is a great tool to bring databases together it needs investment of time and resources. **The general conclusion was that this was an excellent training project which had benefited the students involved.** Robin Falconer ended by thanking the students for their efforts.

27. DATES AND PLACES OF FUTURE TECHNICAL MEETINGS

187. There was widespread agreement that it was better for the Guiding Committee, TSCOM and iSCRUM to meet together and that overlapping in time with SCUFN was unsatisfactory.

188. Hans-Werner Schenke stated that SCUFN might meet separately from the rest of GEBCO in 2011 because it needed five working days. He expected an invitation for the next meeting in August or early September.

189. Walter Smith suggested reviving the earlier model of SCDB meeting in week 1 and the Guiding Committee meeting in week 2 in the same country, but not necessarily in the same venue. For example, the technical meeting could be in a university and the Guiding Committee could meet in a naval establishment. Etienne Cailliau wondered how the Science Day would fit such a plan. Hugo Gorziglia added that GEBCO was always welcome to meet at the IHB in Monaco.

190. A discussion on which month was optimal was inconclusive and it was left to the incoming Secretary of GEBCO to poll participants after the meeting. April and May were favoured by some, July-October was unpopular with several and no opinions were offered about June or November.

ANNEX 1

Detailed Agenda

for the GEBCO technical discussions in Lima and Callao, Peru,

13-17 September, 2010[1]

(excepting the Sub-Committee on Undersea Feature Names (SCUFN) which met in parallel on Monday 13th and Tuesday 14th and the Guiding Committee which met on Saturday 18th September)

Monday 13 September: Nippon Foundation/GEBCO Scholars, Outreach and Metadata

09.00: Welcome by Rear Admiral Javier Gaviola

09.10: Introductions, program for the week (Robin Falconer)

0920: Ten minute presentations by Nippon Foundation/GEBCO scholars

10.00-10.30 Refreshment Break

10.30: Ten minute presentations by Nippon Foundation/GEBCO scholars - continued

11.20: Education/Outreach (Paolo Luciano, Paola Travaglini)

The Jason project (Walter Smith)

12.00-13.30 Lunch

13.30: Meta data and data exchange (Tony Pharaoh)

14.40: The GEBCO Globe project (Bob Anderson)

15.00-15.30: Refreshment Break

15.30 World maps and paper maps (Jakobsson)

15.45: Nippon-GEBCO projects Masters and PhD programs (Falconer, Jakobsson)

16.00: Poster session

17.00: End of session

Tuesday 14 September: iSCRUM and TSCOM

Introduction to iSCRUM

09:00: Martin Jakobsson: the idea behind iSCRUM

[1] All meetings were held at the Centro Naval del Peru (Navy Club), Av. San Luis Cuadra 24, San Borja, Lima except for the Science Day on Wednesday 15 September which was held in Callao, a suburb of Lima.

Introduction to TSCOM

09:10: Walter Smith: TSCOM's current activities and preoccupations

IOC

09:20: ????: IOC mapping initiatives

IBC reports

09.30: International Bathymetric Chart of the East Pacific (IBCEP) (Hugo Montoro)

09.45: International Bathymetric Chart of the Southern Ocean (IBCSO)

10:00: International Bathymetric Chart of the Arctic Ocean (IBCAO) (Martin Jakobsson)

10:15: International Bathymetric Chart of the Mediterranean (IBCM) (John Hall)

10.30-11.00 Refreshment Break

11:00: Mapping the West Pacific Ocean

11:15: Additional reports from IBC activities

11.30: A test of a model for GEBCO's editorial function: The review and incorporation of a new bathymetric grid of the Black Sea, Weddell Sea and Caspian Sea (Pauline Weatherall)

12.00-13.30 Lunch

13.30: Algorithms for filling the gaps in the unsurveyed areas (Walter Smith)

14.00: Round table discussion for afternoon Chaired by Robin Falconer

- GEBCO's review process
- integration of the International Bathymetric Commissions

  Example: An initiative for a new Baltic Sea Bathymetric grid through the Baltic Sea Hydrographic Commission
- GEBCO regional mapping projects: How to initiate? What is required? Technical support required? Databases? Focused on shelf areas or also deep ocean?

15.00-15.30: Refreshment Break

15.30: Discussion continued

- New data sources: Olex, more? How do we integrate data that is not within a specific mapping project (i.e. what is the status of GEBCO's own tools for gridding etc)

16.00: Summary, action items and assignments

16.40: Sea-bed Authority talk (????)

17.00: End of session

Wednesday 15 September: (Science Day at DHN, Callao)

Note *The Science Day took place at the Directorate of Hydrography and Navigation, also known as Dirección de Hidrografía y Navegación*, *Jr. Roca 2da. Cuadra con Av. Gamarra - Chucuito*, *Callao*

Science talks and posters: Convenor Walter Smith (Walter.HF.Smith@noaa.gov)

Posters (may also be displayed at Navy Club)

Additional posters and papers are welcomed. Please submit titles to the convenor as soon as possible.

Tours of DHN Facilities To be scheduled during the day

Thursday 16 September: iSCRUM and TSCOM

09.00: Antarctic and Arctic Mapping Activities: Reports

09.00: Vaughan Stagpoole: New Zealand Antarctic mapping activities

09.15: Bruce Goleby: Australian Antarctic mapping activities

09.30: Hans-Werner Schenke: AWI Antarctic mapping activities

09.45: Martin Jakobsson: Mapping West Antarctic waters with Swedish icebreaker Oden

10.00: Anthony Pharaoh: Hydrographic Commission on Antarctica (HCA) activities

10.30-11.00 Refreshment Break

11:00: George Newton: Arctic submarine data

11.20: ***Mid latitude Mapping Activities: Reports*** (Goleby, Stagpoole)

11.40: ***Low latitude Mapping Activities: Reports***

12.00: Antarctic and Arctic Mapping Activities: Chaired by Martin Jakobsson

12.30-13.30 Lunch

Afternoon Workshop sessions

13.30: South East Pacific Region project: Chaired by Colin Jacobs

14.30: Nippon Foundation/GEBCO Projects : regional mapping

15.00: GOOGLE: an update on Google Ocean and further discussion of Google-GEBCO relationship (Jenifer Foulkes)

16.00: End of session

Friday 17 September: iSCRUM and TSCOM

09.00: Report from Digital Atlas Manager (Pauline Weatherall)

09.20: Report from Bathymetric Editor (Colin Jacobs)

09.40: Report from IHO Data Center for Digital Bathymetry (Lisa Taylor)

10.00: Future plans for the GEBCO-08 grid (Walter Smith)

10.15: Plans for US integrated mapping (Chris Fox)

10.30-11.00 Refreshment Break

11.00: Gridding Cook book (Martin Jakobsson/Benjamin Hell, Anstasia Abramova, Barry Eakins) Reports from the gridding exercises, followed by a discussion.

12.00-13.00 Lunch

13.00: Gridding Cook book (continued)

14.00: GIS workshop (Dave Monahan, Martin Jakobsson, Benjamin Hell, Shereen Sharma, James Daniell)

15.00-15.30: Refreshment Break

15.30: Nippon Foundation/GEBCO Projects: International workshop of users and providers (Monahan/Falconer)

16.00: Discussion on future structuring of GEBCO's technical activities (Chaired by Robin Falconer)

16 .40 Dates and Locations of future sessions (Falconer)

17.00: End of session

ANNEX 2

The Ocean, Mapped and Unmapped

Walter Smith

I would like the world to have a tool that would let anyone see at a glance what parts of the ocean are mapped and unmapped.

The unmapped areas would be populated with estimates of depth and uncertainty, interpolated from the measurements in the mapped areas using the best methods available.

The mapped areas would include estimates of depth and uncertainty. They would also include metadata, including attribution and recognition of the source(s) that contributed the measurements, and whatever it takes to facilitate finding and retrieving quality controlled data and metadata. Contributors could be credited in some way that could be displayed in the visualization tool.

The unmapped area might be populated with estimates on a grid of a fixed size, whatever is appropriate. (If altimetry is used as an interpolation tool or guide, this leads naturally to a fixed range of scales for the unmapped area.)

The mapped area would be scale independent. One could "zoom" or "drill down" as much as could be supported.

Of critical importance, in my view, is that the supporting data be public and freely available. That is, a "mapped" area is "mapped" if the data are made freely and publicly available. In many areas, states, institutions or agencies might hold the highest resolution data and might not share it, but if they would make available lower resolution versions of these data, these would be shown in the "mapped" areas.

The tool would allow not simply visualization of the data, but also extraction and download of the data. In this way, those who wish to build interpolations in the unmapped areas, or want to build maps combining their own data with the public data, will be able to build their products to be seamless with the mapped areas. Some appropriate metadata will allow automatic discovery of updates. Thus the interpolators and new mappers can keep up with public additions to the mapped area data.

1, Does GEBCO share this vision and want to make this happen?

I think that letting the world see how much of the ocean is not explored is the most important thing we could do for outreach and education.

I think letting the world see what is mapped, and which agencies and institutions are contributing to public knowledge, would give credit where it is due and stimulate new explorations and new contributions of data and expertise, to the public good.

I think building this as a GEBCO product is the best way to preserve our reputation for authoritative and publicly available data.

2. What would it take to make this happen?

How hard is this? What can we do? What are the first steps? Perhaps much of what we want is already done, but it doesn't all seem to be in one place – could GEBCO build the "one stop shop"?

3. On the visualization and output side, is Google Earth the way to go, or the GEBCO Digital Atlas, or do we need something else, or all of these?

Google Earth reaches an enormous number of people, and may be the best way to do the public outreach and education. But can Google serve numbers (depths, uncertainties, other information) or is it just for visualization? Where does the GDA fit in?

4. What do we need to do on the data input and data management side? Is our metadata discussion going to facilitate the needed data discovery and data exchange? Can we provide the information we want to show and display about what is mapped, and who should be credited with mapping it?

5. Suppose that someone wants to interpolate the unmapped areas, building a global grid at 30-arc-seconds, and wants to constrain it to fit the mapped areas. Can this system supply a depth and an uncertainty in 30-arc-second boxes that somehow aggregate together all the higher resolution depths and uncertainties in the mapped areas? Such a supplied data set might be an input to an interpolation exercise.

6. What happens in the case of multiple versions or multiple sources? How do we deal with conflicts or discrepancies?

7. What standards do we set to indicate what contributions are acceptable?

8. How does the SCUFN experience apply to building the product described here?

SCUFN has clear standards and protocols for how things can be named, what supporting data are required, what has to be shared, etc., and a well-defined process for managing work flow and updating products. (Or so it seems from where I sit.)

There are technical questions in the above for the TSCOM and its WGs on Metadata and perhaps other WGs. There are questions for Google. There are policy questions for the GC. There are Education/Outreach issues. There is potential interface with SCUFN.

ANNEX 3

Report of the GEBCO Digital Atlas Manager (September 2009 – August 2010)

This report covers the work carried out at the British Oceanographic Data Centre (BODC) for GEBCO since the previous GEBCO meetings in September 2009.

In addition, Annex I includes statistics on the distribution of GEBCO's data sets. Annex II includes information on access to GEBCO's web site.

GEBCO's gridded bathymetric data sets

Release of an updated version of the GEBCO_08 Grid

An updated version of the GEBCO_08 Grid was released in November 2009. This release, version 20091120, includes version 2.23 of the International Bathymetric Chart of the Arctic Ocean (IBCAO). The IBCAO data set, at 30 arc-second intervals, was supplied to GEBCO, on behalf of the IBCAO, by Prof. Martin Jakobsson.

The data set was included in the GEBCO_08 Grid, north of 64°N. The work to merge the data sets at 64°N was done using a feather-blending software routine from Global Mapper.

Release of the GEBCO_08 Source Identifier (SID) Grid

The GEBCO_08 Grid is accompanied by a Source Identifier (SID) Grid. This identifies which cells in the GEBCO_08 Grid are based on soundings or data values from existing grids, i.e. 'controlled' and which have been interpolated.

Currently, the SID grid is largely in the form of a 'yes/no' grid, i.e. grid cells are identified as 'controlled' or 'interpolated'. It is aimed to provide metadata to accompany the data set that will identify and provide information on individual data sources.

The SID grid was released in November 2009, is available to download from the Internet and is included as part of the GEBCO Digital Atlas DVD.

Updating the GEBCO_08 Grid

The following details the update work currently in progress.

Black Sea and Caspian Sea areas

Gridded bathymetric data sets for the Black Sea and Caspian Sea have been supplied to GEBCO by Dr. John Hall for updating the GEBCO_08 Grid. The grids are largely based on soundings digitised from Russian hydrographic charts.

The Black Sea region grid covers the area 25° 56'E – 41° 46'E; 39° 55'N – 47° 17'N and was supplied at a resolution of 15 arc-second intervals. It is based on over 196,400 bathymetric soundings.

The Caspian Sea grid covers the area 46° 32'E – 54° 34'E; 36° 31'N – 47°N was supplied at three arc-second intervals. It is based on over 280,700 bathymetric soundings and points digitised from bathymetric contours.

Quality control checks were carried out on the data sets and the data were sampled to 30 arc-seconds using Generic Mapping Tools (GMT) software.

The data sets were then incorporated into the GEBCO_08 Grid. This was achieved by firstly extracting grid points (largely land elevation) from the GEBCO_08 Grid that fall outside the geographic coverage of the Black Sea and Caspian Sea grids. The GMT routine 'surface', a minimum tension gridding algorithm, was then used to combine the Caspian and Black Sea grid data points with the extracted GEBCO_08 Grid for these regions.

A Source Identifier Grid was produced for each updated area. The SID file in these areas identifies which grid cells contain sounding(s) from the source data set used to generate the grids.

It is planned that these data sets will be included in the next release of the GEBCO_08 Grid.

Further information about these data sets can be found in: Bathymetric compilations of the seas around Israel I: The Caspian and Black Seas, J.K. Hall, Geological Survey of Israel, Current Research, Vol. 13, December 2002.

Weddell Sea

A gridded data set for the Weddell Sea region was supplied to GEBCO by the Alfred Wegener Institute for Polar and Marine Research (AWI) in July 2009.

The data set covers the region 60°S to 66°S; 75°W to 15°W, 66°S to 78° 20'S; 65°W to 2°E. The grid is based on the bathymetric contours from the Bathymetric Chart of the Weddell Sea (BCWS). This data set consists of contours at bathymetric contour lines, generally at interval of 100 m, but at 50 m in the southern Weddell Sea.

The data was incorporated into the GEBCO_08 Grid using a feather-blending routine, part of the Global Mapper v11.01 software package.

A Source Identifier Grid was produced for the updated area. The SID file in this area identifies which grid cells are 'crossed' by the trackline control (ship tracks and isolated soundings) from the source data set used to generate the contours on which the grid is based.

It is planned that the data set will be included in the next release of the GEBCO_08 Grid.

Further information about the BCWS data set can be found at: www.awi.de/en/research/research_divisions/geosciences/marine_geology_and_paleontology/research_themes/bathymetry_and_geodesy/bathymetric_chart_of_the_weddell_sea/

Waters around Australia

Geoscience Australia's gridded data set: 'Australian bathymetry and topography grid, June 2009' has been supplied to GEBCO by Mr. Bruce Goleby. The data set covers the area 92°E-117°E; 8°S-60°S.

Work has been done on comparing the data set with the existing GEBCO_08 Grid and looking at the possibility of including data from the grid, based on fair sheets, Lidar and multi-beam surveys into the GEBCO_08 Grid.

Bathymetric data sets received for updating GEBCO's data sets

The following lists the data sets supplied to GEBCO for updating its data sets and products and their status with regard to inclusion in the GEBCO_08 Grid.

Data set	Data set supplier/originator	Date supplied	Status
Shallow water bathymetric soundings extracted from Electronic Navigation Charts (ENCs) for the area around Chile and areas for which they have responsibility off the Antarctic Peninsula. Area coverage 77.786°W-67.05°W; 17.94°S-54.5°S and 61.694°W-57.651°W; 62.67°S-64.073°S. There are data from 55 charts with a total of 111,906 sounding points.	Servicio Hidrográfico y Oceanográfico de la Armada, Chile	June 2010	Yet to be included
Australian bathymetry and topography grid, June 2009. The grid is at 0.0025 decimal degree intervals and covers the area 92°E-117°E; 8°S-60°S.	Supplied by Mr. Bruce Goleby on behalf of Geoscience Australia	April 2010	Investigating the inclusion of the data set
Gridded bathymetry data for the Black Sea region. The data set covers the area: 25.9491°E-41.7801°E; 39.9325°N-47.2876°N.	John Hall, Geological Survey of Israel (retired)	February 2010	Included (to be released)
Gridded bathymetry data for the Caspian Sea region. The data cover the area: 46.545°E-54.5683°E; 36.5125°N-47.0387°N.	John Hall, Geological Survey of Israel (retired)	February 2010	Included (to be released)
Gridded bathymetry data, at 30 arc-	John Hall, Geological	February	Yet to be

second intervals, for Lake Baikal. The data cover the area 103.701°E-109.967°E; 51.448°N-55.7812°N.	Survey of Israel (retired)	2010	included
Measured bathymetric depths from multi-beam surveys in the South Atlantic for the region around the Vitoria-Trinadade Ridge, 37°W-31°W; 21.6°S-20°S. The data set consists of xyz files of survey points, imagery of the track distribution and along track profiles in the form of spreadsheets.	Nataliya Turko, Geological Institute, Russian Academy of Sciences	November 2009	Yet to be included
Bathymetry survey data for the Arctic Ocean region. The data were collected by the US Navy under ice surveys between 1993 and 2000.	Supplied by Mr. George Newton	September 2009	Yet to be included
Bathymetric grid at 30 arc-second intervals for the Weddell Sea region	Alfred Wegener Institute (AWI), Germany	July 2009	Included (to be released)
30 arc-second interval version of the bathymetric grid for the International Bathymetric Chart of the Arctic Ocean (IBCAO) version 2.23.	Martin Jakobsson (on behalf of IBCAO)	July 2009	Included in GEBCO_08 Grid north of 64ºN (version 20091120)
Gridded bathymetry data for Irish designated waters in the North Atlantic Ocean (within a polygon defined by 25°W-6°W; 46° 50'N - 57° 30'N). The grid is at 0.002 degree spacing and was generated from a number of multi-beam surveys carried out between 2000 and 2007.	Data passed to BODC, for use by GEBCO, by Colin Jacobs on behalf of the Geological Survey of Ireland.	2009	Included in GEBCO_08 Grid (version 20081212)
Bathymetry data from the Olex system - collected by a number of fishing vessels using the ship's echo-sounder. The data set is mainly in shallower water areas and mainly in Northwest European Continental Shelf regions but there are data for other areas worldwide. The data set consists of an ASCII file of latitude, longitude and depth values. The data points represents the depth value of a 450m square tile located at that point. Data for shallow water regions of the NW European Continental Shelf have been included in the	Data passed to BODC, for use by GEBCO, by Colin Jacobs on behalf of Olex AS, Norway.	2009	Part of the data set has been included in the GEBCO_08 Grid (version 20081212). Data passed for use in IBCAO.

GEBCO_08 Grid.			
Shallow water bathymetry data, in the form of bathymetric contours, sounding points, coastline and quality of data information, for the South China Sea region (102°E-122°E; 5°S-25.5°N). The data have been extracted from Electronic Navigation Charts (ENCs).	Data passed to BODC by Tony Pharaoh (IHB) on behalf of the East Asia Hydrographic Commission.	2009	To be included
Ship track bathymetry data - South Atlantic Ocean off Brazil	Cmdr. Izabel King Jeck (Centre of Hydrography, Brazilian Navy).	2009	To be included
A collection of bathymetric data sets covering a range of geographic areas – discovered through searching the Internet	Tony Pharaoh, IHB	2009	To be included
One arc-minute interval grid of version 2.23 of the International Bathymetric Chart of the Arctic Ocean (IBCAO).	Martin Jakobsson (on behalf of IBCAO)	2008	Included in GEBCO One Minute Grid (version 2).
Bathymetric grids for coastal waters off Canada (between approximately 140°W-50°W). The data are from cruises of the Canadian Coast Guard ship (CCGS) Amundsen and other platforms The data set consists of 2,248 files. Each file covering 15' of latitude and 30' of longitude. The data are gridded at a resolution of 10 metres. The grid files are supplied as IEEE floating-point format 32-bit signed binary files.	Jonathan Beaudoin of the University of New Brunswick. Thanks to Ms Paola Travaglini for facilitating the release of the data set.	2008	To be included in GEBCO_08 Grid (data passed to IBCAO project)
Bathymetry data for the Pacific-Cocos Nazca Triple Junction area of the Pacific Ocean, in the region enclosed by a box of approximate geographic co-ordinates: 125°W-115°W; 5°S - 3°N. The data set consists of a grid and transit leg data .The bathymetry data are from the cruise SO180 with SONNE from Tahiti to Valparaiso, Chile. The data have been processed and gridded to a 100m x 100m grid.	The data are made available by the IFM-GEOMAR Leibniz-Institut fur Meereswissenschaften an der Universitat Kiel, Germany. Thanks to Dr. John Hall for providing the link for access to this data set.	2008	To be included

Making GEBCO's data sets available

GEBCO's bathymetric data sets are made available by BODC via the Internet and on DVD.

Internet access

The web application for delivering GEBCO's gridded data has been updated, by Dr. Ray Cramer at BODC to include delivery of Source Identifier (SID) Grid. The revised application was launched in November 2009.

The application can be accessed from:

http://www.gebco.net/data_and_products/gridded_bathymetry_data/
https://www.bodc.ac.uk/data/online_delivery/gebco/

Statistics detailing access to GEBCO's gridded data sets from the Internet can be found in Annex I of this report.

GEBCO Digital Atlas (GDA)

The GEBCO Digital Atlas is a collection of GEBCO's digital bathymetric data sets. The data sets can be viewed and accessed through a software interface. It is distributed on DVD.

The GDA was updated in December 2009 to include the GEBCO_08 Source Identifier grid and the latest release of the GEBCO_08 Grid.

Since its release in 2003, 1,527 copies of the GDA have been distributed.

Royalties contributed to GEBCO from the sale of the GDA for 2009 amounted to £11,580. This makes a total of £68,732 since the release of the GDA in 2003.

Further statistics about the distribution of the GDA can be found in Annex I of this report.

Data set user support

We have dealt with 142 email enquiries concerning GEBCO's data sets and products since September 2009. A number of these enquiries include requests for use of GEBCO's data sets in commercial products or to reproduce imagery from the GEBCO world map.

Further information concerning some of these requests can be found in Annex I.

Data delivery development work: CF compliant netCDF and web services

Developing versions of GEBCO's grids that use the climate and forecast (CF) metadata conventions

As reported previously, work has been done on developing a version of the GEBCO_08 grid that uses the conventions for climate and forecast (CF) metadata (http://cf-pcmdi.llnl.gov/). This work has been extended to include all GEBCO's gridded data sets.

The CF conventions have been designed to promote the processing and sharing of netCDF files. They define metadata that provide a description of what the data in each variable represents, and their spatial properties.

These conventions have been adopted by a number of projects and groups and are designed to be backward compatible with the Cooperative Ocean/Atmosphere Research Data Service (COARDS) conventions.

One of the requirements of the CF conventions is to use a 'standard name' to define the data set variables. A list of standard names is provided.

http://cf-pcmdi.llnl.gov/documents/cf-standard-names/

For GEBCO's gridded bathymetric data sets, it is intended to use the standard name: "sea_floor_depth_below_sea_level".

It is planned that GEBCO's grids, in cf-netCDF format, will shortly be available from GEBCO's web site.

The following is an example of an ASCII listing of the metadata information supplied within the cf-netCDF grid file.

```
netcdf gebco_cf_08_ex {
dimensions:
      lat = 21600 ;
      lon = 43200 ;
variables:
      short depth(lat, lon) ;
            depth:standard_name = "sea_floor_depth_below_sea_level" ;
            depth:long_name = "Elevation relative to sea level" ;
            depth:units = "m" ;
            depth:scale_factor = 1. ;
            depth:add_offset = 0. ;
            depth:positive = "up" ;
            depth:coordinates = "lat lon" ;
            depth:grid_mapping = "crs" ;
      double lat(lat) ;
            lat:long_name = "latitude" ;
            lat:units = "degrees_north" ;
            lat:actual_range = 50., 60. ;
      double lon(lon) ;
            lon:long_name = "longitude" ;
            lon:units = "degrees_east" ;
            lon:actual_range = -20., 0. ;
      int crs ;
            crs:grid_mapping_name = "latitude_longitude" ;
            crs:longitude_of_prime_meridian = 0. ;
            crs:semi_major_axis = 6378137. ;
            crs:inverse_flattening = 298.257223563 ;

// global attributes:
            :Conventions = "CF-1.4" ;
```

```
            :title = "The GEBCO_08 Grid - a continuous terrain model for
oceans and land at 30 arc-second intervals" ;
            :institution = "On behalf of GEBCO, the data are held at the
British Oceanographic Data Centre (BODC)." ;
            :source = "The grid was developed from a database of ship-
track soundings with interpolation between soundings guided by satellite-
derived gravity data. However, in areas where they improve on the
existing GEBCO_08 Grid, data sets generated by other methods have been
included. The grid is accompanied by a Source Identifier grid which
identifies which grid cells are based on soundings and which have been
interpolated." ;
            :history = "This is version 20091120 of the data set released
on 20th November 2009. Information on data set version numbering can be
found in the data set documentation available from the web:
http://www.gebco.net/data_and_products/gridded_bathymetry_data/" ;
            :references = "Information on the data set is available from
GEBCOs web pages:
http://www.gebco.net/data_and_products/gridded_bathymetry_data/" ;
            :comment = "The data in the GEBCO_08 Grid should not be used
for navigation or any purpose relating to safety at sea." ;
            :node_offset = 1 ;
```

Creating a Web Map Service (WMS) for the GEBCO_08 Grid

A demonstration Web Map Service (WMS) has been developed for the GEBCO_08 Grid. The WMS is based on imagery produced from the GEBCO_08 Grid by Prof. Martin Jakobsson.

It is planned that the WMS will shortly be made generally available.

The demonstration version of the WMS can be accessed from the following links:

1. GetCapabilities request, returns an XML format file with information about the available layers and WMS parameters, such as geographic coverage and supported projections. You may be asked to save this information in a file before it can be accessed. It can be viewed in a web browser or text editor.

http://www.gebco.net/data_and_products/web_map_service/mapserv?request=getcapabilities&service=wms&version=1.1.1

2. GetMap request, returns a map file using parameters provided by the user:

http://www.gebco.net/data_and_products/web_map_service/mapserv?request=getmap&service=wms&BBOX=-180,-90,180,90&srs=EPSG:4326&format=image/jpeg&layers=GEBCO_08_Grid&width=1100&height=750&version=1.1.1

Gebco's web site

Since July 2008, GEBCO's web site has been maintained and updated at BODC on behalf of GEBCO. It can be accessed at the domain www.gebco.net.

The web page content has been updated to reflect the release of new data sets and/or on request for content update by GEBCO colleagues.

At the request of the chairman of the GEBCO interim Sub-Committee on Regional Undersea Mapping iSCRUM, a new section on regional mapping has been included.

http://www.gebco.net/regional_mapping/

The 'news and events' web pages (http://www.gebco.net/about_us/news_and_events/) have been kept updated with information on data set and software releases. Users can be kept informed about the release of news items via a Really Simple Syndication (RSS) feed.

Since its re-launch in July 2008, there have been over 346,000 pages viewed. Further statistics concerning access to GEBCO's web site can be found in Annex II.

Annex I

Distribution of GEBCO's bathymetric data sets and products

This includes:

- Downloads of GEBCO's gridded data sets from the Internet
- Downloads of the Grid Viewing Software
- Distribution of the GEBCO Digital Atlas on DVD
- Enquiries received concerning the use of GEBCO's data sets and the GEBCO world map

1. Internet downloads of GEBCO's gridded bathymetric data sets*

*Please note that due to an error in recording download information, it is not possible to distinguish between the types of data downloads for May and June 2010. During this period, 1,782 grid files were downloaded.

GEBCO_08 Grid (since release, 29 January 2009)

Full global data set: 2,122
User-selected sub-regions of the global grid: 4,028

GEBCO_08 Source Identifier Grid (since release, 27 November 2010)

Full global data set: 385
User-selected sub-regions of the global grid: 304

GEBCO One Minute Grid (since 01 January 2009)

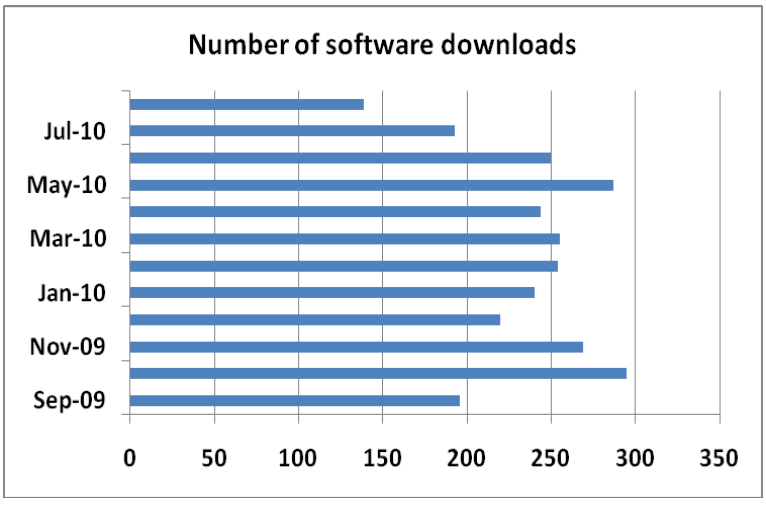
Full global data set: 2,044
User-selected sub-regions of the global grid: 1,792

2. Internet downloads of viewing software for displaying and accessing data from GEBCO's grids

Total number of downloads since launch in January 2007: 8,155

Total number of downloads since September 2009: 2,842

Month	Number of Downloads
Sep-09	196
Oct-09	295
Nov-09	269
Dec-09	220
Jan-10	240
Feb-10	254



Mar-10	255
Apr-10	244
May-10	287
Jun-10	250
Jul-10	193
Aug-10	139

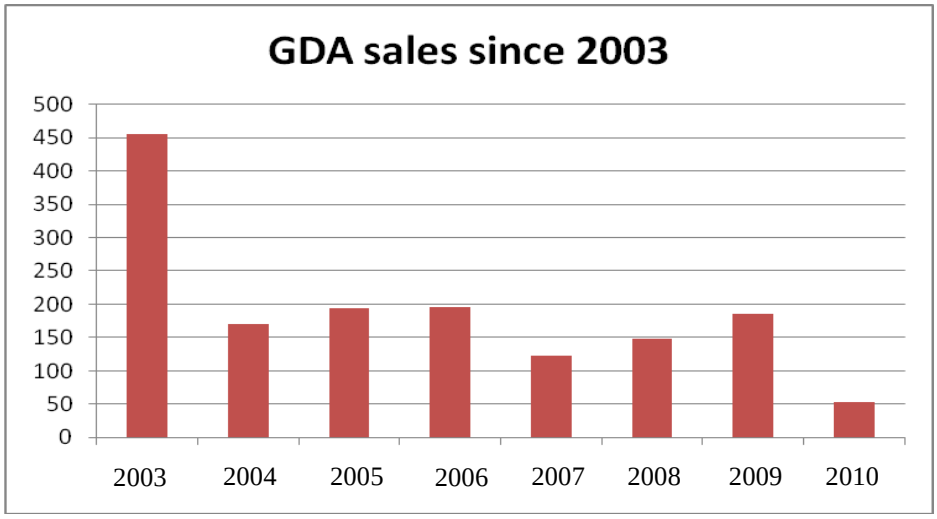
3. Distribution of the GEBCO Digital Atlas (GDA)

Since 1st September 2009, 108 copies of the GDA have been distributed. This includes copies sold to commercial companies and complimentary copies given, for example, to participants on training courses.

Since its release in 2003, 1,527 copies of the GDA have been distributed.

Royalties contributed to GEBCO from the sale of the GDA for 2009 amounted to £11,580. This makes a total of £68,732 since the re-release of the GDA in 2003.

The following diagram details the number of copies of the Centenary edition of the GDA distributed since its release in 2003.



GEBCO data sets are used by a diverse user community and included in a number of products. The following requests have been received over the last year concerning the use of GEBCO's data sets.

GEBCO's gridded data sets and bathymetric contours

- Use by ESRI in developing a Web Map Service
- Use as a bathymetric layer in OpenSeaMap (http://www.openseamap.org) (part of OpenStreetMap: http://www.openstreetmap.org/).

- Imagery created from the GEBCO_08 Grid in the development of a seismic hazards model database as part of a research project to reassess the seismic hazards in the Central and Eastern United States

- Use of the GEBCO_08 Grid in a training software package for the petroleum industry

GEBCO world map

- Use in an exhibition about the oceans at the Alaska Sea Life Center

- Request to include the map as background imagery on a DVD dealing with the composition and distribution of Deep-Sea Hydrothermal Vent Fauna. The DVD will be presented at the Census of Marine Life last meeting in London next October where it will be distributed freely (distribution will be free also after this meeting).

- Request to use imagery in a TV program about the oceans

- Use in a sanctuary system map at the Office of National Marine Sanctuaries/NOAA

- Use as inner shades for lamps

Annex II

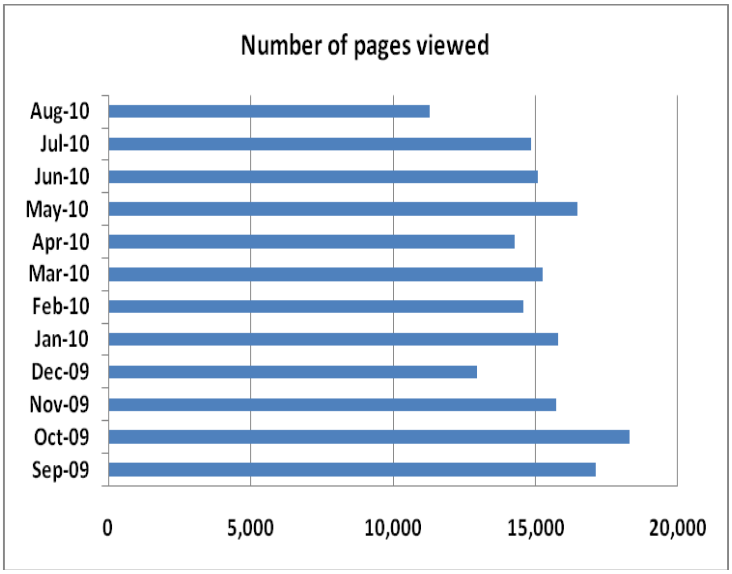
GEBCO's web site was re-launched in July 2008, since then there have been over 346,000 visits to the web site.

1. Visits to GEBCO's web site

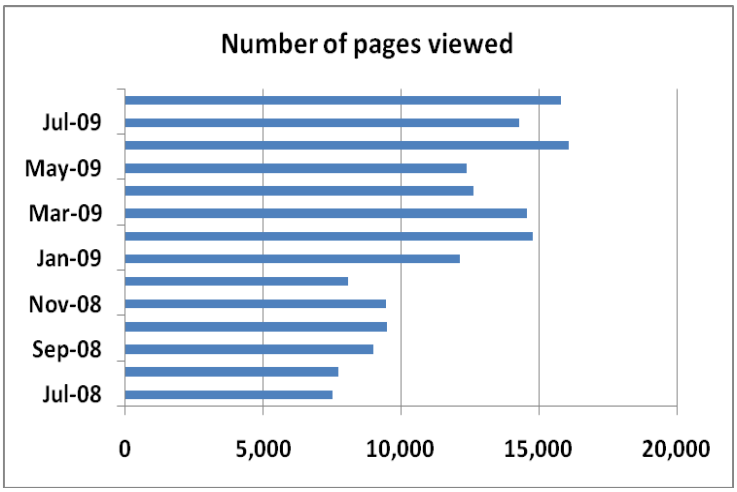
The following tables and diagrams provide statistics about access to GEBCO's web site (www.gebco.net) for the period 1st September 2009 to 20th August 2010.

In summary, there were over 67,900 visitors to the site, viewing over 181,700 pages.

Month	Number of pages viewed
Sep-09	17,132
Oct-09	18,307
Nov-09	15,733
Dec-09	12,946
Jan-10	15,788
Feb-10	14,578
Mar-10	15,264
Apr-10	14,270
May-10	16,468
Jun-10	15,098
Jul-10	14,850
Aug-10	11,282



For comparison with last year's figures:



2. Number of visits to individual GEBCO web pages

The Following table details the number of visits to the most popular pages on GEBCO's web site.

Explanation of terms used:

Page title	Title of the GEBCO web page viewed
Page views	The total number of pages viewed. Repeated views of a single page are counted.
Average time on page (minutes)	The average amount of time that visitors spent viewing this set of pages or page.

Page title	**Page views**	**Average time on page (minutes)**
GEBCO world map	48,138	1.8
GEBCO home page	27,658	0.9
GEBCO gridded bathymetry data*	24,736	1.5
GEBCO Digital Atlas	10,024	0.8
Data and products	7,045	0.3
GEBCO Grid display software	5,158	1.3
Undersea feature names	4,422	1.7
Link to GEBCO grid download page	3,557	3.8
List of GEBCO contacts	3,139	2.1
Hard copy charts	2,788	0.8
News item on release of updated GEBCO_08 Grid (Dec. 2009)	2,755	1.0
News item on release of GEBCO_08 Grid	2,691	0.6
Plots of the GEBCO One Minute Grid	2,294	1.2
Nippon Foundation/GEBCO Training project	2,236	2.7
Committees and Groups	1,676	2.1
Regional mapping projects	1,630	1.2
Search facility	1,545	0.8
GEBCO Science Day	1,345	1.1
GEBCO overview	1,227	1.2
General interest	1,098	0.8
About us	1,066	0.5
Posters and publicity	913	0.9

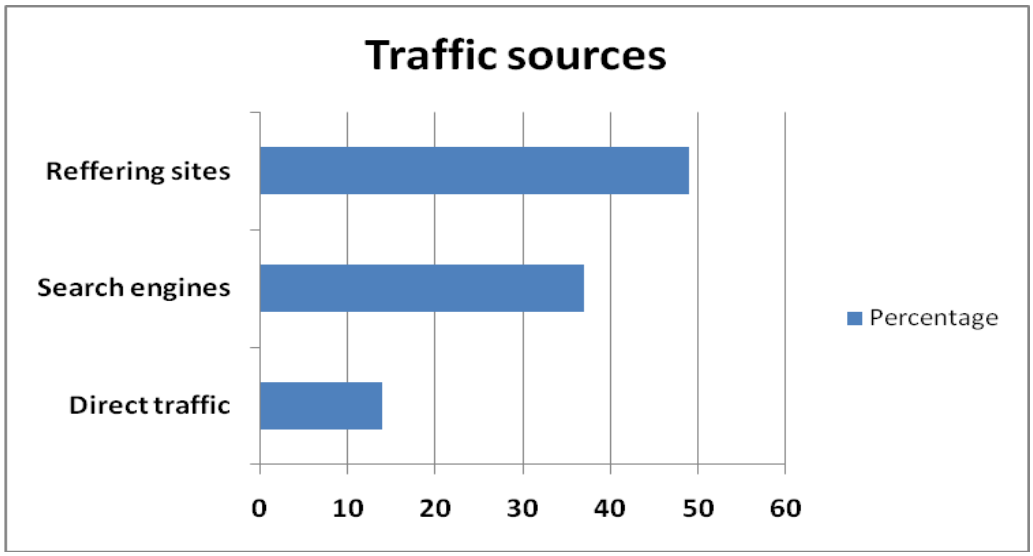
*See Annex I for details on Internet downloads of GEBCO's gridded bathymetric data sets.

3. Traffic sources to GEBCO's web site

The following section details the routes used to find GEBCO's web pages.

Explanation of terms used:

Direct traffic	The user has entered the URL of the web page directly
Search engines	Web pages found by searching using a keyword in a search engine such as Google or Yahoo etc.
Referring sites	Web page found by following a link from another web site



The table below details on how users are finding GEBCO's web site, either directly, using keywords in a search engine or from referral sites. The 'top 25' traffic sources are listed.

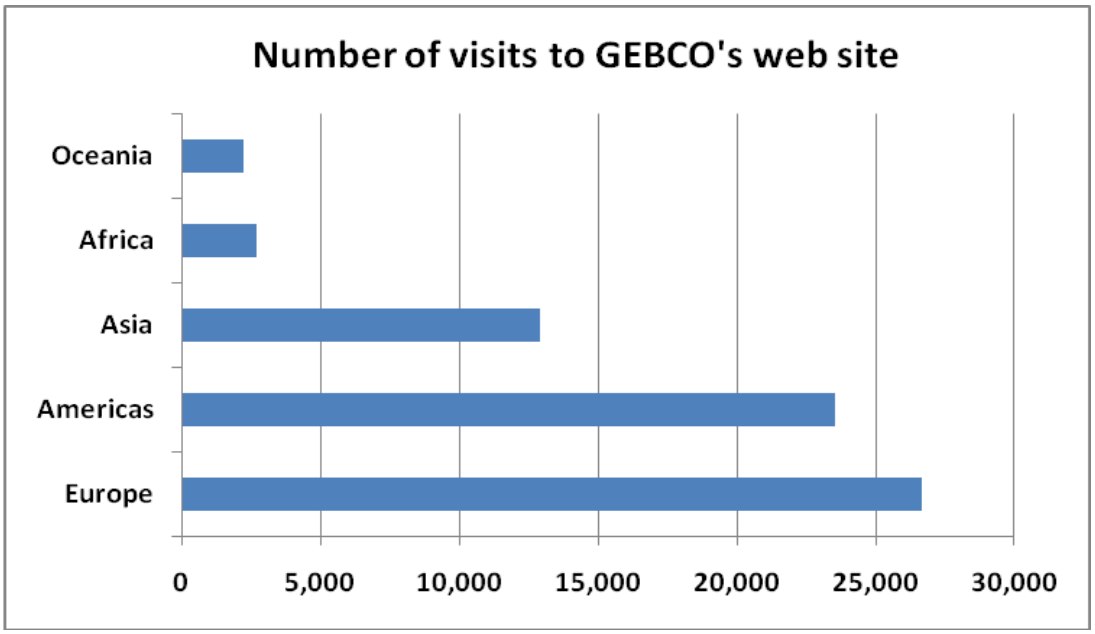
Explanation of terms used:

Source	The source of traffic to the site, e.g. the name of the referral site or search engine:
Medium	The type of traffic: Organic = search engine Referral = from an external web link (none) = direct – i.e. the user has entered the URL of a GEBCO web page
Visits	The number of visits to the site
Pages/Visit	The average number of pages per visit
Average time on site (minutes)	The average amount of time spent on the site in minutes

Source/Medium	Visits	Pages/Visit	Average time on site (minutes)
google / organic	18,171	3.5	3.23
images.google.com / referral	7,493	1.6	0.93
(direct) / (none)	7,471	2.9	2.72
ngdc.noaa.gov / referral	4,880	4.1	3.78
google.com / referral	3,837	1.6	0.77
en.wikipedia.org / referral	1,542	3.8	3.24
images.google.co.uk / referral	1,454	1.6	0.83
bing / organic	937	2.0	1.29
images.google.co.in / referral	854	1.3	0.73
iho-ohi.net / referral	825	3.4	3.33
bodc.ac.uk / referral	770	4.2	3.58
google.co.uk / referral	705	1.6	0.87
google.co.in / referral	704	1.4	0.55
images.google.ca / referral	597	1.5	0.85
yahoo / organic	592	3.3	3.18
images.google.de / referral	553	1.7	0.91
images.google.fr / referral	440	1.8	0.67
images.google.com.au / referral	337	1.4	0.90
google.ca / referral	327	1.7	0.96
images.google / organic	321	1.7	1.35
iho.shom.fr / referral	310	3.8	4.10
images.google.pl / referral	305	1.6	0.71
google.de / referral	284	1.7	0.88
images.google.nl / referral	281	1.7	1.09
images.google.it / referral	272	1.7	0.81

4. Geographic distribution of Internet Protocol (IP) addresses accessing GEBCO's web site

The diagram below outlines the geographic distribution by continent.



The table below details the geographic distribution by country (top 25 'number of visits' listed) of IP addresses accessing GEBCO's web site.

Explanation of terms used:

Country/Territory	The name of the country or territory of the origin of the IP address accessing GEBCO's web site
Visits	The total number of visits to the site from this country/territory
Pages/visit	The number of pages viewed per visit
Average time on site (minutes)	The average amount of time that visitors spent on the site

Country/Territory	Visits	Pages/visit	Average time on site (minutes)
United States	16,254	2.4	1.7
United Kingdom	5,688	2.7	2.1
Germany	3,173	3.3	2.5
France	2,904	3.4	2.7
India	2,676	2.1	1.6
Canada	2,479	2.7	2.2
Spain	1,901	3.4	3.0

Italy	1,803	3.4	2.7
Japan	1,778	3.3	3.3
Australia	1,623	2.5	2.3
Brazil	1,353	2.9	2.7
Russia	1,302	3.4	3.5
Mexico	1,114	2.8	3.2
China	1,053	3.1	3.8
Netherlands	1,052	2.7	2.3
Norway	1,019	2.8	2.1
Indonesia	1,013	3.0	3.6
Portugal	756	3.1	2.3
Philippines	756	1.7	1.7
Poland	681	2.4	1.4
South Korea	627	3.1	3.3
Turkey	597	2.8	2.1
New Zealand	568	2.6	2.3
Greece	553	3.3	2.7
Sweden	545	2.5	1.9

ANNEX 4

Bathymetric Editor Report

Action Items from 2009 General Meeting

There were no direct action items from the last meeting.

Updates to the GEBCO_08 grid

My role in grid updates was limited to looking at grids supplied to the Digital Atlas Manager and reviewing, making comments and suggestions regarding those grids and their incorporation into the main GEBCO_08 grid.

I have additional multibeam grids available for inclusion into the GEBCO_08 grid and had planned for one of the CCOM-GEBCO students to make these this past summer during his lab visit – see below for details.

Data and Contacts

I have initiated a contact with Verizon, a huge multinational that owns and operates a large number of submarine cables around the world, with a view to obtaining the bathymetry collected along the installation routes. This will be a lot more complex than it initially sounds, as often the survey data may reside with a third-party survey company, the cable may be owned by a consortium and permission will be required from all members etc. etc. However it is an ongoing process and at present I have a request in for the sounding data from one recent cable that stretches from the UK through the Mediterranean and Red Sea to India. Furthermore we may only get access to the route-planning spreadsheets which will effectively give us data just at cable 'turning points'. This will effectively be spot soundings that may vary in spatial separation from a few tens of metres to many tens or even hundreds of kilometres. However it is a start and once (if) we get agreement on this cable we may then be able to lever more data from more companies.

I have also dealt with a number of individual (and commercial) enquirers as to how to get and use the GEBCO_08 grid.

GEBCO scholars and Regional Study Groups

Due to visa problems, the NIPPON-GEBCO student identified to come to the UK was unable to attend my Institution. Sadly I was not made aware of any problems until it was too late for me to intervene or help in any positive way. This would appear to be an isolated event and should not require action from NIPPON, CCOM or any other party.

I have had no contact with any other GEBCO alumni, which considering the interest generated two years ago in developing a regional mapping programme, reinforced with the creation of iSCRUM last year has been disappointing. My own commitments this past year have not helped in this aspect (see below).

Bathymetric Editor Resource Information

NERC has been subject to budget restrictions, over the past year, coupled with a re-evaluation of some of the strategic objectives and an internal reorganisation of the Geology and Geophysics Group at NOCS. This has further restricted the time I have had available for GEBCO work over the past year. However, I have managed to preserve GEBCO within my remit, although it has now been subsumed under a "Global Mapping" branding. The next few years are not likely to see any positive change, though I believe that GEBCO will not be subject to further cuts in the short term.

However, as mentioned last year, to ensure future funding for GEBCO work, I will need to demonstrate achievements, uses, plans etc

ANNEX 5

International Hydrographic Organization
Data Center for Digital Bathymetry
World Data Center for Geophysics and Marine Geology at Boulder
And
United States Department of Commerce
National Oceanic and Atmospheric Administration
National Environmental Satellite, Data, and Information Service
National Geophysical Data Center

Report to the
Technical Sub-Committee on Ocean Mapping
of the

September 2010
Directorate of Hydrography and Navigation
Callao, Peru

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Appendices

I. REPORT OF THE INTERNATIONAL HYDROGRAPHIC ORGANIZATION DATA CENTER FOR DIGITAL BATHYMETRY

The National Geophysical Data Center (NGDC) in Boulder, Colorado, USA, operates a worldwide digital data bank of oceanic soundings on behalf of the Member Countries of the International Hydrographic Organization (IHO). The IHO is based in Monaco and presently has over 80 Member States. In 1988, NGDC offered to host and operate a worldwide digital oceanic bathymetry data centre on behalf of the IHO Member States. This led to the official establishment (in June 1990) of the IHO Data Centre for Digital Bathymetry (DCDB). Since that time, the IHO DCDB has made substantial progress toward establishing itself as the focal point for digital hydrographic data services for IHO Member States.

Since the September 2009 Meeting of the General Bathymetric Chart of the Oceans (GEBCO) Technical Sub-Committee on Ocean Mapping (TSCOM), the National Geophysical Data Center (NGDC) has responded to 13 international requests for marine geology and geophysics data and 144 total sales requests from 7 countries, all of which are International Hydrographic Organization (IHO) Member States. Hard copy posters used by educators and bathymetric maps used by fisherman continue to be the bulk of products shipped by NGDC, as most of our digital data are online free of charge.

I-A. IHO DCDB Website

NGDC is coordinating with the International Hydrographic Organization (IHO) to update and restructure the International Hydrographic Organization Data Center for Digital Bathymetry (IHO DCDB) website to allow IHO member states easier access to hydrographic and bathymetric data through interactive graphical display and search capability. Given sufficient resources, the new site will also provide user-friendly data and metadata submittal through a custom on-line interface and editor. NGDC is prepared to leverage custom infrastructure developed for the U.S. Extended Continental Shelf Project to search, display and upload data and metadata. The website will provide users with all unrestricted multibeam swath sonar data, track line geophysical data, bathymetric and bathymetric/topographic digital elevation models, and point soundings archived at NGDC as well as metadata for locating data that is not archived at NGDC. The website restructuring is part of a larger IHO effort to engage the Regional Hydrographic Commission members in contributing data and metatdata to the IHO DCDB.

I-B. Bathymetric Data Holdings

Over the reporting period, NGDC received 1.9 terabytes of deep-water multibeam bathymetric data from 127 surveys. Significant contributions included surveys from Lamont-Doherty Earth Observatory (38), National Science Foundation Rolling Deck to Repository (11), the Geological Survey of Ireland (10), NOAA (32), the United States Naval Oceanographic Office (31), the United States Geological Survey (2), and the University of New Hampshire (3). The Multibeam Bathymetric Database now provides 4.9 terabytes of data from 1,589 cruises.

NGDC offers online access to its multibeam bathymetric data holdings using an interactive mapping tool with query capabilities at http://map.ngdc.noaa.gov/website/mgg/multibeam/. In addition, NGDC has provided an interactive website, which allows the user to generate color relief maps, with contours, if desired, and grids of the data using NOAA's Pacific Marine Environmental Laboratory (PMEL) AutoChart, Generic Mapping Tools (GMT), and MB-System software. The maps and grids output formats are in Postscript and GMT, respectively, and users have the option

to download the source data. Most of these datasets have associated Federal Geographic Data Committee (FGDC) metadata files, viewable online through a link in the survey listing of a search or downloaded with the full resolution data. NGDC developed a pipeline with National Science Foundation (NSF) Rolling Deck to Repository (R2R) Project to download and archive raw shipboard sensor data.

During the reporting period, NGDC archived and made publicly available 357 hydrographic surveys and 2,831 Bathymetric Attributed Grid (BAG) files. For more information about the BAG format and the Open Navigation Surface Working Group (ONSWG), please visit http://www.opennavsurf.org. NGDC now provides an online conversion tool to translate the binary BAG files to XYZ depth and uncertainty, which provides the public greater access to NOS surveys.

NGDC continues to archive digital sidescan sonar data. NGDC offers sidescan sonar mosaic images on-line and continues to develop products derived from these data. This year through American Recovery and Reinvestment Act (ARRA) funding, NGDC produced over 250 new sidescan mosaics. Current NOS sidescan sonar holdings exceed 18 terabytes; the sheer volume of the data is providing Information Technology (IT) challenges in the areas of data archive and access.

NOS hydrographic survey data is accessible to the public through an interactive map service maintained at http://map.ngdc.noaa.gov/website/mgg/nos_hydro/. The NOS Hydrographic Survey Data Map Service is a data discovery and download tool that allows the user to quickly and easily make spatial or textual searches for surveys of interest, then download survey-related data products. NGDC is now archiving numerous types of digital survey data files, including Extensible Markup Language (XML) metadata document files, survey plots, sounding data in American Standard Code for Information Interchange (ASCII) XYZ and the Hydrographic Surveys Data Exchange Format (HYD93), sidescan sonar mosaics, shaded-relief images, and gridded data in text and BAG file formats.

Over 9,500 NOS Descriptive Reports containing detailed survey metadata are currently available, as well as over 23,400 final smooth sheet images scanned from original plots of the survey area using corrected hydrographic data. The map service enables NGDC to deliver these products, including high-resolution multibeam and sidescan sonar data, over one interactive, web-based system

I-C. Marine Trackline Geophysics Dataset

NGDC released the current Version 5.0.13 of the global Marine Trackline Geophysics dataset with GEODAS search and retrieval software in August 2009 on a single DVD. The last version of this DVD will be released within the next year and will contain at least an additional 142,000 nautical miles of bathymetry, magnetics and gravity from 33 cruises. All current holdings and future additions to the database will continue to be available with search and retrieve capabilities via the Internet. NGDC's global Marine Trackline Geophysics database now includes 50.8 million soundings from 4867 cruises. http://map.ngdc.noaa.gov/website/mgg/trackline/viewer.htm http://www.ngdc.noaa.gov/mgg/gdas/ims/trk_cri.html

I-D. Global Database Management and GEODAS Software Development

NGDC's United States single-beam, multi-beam, and sidescan sonar coastal databases have been migrated to a spatially enabled Oracle Relational Database Management System (RDBMS). This migration aids data managers in maintaining data consistency across other National Ocean Service (NOS) databases and increases overall data quality and ability to search the data.

NGDC continues to enhance the Geophysical Data System – Next Generation (GEODAS-NG) software management system. Originally developed to manage marine geophysical trackline data, GEODAS-NG is now a universal software data management tool, which can handle a variety of

data formats and types including single-beam, multibeam, trackline, hydrographic survey, and gridded bathymetric and topographic data. The software serves users as an online search, display, and retrieval system. NGDC is in the process of moving the GEODAS-NG system to a RDBMS. NGDC has successfully migrated all GEODAS data, metadata, and navigation information to Oracle relational databases. Online user access is through geospatially enabled Arc Internet Map Services (ArcGIS) developed by Environmental Systems Research Institute (ESRI).

The GEODAS Grid Translator page at http://www.ngdc.noaa.gov/mgg/gdas/gd_designagrid.html offers translation of GEODAS gridded databases to several formats using various grid parameter options. Online users can create and download custom grids of NGDC gridded datasets: ETOPO1, U.S. Coastal Relief Model, and (U.S.) Great Lakes Bathymetry.

II. REPORT OF THE WORLD DATA CENTER FOR GEOPHYSICS AND MARINE GEOLOGY, BOULDER

NGDC, in its capacity as the World Data Center for Geophysics and Marine Geology (WDC-GMG), Boulder, promotes excellence in archiving, managing, and exchanging data obtained from measurements of the seafloor. NGDC works with national and international groups on many projects outside the scope of the International Hydrographic Organization Data Center for Digital Bathymetry (IHO DCDB), GEBCO, and the Intergovernmental Oceanographic Commission (IOC) Regional Mapping Projects. Although the WDC-GMG, Boulder, manages all types of data from the ocean floor, including descriptions and analyses of seafloor samples, deep sea drilling data, underway geophysical measurements, and derived gridded data sets, this report will only describe activities regarding bathymetry.

II-A. Tsunami Research and Training Activities

The data center has been actively involved in a number of tsunami-related activities, supporting both research and mitigation efforts.

II-A-1. Building High-Resolution Digital Elevation Models of U.S. Coastal Zones

NGDC builds high-resolution digital elevation models (DEMs) for select United States coastal regions to support tsunami forecasting and modeling efforts at the NOAA Center for Tsunami Research, Pacific Marine Environmental Laboratory (PMEL), the National Tsunami Hazard Mitigation Program, the Hurricane Forecast Improvement Program (HFIP), and NOAA's National Ocean Service (NOS). The DEMs can also be used for modeling of coastal processes, ecosystems management and habitat research, coastal and marine spatial planning, and hazard mitigation and community preparedness.

Bathymetric, topographic, and shoreline data used in DEM compilation are obtained from various sources, including NGDC, NOAA's NOS, the U.S. Geological Survey (USGS), the U.S. Army Corps of Engineers (USACE), the Federal Emergency Management Agency (FEMA), and other federal, state, and local government agencies, academic institutions, and private companies. Reference datums used by the DEMs are vertical tidal datums of North American Vertical Datum of 1988 (NAVD 88) or mean high water (MHW), and horizontal datums of World Geodetic System 1984 geographic (WGS 84) or North American Datum of 1983 (NAD 83). Cell sizes for the DEMs range from 1/3 arc-second (~10 meters) to 3-arc-seconds (~90 meters).

The DEMs are available to the public at http://www.ngdc.noaa.gov/mgg/coastal/coastal.html. Web site visitors may view planned DEMs, and download completed DEMs with corresponding metadata and documentation. Between August 2009 and July 2010, NGDC completed 25 coastal DEMs, all of which are available to the public online. Since the start of the DEM development project in 2006, NGDC has developed 71 DEMs covering all of Puerto Rico and portions of the United States' East, West, Gulf, Hawaiian, and Alaskan coasts, as well as several Pacific Islands.

II-A-1. Online Catalog of Historic and Prehistoric Tsunami Events

The Global Historic Tsunami Event and Runup database allows users to search, display, and download data on-line via web forms, interactive ArcIMS maps, and Keyhole Markup Language (KML), which is an XML-based language schema for expressing geographic annotation and visualization on Google Earth. This database contains information on the date and location of the tsunami source and runups, as well as deaths, damages, and monetary impact. Tsunami history provides clues to what might happen in the future, including frequency of occurrence and maximum wave heights. However, instrumental and written records commonly span too little time to reveal the full range of a region's tsunami hazard, so NGDC added a global database of citations on tsunami deposits to the archive. The citation database provides additional data on historical

events and extends the record of tsunamis backward, in some cases to prehistoric time, with paleotsunami deposits preserved in the geologic record. There are currently over 1,190 citations describing deposits from all over the world and over 400 are associated and linked to a specific historic tsunami event. The service is an important component of worldwide efforts to mitigate against tsunami threat and is available at http://www.ngdc.noaa.gov/hazard/tsu.shtml.

II-B. World Magnetic Model Crustal Anomaly Analysis

NGDC released an Earth Magnetic Anomaly Grid (EMAG2) compiled from satellite, ship, and airborne magnetic measurements during a 2-year international collaborative effort in February 2009. Magnetic anomaly maps provide insights into the subsurface structure and composition of the earth's crust. They are widely used in the geological sciences and in resource exploration. Furthermore, the global magnetic map is useful in science education to illustrate plate tectonics, crustal interaction with the deep mantle, and other aspects of Earth evolution. Distinct patterns and magnetic signatures on magnetic anomaly maps are attributed to the formation (seafloor spreading) and destruction (subduction zones) of oceanic crust, the formation of continental crust by accretion of terranes to cratonic areas, and large-scale volcanism. NGDC contributed EMAG2 to the Magnetic Anomaly Map of the World (http://ccgm.free.fr/index_gb.html), improving the current grid resolution to 2 arc-minute from 3 arc-minute grid resolution of the previous version, EMAG3.

Included in this revision are additional grid and trackline data over land and oceans. Moreover, NGDC improved interpolation between sparse tracklines in the oceans by using directional gridding and extrapolation using an oceanic crustal age model. The longest wavelengths (>330 kilometers) were replaced with the latest Challenging Mini-Satellite Payload (CHAMP) satellite magnetic field model 6 (MF6). The EMAG2 publication details improvements in data processing. The digital grid, images, and various derived products, including the KMZ file enabling visualization in Google Earth are available on the EMAG2 homepage at http://geomag.org/models/emag2.html and permanently archived at http://earthref.org/cgi-bin.cgi?s=erda.cgi?n=9700.

II-C. United States–Canada Cooperation on New Bathymetry for the Great Lakes

NGDC/WDC partnered with NOAA's Office of Oceanic and Atmospheric Research (OAR) Great Lakes Environmental Research Laboratory (GLERL) and the Canadian Hydrographic Service (CHS) in a long-term international cooperative effort to produce bathymetric contours for Lakes Ontario, Michigan, Erie, St. Clair, and Huron. NGDC maintains web pages for Great Lakes bathymetry at http://www.ngdc.noaa.gov/mgg/greatlakes/. These pages provide direct links to related external organizations, and an online, interactive map service featuring the Great Lakes. The map includes a coastline for the Great Lakes as well as bathymetric contours for Lakes Ontario, Michigan, Erie, St. Claire, and Huron. The Great Lakes websites received an average of 36,674 hits per month and 5.04 gigabytes a month of data downloaded during this reporting period.

II-D. United States-Canada Cooperation on the Development of Tsunami Propagation and Inundation Models

NGDC and NOAA's Pacific Marine Environmental Lab (PMEL) are collaborating with the Canadian Hydrographic Service (CHS) to create Digital Elevation Models (DEMs) to enhance tsunami forecast models and warnings issued by the West Coast Tsunami Warning Center. CHS is providing digital bathymetry files and gridded bathymetric data for the west coast of Canada. NGDC compiles these data into high resolution DEMs for use by both nations. A data sharing agreement was finalized in August of 2010 to formalize this collaboration among the three partners.

II-E. United States–Japan Cooperative Program in Natural Resources

NGDC presented a report and presentation on activities of NGDC/WDC related to sea bottom surveys at the 36th annual United States-Japan Cooperative Program in Natural Resources (UJNR) Sea-Bottom Surveys Panel Meeting held in Tokyo, Japan, on January 20-22, 2009. This panel continues to be one of the principal mechanisms by which Japan and NGDC exchange technologies and marine geophysical data, including bathymetry.

II-F. World Data Center for Geophysics and Marine Geology, Boulder, Online Activities

The web pages of the World Data Center for Geophysics and Marine Geology (WDC-GMG), Boulder, collocated with those of the NGDC's Marine Geology and Geophysics Division, averaged 4.7 million hits per month, during the period from August 2009 through July 2010, up from 3.3 million during the last reporting period of June 2008 through August 2009. Users downloaded an average of 5.04 terabytes of data each month, a decrease from the 5.87 terabytes per month for the last reporting period. The WDC-GMG website is at http://www.ngdc.noaa.gov/mgg/wdc/wdcgmg.html.

III. REPORT OF NGDC ACTIVITIES IN SUPPORT OF IOC/GEBCO

III-A. GEBCO Reviewers' Reports

III-A-1. Assessment of Gridding Techniques

NGDC is participating in a test of various gridding algorithms for compiling sparse and heterogeneous bathymetric data. This task was assigned to gridding algorithm working group by the GEBCO Technical Subcommittee on Ocean Mapping led by Martin Jakobsson. NGDC is testing the tight spline gridding methodology and developed data to support the grid comparisons. This included: (i) obtaining multibeam swath sonar data from NGDC's multibeam bathymetry database; (ii) cleaning the data to remove artifacts and eliminate superseded surveys; (3) creating a grid of the cleaned data at 500-m cell size that could serve as the "true" seafloor elevation grid for comparisons; (iv) obtaining sparse, trackline bathymetry data from NGDC's Marine Geophysical Trackline Database; and (v) extracting elevation values from the "true" grid at every trackline sounding position. The intent is for each working group member to grid the sparse "trackline" data using their respective gridding technique and to then compare their grid to the "true" elevation grid. Results from each working group member's efforts would then be compared to identify which technique is most suitable for GEBCO.

III-B. Related Activities Supporting IOC/GEBCO Programs and Projects

III-B-1. GEBCO Online Activities

III-B-1-a. IOC Regional Bathymetric Chart Web Pages

The following table shows the web activity over this reporting period for the International Bathymetric Chart web sites hosted by NGDC.

Web Activity for Regional Mapping Project Sites	
IBC	**Average Hits/Month**
IBCAO	15,670
IBCCA	6,200
IBCM	3,123
IBCEA	1,905
IBCWIO	1,151

III-B-1-b. GEBCO List Servers

NGDC continues to maintain the GEBCO Folk List Server to facilitate communication between members of the GEBCO personality list at gebco_folk@mailman.ngdc.noaa.gov. NGDC welcomes comments from the GEBCO community on how we can improve or enhance these services. NGDC also maintains the following GEBCO list servers:

- International Bathymetric Chart of the Arctic Ocean (IBCAO)
- International Bathymetric Chart of the Caribbean Sea and the Gulf of Mexico (IBCCA)
- International Bathymetric Chart of the Eastern Atlantic Ocean (IBCEA)
- International Bathymetric Chart of the Mediterranean (IBCM)
- International Bathymetric Chart of the South East Pacific (IBCSEP)
- International Bathymetric Chart of the Southern Ocean (IBCSO)
- International Bathymetric Chart of the Western Indian Ocean (IBCWIO)
- Technical Sub-Committee on Ocean Mapping (TSCOM)
- GEBCO Guiding Committee

III-B-2. Coastal Relief Model Development

NGDC is developing the first of the next-generation Coastal Relief Models (CRMs), which will span Southern California, scheduled for completion in the Fall of 2010. The CRM will have a resolution of 1 arc-second (~30 m), expanded seafloor coverage to the United States Exclusive Economic Zone (EEZ) boundary, have a common vertical datum (NAVD 88), and incorporate the latest hydrographic and multibeam swath sonar surveys and land elevation data. NGDC will also create conversion grids for development of MHW and MLLW versions to support tsunami inundation modeling. NGDC will use NOAA's VDatum tool (http://nauticalcharts.noaa.gov/csdl/vdatum.htm) to convert bathymetric measurements to NAVD 88 and create the conversion grids. NGDC is collaborating with other NOAA offices, the National Geospatial-Intelligence Agency, the U.S. Navy, U.S. Geological Survey, universities, state and local agencies in California, and commercial companies to complete this effort. NGDC expects to update the other nine existing 3 arc-second CRM volumes over the next five years.

III-B-3. Online Geospatially Enabled Gazetteer of Undersea Feature Names

The IHO is populating a new geospatially enabled Oracle database of the GEBCO Gazetteer of Undersea Feature Names developed by NGDC in collaboration with the British Oceanographic Data Center (BODC). The user interface developed by NGDC provides the Sub-Committee on Undersea Feature Names (SCUFN) Secretary secure remote access to the database with full administrative privileges and the public with read-only search and retrieval access. SCUFN members will also have password protected remote access to the database to add features for consideration and edit existing feature names (e.g., add metadata or better define a feature's geometry).

This new database will be continuously updated, thereby eliminating the need for versioning of the Gazetteer. It will provide a geospatially enabled layer of undersea feature names to multiple display interfaces including the GEBCO Digital Atlas. Inclusion of the Gazetteer in Google Earth and other visualization sites via a network link has the potential to give broad exposure to the Gazetteer and the work of GEBCO.

III-B-4. United States Extended Continental Shelf

The United States Extended Continental Shelf (ECS) Task Force designated NGDC as the Data Management and Integration lead for the U.S. ECS Project and the data stewards and archival location for all data related to this project. NGDC is responsible for establishing and maintaining a central repository of data and metadata that is accessible, robust, and effectively promotes ECS regional analyses. NGDC will take the lead in constructing and maintaining the Information

Management System (IMS), linking it where appropriate with other existing databases, and working with other Task Force agencies in developing standards and protocols for data and metadata as part of the overall system for preserving the critical analyses and decisions made in support of the United States ECS submission.

Major accomplishments this past year have been the further development of common metadata templates for marine seismic reflection data, multibeam bathymetric data, and cruise level data. Common metadata supports discovery, understanding and long-term archival of data that will contribute to the ECS Regional analyses. Scientists and data experts from several United States federal agencies and academic science data centers joined together to agree on common vocabularies, documentation rules, best practices and crosswalks to federal and international metadata standards. NGDC also provided scientific staff for a cruise to the Central Pacific (Kingman Reef/Palmyra Atoll) aboard R/V Kilo Moana. NGDC has built and made available to ECS scientists an interactive map tool. This tool, the ECS Dynamic Inventory, will allow regional experts to geographically browse potential ECS areas and identify surveys of interest. Information can be recorded for individual surveys about navigational quality, suitability for the ECS project, etc., along with descriptive comments, and can be used to identify where there are "gaps" in the available data for future survey planning. These regional experts will assess the existing data and metadata to determine suitability for the ECS Project and identify gaps where additional data are required. These data are then stewarded either at NGDC (bathymetry, gravity, magnetic, geologic sample data) or the USGS Menlo Park (original seismic and physical geologic samples).

NGDC has worked with the United Nations Environment Programme's (UNEP) Global Resource Information Database (GRID) and the United States Department of State to identify data coverage for developing States. During the past year UNEP/GRID has obtained seismic data from NGDC to provide aid to Vanuatu and the Maldives. Portugal contacted NGDC requesting permission to use photos of manganese nodules archived at NGDC in their submission report. The Costa Rican Foreign Minister requested assistance from United States Secretary of State Clinton in locating data to support their ECS effort. This request was forwarded to NGDC from the Department of State, and NGDC provided 5 GB from 42 cruises of multibeam bathymetric data to Costa Rica.

Appendix A. Single Beam Bathymetric Data

Sources of single beam bathymetric data and number of cruises contributed to the NGDC during this reporting period:

Institution	Nº Cruises
US Navy, Scientific Ice Expeditions (SCICEX)	6
US Navy, Arctic Submarine Bathymetry Unspecified Cruises; 12,700 Soundings	n/a
Total	**6**

Appendix B. Marine Geology and Geophysics Data Requests

Number of NGDC Marine Geology and Geophysics data requests fulfilled by country during this reporting period:

Country	Nº Requests
Canada	6
China	1
Federal Republic of Germany	1
Italy	1
Republic of Korea	1
United Kingdom of Great Britain and Northern Ireland	1
Republic of China (Taiwan)	2
Total	**13**

Appendix C. Multibeam Bathymetry Database

Number of cruises with multibeam bathymetry added to the Multibeam Bathymetry Database this reporting period:

Institution	Nº Cruises
Lamont-Doherty Earth Observatory (LDEO)	38
United States Geological Survey (USGS)	2
National Oceanic and Atmospheric Administration (NOAA)	32
Geological Survey of Ireland (GSI)	10
Scripps Institution of Oceanography (SIO)	31
University of New Hampshire (UNH) Center for Coastal and Ocean Mapping (CCOM) Joint Hydrographic Center (JHC)	3
Woods Hole Oceanographic Institution (WHOI)	11
Total	**127**

Appendix D. Multibeam Bathymetric Cruises Received

Number of cruises with multibeam bathymetry received during this reporting period:

Institution	Nº Cruises
USA	117
Non-US	10
Total	**127**

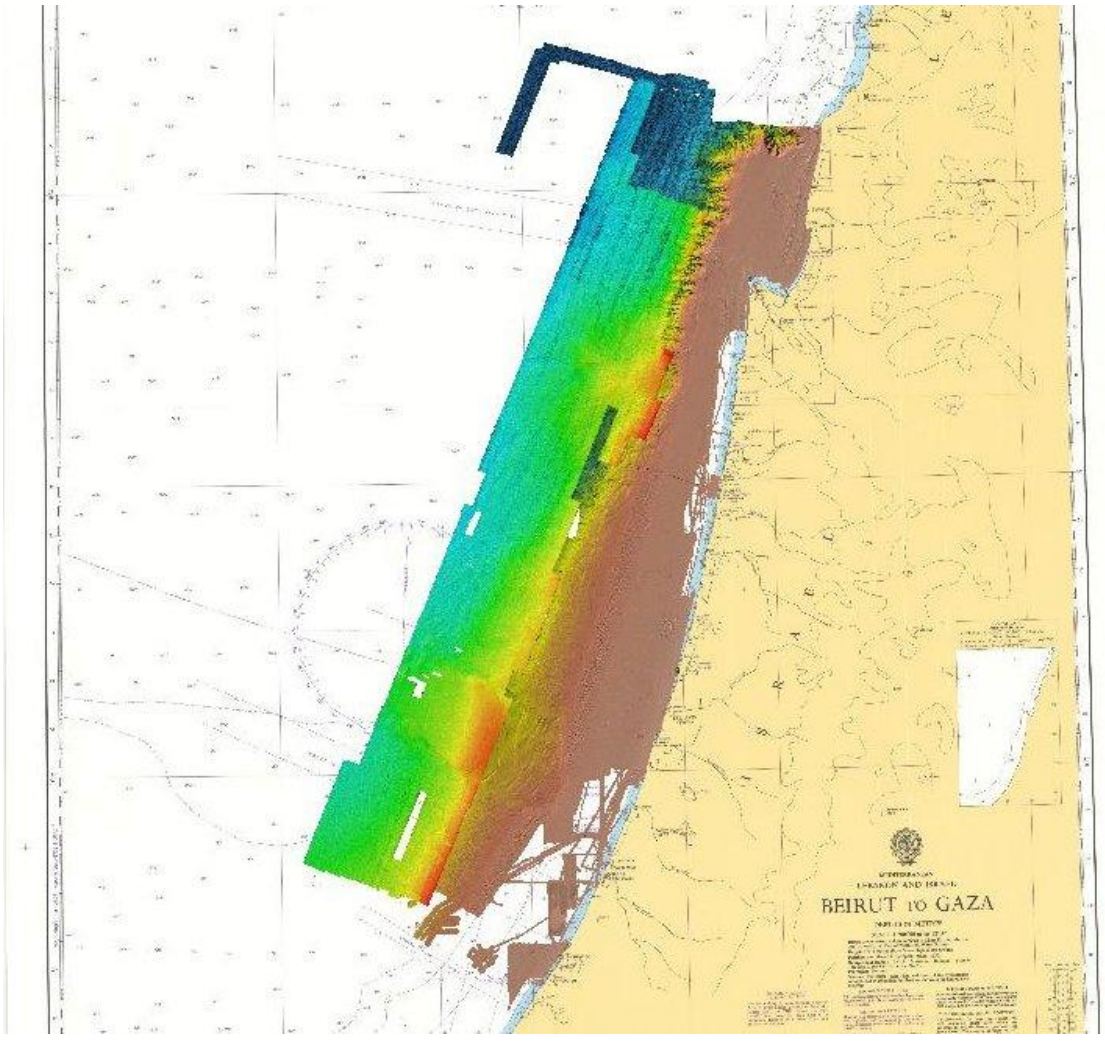
ANNEX 6

Annual report of activities

John K. Hall

1) Multibeam sonar work in and around Israel.
Mediterranean Sea

The Israel National Bathymetric Survey (NBS) is now concluding its 10th year. The Kongsberg Simrad EM1002 on the IOLR research vessel ***R/V Etziona*** has completed some 70% of the mapping of the Israeli continental margin from depths of 10m to 700m. It is hoped that this inshore will be completed in 2011. In mid-October a 5 week cruise of the EcoOcean vessel ***R/V Mediterranean Explorer*** began mapping the deeper areas off Israel with a rented L-3 ELAC SeaBeam 3050 two-ping 50kHz multibeam sonar. The figure shows the inshore coverage plus the results of the first two deep-water legs together with the sum of the inshore work (mostly brown).



Northern Red Sea - Gulf of Elat/Aqaba

In 2006 the ***R/V Etziona*** transited the Suez Canal and over 32 days, in cooperation with colleagues from Jordan, produced a 6 m grid of the Israeli and Jordanian territorial waters to depths of 700m.

The Dead Sea

In early 2007 a rented L-3 ELAC SeaBeam 1050 multibeam sonar was installed aboard Gonen Marine Services' research vessel ***R/V Taglit***. Over a period of a month, in cooperation with Jordanian colleagues, the 305m deep Dead Sea was surveyed. Due to the fact that the sound speed in the Dead Sea is 20% above that of the oceans (1,820 m/sec) it was necessary to tweak the firmware of the system. The results are still being analyzed, due to the need to untweak and then recalculate the ray tracing. This is now being done with crucial input from UNH-CCOM's Dr. Jonathan Beaudoin.

The Kinneret - Sea of Galilee

A two month survey of the Sea of Galilee in 2008 produced a new detailed map of this inland fresh-water lake with maximum depths near 40 m. A rented L-3 ELAC SeaBeam 1180 multibeam sonar was used aboard the IOLR jet-boat the ***R/V Lillian***. Some 38 million soundings were obtained, and a 4m grid was produced.

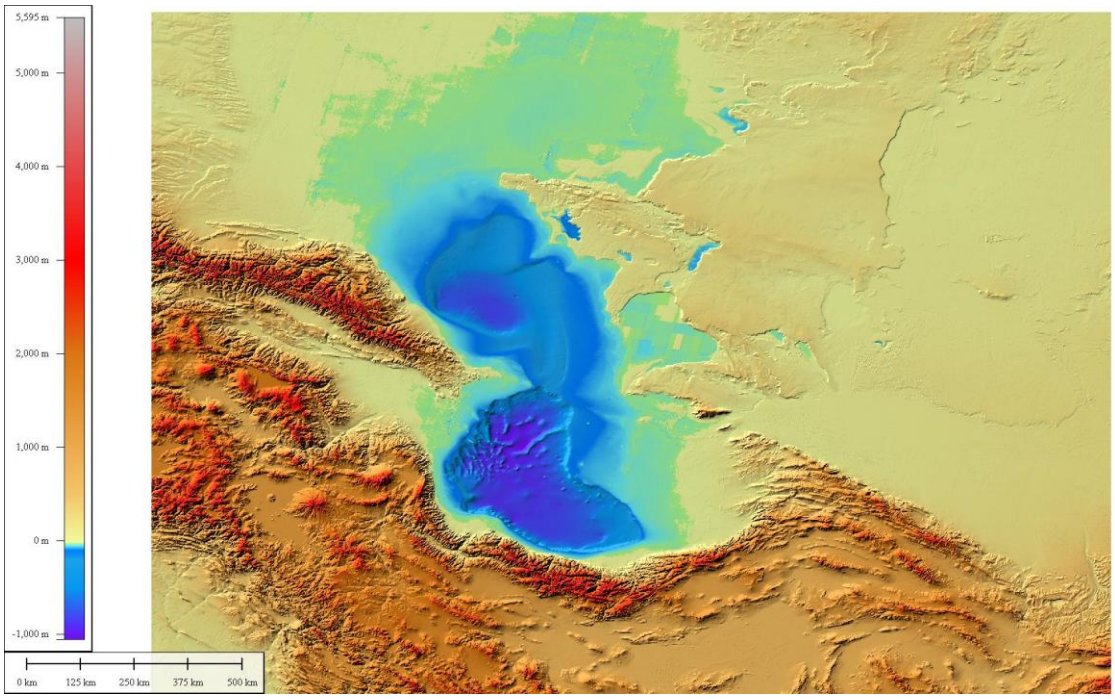
2) Bathymetric Compilations of the Seas around the Arabian Plate (IBCM).

Compilation of the bathymetry of the so-called puddles around the Arabian Plate has been going on for years using spot soundings that we digitized from nearly 800 Russian navigational charts, historical UKHD survey fair-sheets, ship survey tracks, transit tracks, and other sources. These were to be a primarily shallow-water supplement to the gradual deep-water coverage by multibeam sonar surveys, such as the ~55% coverage of the deep Mediterranjean by the MediMap Group. And as of June 29 2009 the task became easier as 30m grids for the land became available from the newly released ASTER-GDEM global coverage from NASA and Japan's METI.

The preparation of these grids has become much easier with time. Software improvements have come via Golden Software's Surfer 9, Global Mapper 12, Able Software's r2v. Hardware improvements include massive storage space, gigabit LANs, 64 bit processing, and linked computers each with large screens. And time has become available as retirement removes the need for observing vacations, holidays, and weekends.

The Caspian Sea

Following the 2009 GEBCO meeting in Brest I reworked the digitized soundings and contours from the Russian navigational chart coverage of the Caspian Sea and provided GEBCO and GeoMapApp with a 100m grid on the UTM projection. Kriging by Surfer was used for the interpolation. Land data was from the newly released 30m ASTER-GDEM global coverage from NASA and Japan's METI. The grid and soundings were supplied to Pauline Weatherall.



The Black Sea

The soundings digitized years ago from the Russian navigational chart coverage of the Black Sea were also supplied to GEBCO and GeoMapApp as a newly reworked 0.25 minute grid.

The Mediterranean Sea

The 2009 GEBCO meeting brought forth several suggestions for a push to improve the GEBCO grid for the Mediterranean, which at 1000m was already based on much finer compilations such as the 500m MediMap Group coverage for the deep-waters. More than one was based on schemes to pool data in huge European databases which would be lavishly funded. Not surprisingly, none of these came to fruition, and to my knowledge will never work because of the proprietary interests of the institutions and individuals involved.

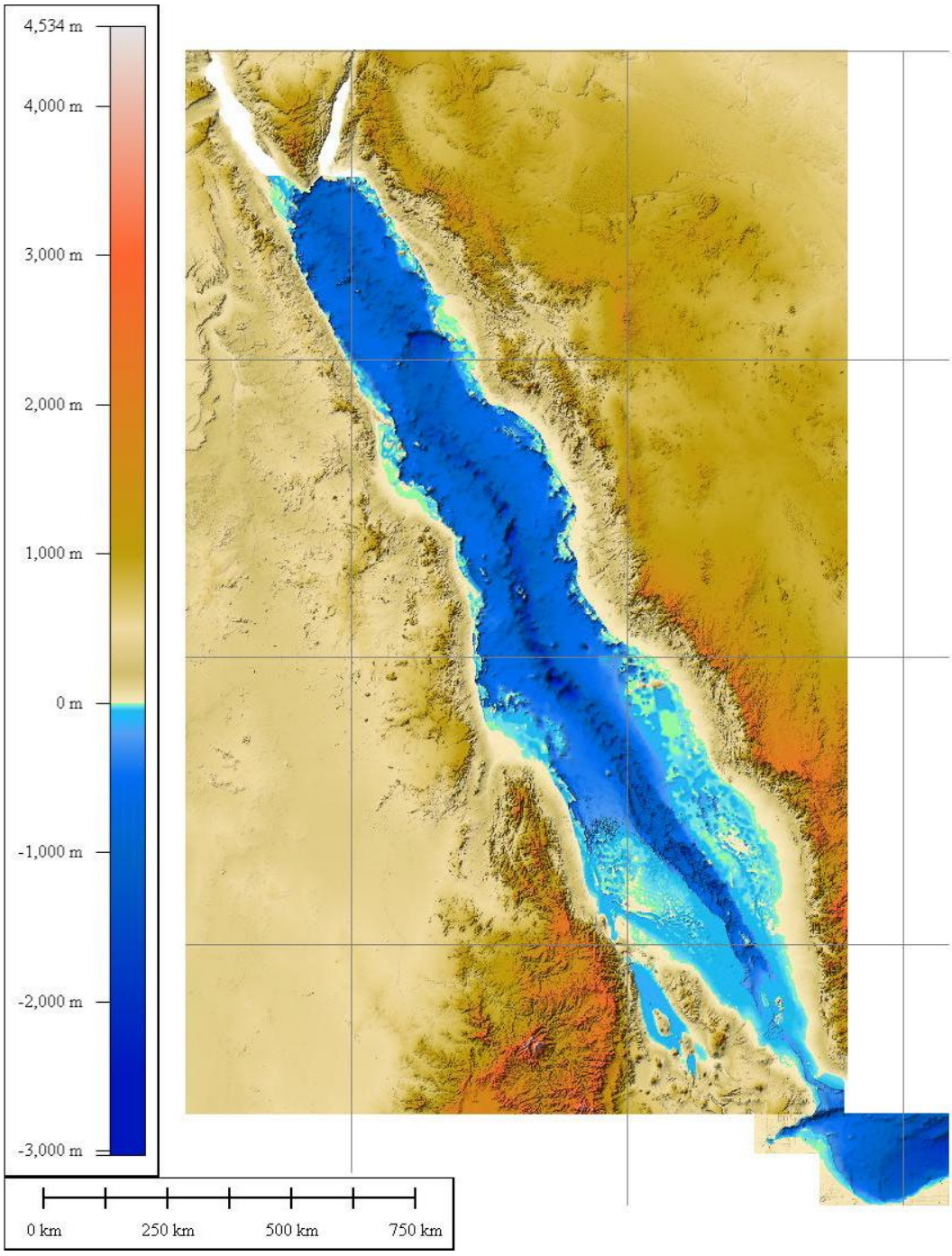
However under the influence of Martin Jakobsson, I began to organize the IBCM with ASTER-GDEM on land, MediMap Group data in the deeps, and some filling of the marginal gaps from my holdings from the past 40 years. This effort dissipated when Martin went off to Antarctica, and I got sidetracked by the Israeli mappings described above, and the Arctic program of the hovercraft below.

However the work on the Caspian and Red Sea (see below) have shown me the methodology to be used to fill in much of the 46,000 km of coast around the Mediterranean with shoal-biased data from navigational charts and other sources, at grid spacings down to 100m.

The Red Sea

This past summer I was privileged to join Dr. Robert Ballard's Vessel of Exploration the ***E/V Nautilus*** for 32 days on Mediterranean Legs NA008 and NA009. These explored Eratosthenes Seamount south of Cyprus, and then the Mediterranean offshore of Israel. Knowing of Bob's interest in exploring the Red Sea, I used the time at sea to begin digitizing the published bathymetric maps of the various Red Sea deeps. This was followed by a concerted effort to again use the Russian navigational charts to fill in the southern areas which I had never worked on. The northern Red Sea is pretty well covered. The

results are a 100m grid on the UTM projection, again using soundings, digitized contours, and assumed depths and heights for the myriad reefs and island.



The Arabian Sea and the Persian Gulf

Soundings digitized over the past two decades offer the possibility of already producing detailed grids of these seas of finer resolution than GEBCO and perhaps more suitable to GeoMapApp and GOMap.

3) The Arctic Ocean

The Research Hovercraft R/H Sabvabaa

This past summer was the third and last year of testing the hovercraft on the ice pack north of Spitzbergen, and testing the various light-weight equipment suites developed for the craft. To date more than 10,000 nmi of travel have been recorded north of the Arctic Circle. Some 13 dredge hauls were made in depths of over 500m using the light weight winch (see below). Seismic profiles were made using 20 in^3 airgun and 6 channel digital streamer, a sparker (white box on wing) and hydrophone which are part of an autonomous drifting seismic buoy, and our four-element Knudsen 3200 CHIRP shallow sub-bottom profiler.

The plan for 2011 is to place the hovercraft for 6 or more months over the area between Ellesmere Island and the North Pole where the oldest cores (~70 Myr) in the Arctic Ocean have been obtained, presumably due to an asteroid impact that has removed up to 500 m of sediment from an area of some 200 by 600 km. Placement of the hovercraft is dependent on carriage by an icebreaker which would also leave a supply of fuel sufficient for mobility. Our past tests have shown that the 2200 kg payload can safely be increased to 3500 kg.

The hovercraft is still seen as a very desirable site-survey vessel for the proposed European polar drillship Aurora Borealis which is slowly nearing construction.

Further Development and Testing of the SSPARR Echo-Sounding buoy.

In 2008 the original circuitry of the GEBCO-inspired SSPARR echo-sounder was moved to Christian Michelsen Research (CMR) SA in Bergen. CMR had been developing our methanol fuel cell powered autonomous drifting seismic buoy and its GPS locater and Iridium satellite communications link. In subsequent tests the original SSPARR was shown not to work, and the effort to revive it was considered to be unrewarding. Instead it was decided to build the system around the innards of a Syqwest EchoBox echo sounder, operating at 3.5 kHz.

The system was extensively tested last summer from the hovercraft. The contract with CMR to produce the control, navigation, and telemetry was concluded. The future suggests that a significantly more expensive SSPARR buoy will be possible, which, at the expense of Iridium air-time, would also supply CHIRP data. Our contribution of some $130,000 to this is in addition to the nearly $500,000 from two NSF grants.

ANNEX 7

Acronyms

AGU	American Geophysical Union
AIMS	Australian Institute of Marine Science
AMVER	Atlantic Merchant Vessel Emergency Reporting (System)
ATLIS	an independent privately owned software and consultancy company
AWI	Alfred Wegener Institute
BODC	British Oceanographic Data Centre
CCOM	Centre for Coastal and Ocean Mapping
CDI	Common Data Index
CGOM	Consultative Group on Ocean Mapping
COAST-MAP-IO	Coastal Mapping Capacity Building in the Indian Ocean
CD	Compact disk
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DCDB	Data Center for Digital Bathymetry
DHN	Direccion de Hidrografia y Navegacion
DTM	Digital terrain model
DVD	Digital video disc
EEZ	Exclusive Economic Zone
EMODNET	European Marine Observation and Data Network
ENC	Electronic Navigational Chart
EOS	Transactions of the AGU
EU	European Union
FTP	File transfer protocol
GDA	GEBCO Digital Atlas
GIS	Geographical information system
GMRT	Global Multi-resolution Topography
GMT	Generic Mapping Tools
GNS	Institute of Geological and Nuclear Sciences
GPS	Global Positioning System
HCA	Home Control Assistant
HO	Hydrographic Office
IBC	International Bathymetric Chart
IBCAO	International Bathymetric Chart of the Arctic Ocean
IBCSEP	International Bathymetric Chart of the SE Pacific
IBCSO	International Bathymetric Chart of the Southern Ocean
IBCWP	International Bathymetric Chart of the Western Pacific
IFREMER	Institut français de recherche pour l'exploitation de la mer
IGC	International Geological Congress
IHB	International Hydrographic Bureau
IHO	International Hydrographic Organization
IOC	Intergovernmental Oceanographic Commission
IOCM	Integrated Ocean and Coastal Mapping
iSCRUM	Interim Sub-Committee for Regional Undersea Mapping

ISO	International Organization for Standardization
IUGG	International Union of Geodesy and Geophysics
JAMSTEC	Japan Agency for Marine-Earth Science and Technology
JCU	James Cook University
KML	Keyhole Markup Language
LIDAR	Light Detection And Ranging
LDEO	Lamont-Doherty Earth Observatory
MBARI	Monterey Bay Aquarium Research Institute
MIT	Massachusetts Institute of Technology
NARA	National Aquatic Resources Research and Development Agency, Sri Lanka
NASA	National Aeronautics and Space Administration
NERC	Natural Environment Research Council
netCDF	Network Common Data Form
NF	Nippon Foundation
NGDC	National Geophysical Data Center, Boulder (USA)
NIWA	National Institute of Water and Atmospheric Research, New Zealand
NOAA	National Oceanic and Atmospheric Administration
NOCS	National Oceanography Centre - Southampton
NSF	National Science Foundation
PRC	People's Republic of China
QA/QC	Quality assurance/quality control
ROPME	Regional Organization for the Protection of the Marine Environment
SCAR	Scientific Committee on Antarctic Research
SCICEX	Scientific Ice Expeditions
SCUFN	Sub-Committee on Undersea Feature Names (GEBCO)
SID	Source Identifier
SOPAC	Pacific Islands Applied Geoscience Commission
SRTM	Shuttle Radar Topography Mission
TSCOM	Technical Sub-Committee on Ocean Mapping (GEBCO)
UKHO	UK Hydrographic Office
UNCLOS	United Nations Convention on the Law of the Sea
UNESCO	United Nations Educational and Scientific Organisation
UNH	University of New Hampshire
USB	Universal Serial Bus
USGS	United States Geological Survey
WG	Working group