

# HYDROGRAPHISCHE NACHRICHTEN

Fachzeitschrift für Hydrographie und Geoinformation

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HN 100

**First International Issue**

*Hydrography made in Germany*

4

- Bathymetry of Lake Constance
- Extensive sheet pile wall inspection in the Port of Hamburg
- Disputed boundary in the Ems-Dollart estuary
- Peter Ehlers: »In development aid Germany should adopt a leading role«





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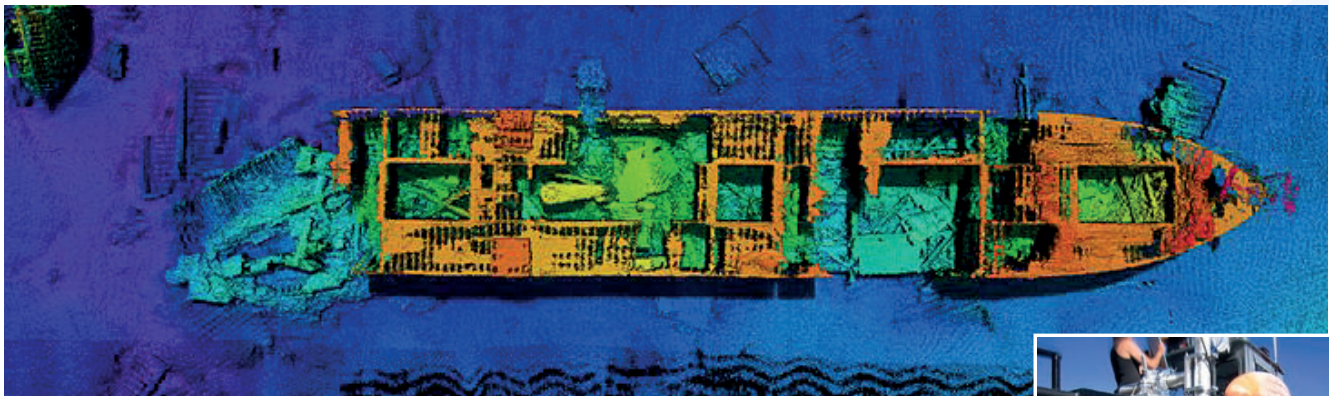
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# Dear readers,

*Hydrographische Nachrichten* is usually published in German; however, I presume that your job demands occasional or even daily communication in English with colleagues from all over the world. Not surprisingly, as the waters we survey are often between countries or even continents and do not know any language barriers. Therefore, this current edition is published entirely in English. You may find it strange at first, but I am sure, you will enjoy it from the very beginning.

Already in the Middle Ages there existed a common working language in seafaring: the so-called *lingua franca*. People communicated predominantly in Italian with a medley of French, Greek, Arab and Spanish. Fortunately, nowadays there is only one foreign language. English has become the *lingua franca* in science and technology.

We notice this especially in professional publications. You need to write in English if you want to be read and understood worldwide, or you publish an article right away in an English speaking journal. During the past years *Hydrographische Nachrichten* has been presenting some articles in English. Most of them were written by German native speakers, others were contributions by authors from abroad, whose feedback sometimes was: »I wish I could read the rest of your journal.«

So here we go. We are proud to present our first »International Issue« of *Hydrographische Nachrichten* completely in English. This premiere is at the same time the hundredth edition of our journal, which the German Hydrographic Society has been

publishing for more than 30 years now. We want to celebrate this anniversary with the most comprehensive and highest-circulation edition ever.

On more than 60 pages you will find exclusively high-quality articles by authors who work and research in Germany. However, thematically we don't focus on national topics, we rather want to present the wide spectrum and performance of hydrography made in Germany. You will find a lot of Germany in this issue, but also articles about the rest of the world, which we are part of. Although the starting point are German inland waters (Lake Constance, Hamburg Port) we will also look at the frontier relationship with the Netherlands at the Ems, go on to the world oceans and finally land in Micronesia.

We hope that the topics of this edition are of interest not only for our new international readers but also for the German readers. They will have the chance to discover the articles in a different context and in a more or less foreign language.

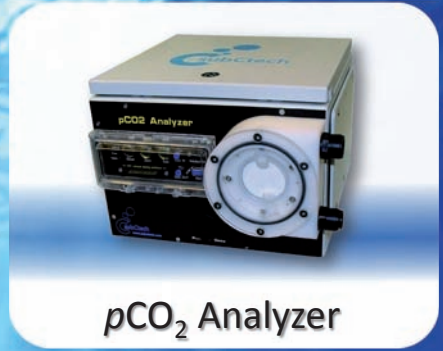
I hope you enjoy the inspiring and informative articles of this anniversary issue. And don't worry! The next edition of *Hydrographische Nachrichten* in June 2015 will again be in German.

Yours,

Lars Schiller



Lars Schiller



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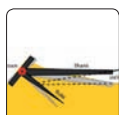
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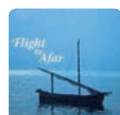
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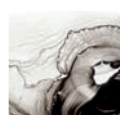
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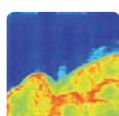
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The next issue of *Hydrographische Nachrichten* will be published in June 2015.  
Editorial deadline: 15 May 2015  
Advertising deadline: 15 May 2015

# Bathymetry of Lake Constance

## State-of-the-art in surveying a large lake

An article by MARTIN WESSELS and FLAVIO ANSELMETTI<sup>1</sup>, ROBERTO ARTUSO<sup>2</sup>, RAMONA BARAN<sup>3</sup>, GERHARD DAUT<sup>4</sup>, ALAIN GEIGER<sup>5</sup>, STEFAN GESSLER<sup>6</sup>, MICHAEL HILBE<sup>1</sup>, KARIN MÖST<sup>7</sup>, BERTHOLD KLAUSER<sup>8</sup>, STEFFEN NIEMANN<sup>1</sup>, ROBERT ROSCHLAUB<sup>7</sup>, FRANK STEINBACHER<sup>3</sup>, PAUL WINTERSTELLER<sup>9</sup>, ERNST ZAHN<sup>10</sup>

In 2014 the by far largest German lake has been newly surveyed. The transnational project is funded by the European Union and delivers a detailed 3D-model of the lake-floor. The German project name is »Tiefenschärfe – Hochauflösende Vermessung Bodensee«, which in English roughly means: high-resolution survey of Lake Constance. The German term »Tiefenschärfe« (in optics and photography: depth of field) plays with the meanings of »Tiefe« (depth) and »Schärfe« (sharpness). The result of the survey shall be a clear and sharp image of the deep and shallow lake-floor. At present the LiDAR and multibeam data are still processed, but first results are presented in this article.

### Authors

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Lake Constance | Tiefenschärfe | IGKB | lake level | geoid | groundwater intrusions | megaripples | pockmarks

### Introduction

Large institutions handling hydrographic information and companies developing tools in collecting and processing bathymetric data have a strong focus on marine environments. Nevertheless, there is a long tradition in collecting bathymetric information from inland waters, such as Alpine lakes. With this contribution, we present technical details and results of a state-of-the-art bathymetric survey of Lake Constance showing a number of specific aspects relevant for future surveys of other large lakes.

### Lake Constance

Lake Constance (9°30' E, 47°30' N) is a large (536 km<sup>2</sup>) and deep (254 m) lake with ~50 km<sup>3</sup> of water volume and a theoretical residence time of approximately 4.5 years. The lake has a catchment area of 11,500 km<sup>2</sup>, mainly located in the Alps and its foreland. The main tributary is the Alpine River Rhine (mean annual discharge of 7.66 km<sup>3</sup>), which contributes ~64 % of the total average inflow (Gillfedder et al. 2010) and which strongly determines sediment distribution and lake-floor morphology (Wessels 1995). Strong intra-annual variability of the runoff is reflected by mean water level-fluctuations of ca 1.5 m.

Politically, the lake is shared between Germany, Austria and Switzerland. Their boundaries were never defined for most parts of the lake (legal term: »condominium«), so that there rose the need for cooperation and the development for a number of trans-boundary organisations already in the late 19th century. As the lake is shared between these countries, different local coordinate systems with different lake levels are in use, which refer to Marseille (Switzerland), Trieste (Austria) and Amsterdam (Germany) and which result in height differences of 32 cm for the same lake level between the grids.

Ecologically, eutrophication problems became aware in the 1950s, which then initiated the foundation of the International Commission for the

Protection of Lake Constance (IGKB) in 1959 by the member states of Baden-Württemberg, Bavaria, Austria and Switzerland. After a maximum degree of eutrophication in 1980, the lake has recovered and returned to an oligotrophic state with low nutrients and declining fish yields. Today, the lake is regarded as one of the best studied lakes worldwide and supplies drinking water for about five million people. Independent of this successful re-oligotrophication, Lake Constance remains an ecosystem with multiple stressors and conflicts (e.g. intense leisure activities, ca 55,000 boats, a large diving community, rich archeological history (pile dwellings are UNESCO cultural heritage), use and restoration of shore lines, commercial fisheries, micropollutants, use of thermal energy, etc.), which now are the main tasks for the IGKB.

### Historical aspects in yielding bathymetric information

Lake Constance may act as an example for the long term development in bathymetric data, as already in 1825/26 Captain Gasser from the kingdom of Baden made a first bathymetric survey to describe the lake. He used a metal wire to measure 17 profiles crossing the lake. More than 11,000 measurements (20 measures/km<sup>2</sup>) using »bob plumb-ing« then were acquired between 1889 and 1891 (Zeppelin 1893, Hörnlimann 1893). The resulting »Zeppelin-map« was thereafter used as the basis for intensified research (Earl Eberhard Zeppelin is the brother of the constructor of the airship). As in 1900, the mouth of the Rhine river was artificially shifted 12 km to the east to avoid floodings in the Alpine Rhine valley (Wessels 1998), the construction management office for the Rhine River conducted a survey of the Rhine River delta since 1911 every ten years. Initially, mechanic bob plumbings were used along horizontally stretched wires, while later on, hydroacoustic systems, theodolites (e.g. Waibel 1971) and GPS were introduced when available.

A new basis for modern research was the survey of the entire lake between 1986 and 1990, initiated by the IGKB. In this context, echo sounder profiles with a maximum distance of 200 m and photogrammetric analyses of the shallow-water situation resulted in a 40 m grid for the deeper areas, and 10 m grid for the shallow-water zone (Braun and Schärpf 1994). These data already showed large-scale structures of the lake-floor (e.g. a meandering canyon resulting from underflows and turbidity currents of the Alpine Rhine River). Between 2008 and 2011, several small surveys used portable multibeam systems (e.g. Böder and Wessels 2009, Wessels et al. 2010) to collect data for high-resolution digital terrain models (DTM) to investigate pockmarks (concave depressions) at the lake-floor or archeological pile dwellings in the shallow water zone.

The latest step to achieve basic cartographic information was a survey to minimise height differences when modelling the geoid between Switzerland, Austria and Germany. German authorities (BKG) and the Institute for Lake Research agreed to collect data using a ship-mounted gravimeter (Schäfer et al. 2012).

#### Intention for a new topobathymetric survey

As the pilot multibeam surveys mentioned above showed the potential of modern hydrographic survey systems, the needs for a detailed topobathymetric survey were discussed. A working group assigned by the IGKB identified a number of reasons and needs:

- Basic data to evaluate and review long-term environmental changes (climate change, erosional processes within the shallow-water zone, geological risk analysis, etc.);
- Documentation of man-made interventions and precise definition of judicial terms (e.g. 25 m line);
- Planning of lake-shore measures, restoration of shore lines, conservation of archeological sites, measures for the prevention of anthropogenic long-term erosion;
- Input data for advanced 3D-modelling (e.g. for use of thermal energy, intrusion of waste waters);
- Scientific goals (neotectonics, investigation of lake-bottom structures, intrusions of ground water into the lake).

To fulfil these requirements for high-resolution data, the IGKB member states (Baden-Württemberg, Bavaria, Austria and Switzerland) decided to conduct a state-of-the-art multibeam survey, followed by an airborne LiDAR survey of the shallow-water zone. Combining both methods, it is possible to generate seamless DTMs from land into the deep areas. Both methods were complemented by an independent quality management. As a high public interest in these data was expected, the whole project should be accompanied by a professional public relation company.

The EU was approached for co-funding within the INTERREG-IV project, as INTERREG promotes cross-boundary cooperations in the Lake Constance area. A bathymetric survey of such a large inland water with latest technologies is not only a focus for the trans-boundary scientific community, but also for administrative players (e.g. surveying authorities) around Lake Constance. This complex situation (four surveying authorities in three national states), the size of the project (536 km<sup>2</sup>), and the combination of different latest technologies qualifies our project as a key example in handling these new technologies and huge data volumes.

Costs for our project – entitled »Tiefenschärfe – hochauflösende Vermessung Bodensee« – amount to 612,000 euros (shared between IGKB-member states and co-funded by INTERREG) excluding a lot of in-kind contributions (e.g. costs for ship and staff of the project partners from administrations). Preparations for the project began in December 2012, leading to its completion in the middle of 2015.

## Methods

### The multibeam echo sounder survey

The bathymetric survey for areas deeper than 5 m was carried out during 76 days from April to August 2013 using a Kongsberg EM 2040 multibeam echo sounder in a single-head configuration (1° × 1° beam width, 300 kHz standard operating frequency) on RV »Kormoran«. The transducers and ancillary sensors (antennas for RTK-GNSS positioning, GPS compass, motion sensor, sound velocity probe) were incorporated in a portable, rigid mounting attached to the bow of the ship. Predefined survey parameters included maximum swath angles and minimum sounding densities, depending on water depth, as well as general mission planning. For all areas below 40 m water depth, double coverage (~110 %) was required in order to achieve optimum data quality. Dual swath mode of the EM 2040 was used in order to maintain a reasonable survey speed while keeping sufficient point density and full lake-floor coverage.

In total, an area of 460.6 km<sup>2</sup> was covered by 2961 survey lines (total length 6,001 km), yielding 7,210,007,325 soundings. Typical achieved sounding densities are in average about 15 m<sup>-2</sup> in the deepest areas (250 m), where swath angles were restricted to ~40° to each side, >20 m<sup>-2</sup> at 100 m water depth with a swath width of 120° and about 50 to several hundred soundings a m<sup>-2</sup> in the shallowest zones (<10 m), where the full swath (75° to each side) was used.

High spatial and temporal variability of the thermal stratification of the lake made it challenging to maintain a valid sound velocity model of the water column. Therefore, a large number of individual sound velocity profiles (602) were taken during the survey, and applying sound-velocity correction turned out to be a crucial step during post-processing. The initial plans to use real-time



Hochauflösende  
Vermessung  
Bodensee

### Acknowledgements

We thank Kurt Sarembe and Andreas Schiessl, captains of RV »Kormoran«, for their extraordinary endurance with surveyors! We also thank IGKB and the INTERREG IV-programme of the European Union for funding of this project.



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positioning corrections over a cellular network-based Internet connection (which is in theory available for the entire survey area) with NTRIP had to be abandoned due to the insufficient stability of the connection, and post-processed RTK positions were used instead.

Since the new bathymetric data reveals potentially sensitive information (drinking-water intakes, archeological sites), it was decided that these features should be masked in the publicly available data set. During processing, the relevant soundings were classified and flagged, so that raster data sets, both including (equivalent of »digital surface model«, DSM) and excluding these soundings (equivalent of »digital terrain model«, DTM), can be generated.

Investigations of the geoid

The geoid, one of the main research topics in geodesy, corresponds approximately to the mean sea surface topography and serves as the reference for height indications like »above mean sea level«. The three-dimensional geometry of the lake’s surface has been determined simultaneously with the bathymetric survey.

A GPS-antenna and a down-looking acoustic ranger were tightly mounted on an outrigger to starboard ahead on the RV »Kormoran«. The acoustically determined distance from the antenna to the water surface is added to the precise GPS-position of the antenna. In doing so the complete lake’s surface has been sampled at about 3 cm precision in mean height, thus enabling a precise determination of the local geoid (Fig. 1). Disturbances like waves were removed by filtering whereas seasonal and meteorologically induced sea level variations, about 1.7 m during the measuring campaign, have been corrected by gauge data provided by hydrological institutions around the lake.

Topobathymetric LiDAR survey

Airborne laser scanning is a new and very effective concept for fast and economic mapping of large areas to collect high-quality, and high-resolution survey data. We combined a high-resolution spatial view at the lake-floor using LiDAR (>10 points/m<sup>2</sup>),

with high-resolution aerial (<10 cm/pixel) and thermal images.

The airborne hydromapping survey of Lake Constance (Fig. 2) was completed within three days using the hydrographic scanner VQ820-G of Riegl LMS in March and June 2014. A consistent point cloud was calculated with corrections for the individual scan strips by a strip-adjustment process. The relative accuracy of this procedure ranges between 0.07 m and 0.1 m (given as standard deviation). Then the point cloud was geo-referenced to terrestrially measured reference planes, which were distributed around the entire lake (accuracy about 0.08 to 0.09 m, standard deviation). The point density after combining all scan strips reaches up to 40 to 50 points/m<sup>2</sup> and about 20 to 30 points/m<sup>2</sup> near the shoreline in shallow areas, whereas it decreases to ca 10 to 20 points/m<sup>2</sup> at a depth of 4 to 5 m. We classified the point cloud into eleven classes (terrain on land/lake, vegetation, etc.) and three classes where remaining gaps had to be interpolated.

In a first step, flaw echoes were automatically filtered and the remaining was then corrected manually. Within an approximately 50 m wide strip along the shoreline, point classification was done manually to ensure a correct mapping of the water-land-boundary as well as correct classification of complex areas like harbours. The remaining foreland area with a distance of 300 m from the shoreline and the underwater area are classified automatically using algorithms and modules implemented in the software HydroVISH. Runtime and water depth correction were also determined within HydroVISH.

About 22,000 (± 2 %) aerial pictures were acquired using a mid-format camera (Hasselblad H3DII-39). With these pictures, a digital orthophotomosaic for the shoreline of Lake Constance is developed. The images are orientated based on an aerotriangulation, and orthorectified using the official DTM (1 × 1 m) of Austria, Switzerland, Bavaria and Baden-Württemberg. About 60 reference points and 20 control points were defined, and their coordinates were extracted from the LiDAR data in order to perform the aerotriangu-

Fig. 1: Lake’s surface departs from an ideal ellipsoidal reference and runs approximately parallel to the geoid. It reflects directly the form of the gravitational field (Geodesy and Photogrammetry, ETH Zurich)

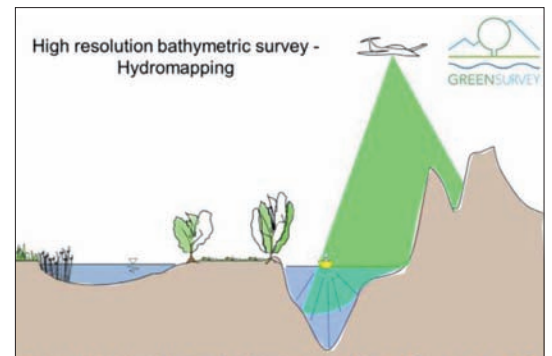
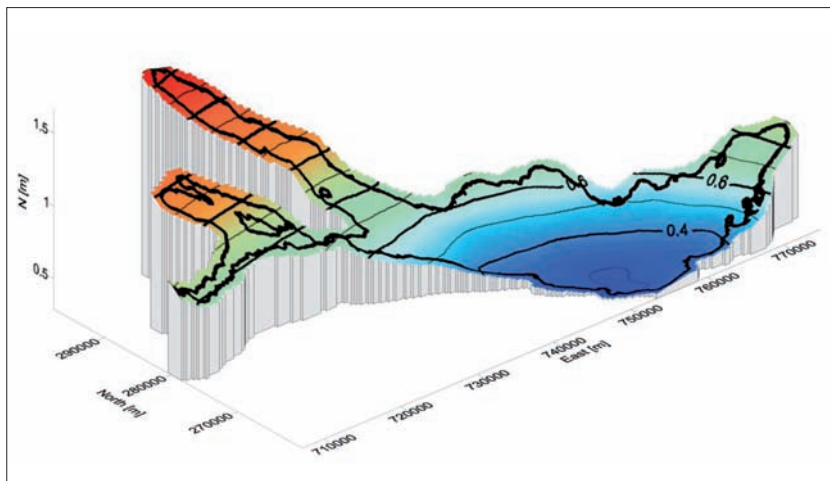


Fig 2: Shallow areas captured by hydromapping, deeper areas captured by echo sounder



lation. Afterwards, the pictures are orthorectified, and a radiometric correction is applied to homogenise the colour distribution of the entire image block. The mosaicking is performed along natural boundaries. Correction of seamlines is carried out only for image boundaries across buildings. The final ground resolution of the orthophotos is about 7 cm with an accuracy of less than 1 m (CE90).

### Quality management

The project »Tiefenschärfe« is attended by an external quality management from the beginning (preparation for tender to multibeam and LiDAR data acquisition) to processing and finalising products. To ensure a high-quality digital terrain model (DTM) the measured data are verified with several methods. An Innomar SES-2000 light sub-bottom profiler (SBP) run parallel to the multibeam measurements. Besides control points and area measurements along sub-aquatic archeological sites and bankside constructions like nose-piece, the depth traced with the sub-bottom profiler is used, once sound velocity profile corrected, to validate the multibeam and LiDAR measurements. In addition, cross lines and small double surveys are used for multibeam data verification in order to assure the requested IHO special order. Another task for the quality management is to cross-check the

SAPOS-based real time kinematic GPS-height/tide correction as well as the applied roll/pitch/heave corrections. Previous and recent digital orthophotos and especially ground control point measurements are used to validate the LiDAR surveys made within this project.

### Public relations activities

Within our public relation activities, a logo and a corporate design was designed by an advertising agency Lorth Gessler Mittelstaedt located in Konstanz. These products were already prepared for the kick-off meeting, which was accompanied by a press conference. Journalists had on board of the RV »Kormoran« the opportunity to observe the capacity of the online-visualisation of the multibeam acquisition software. Later on, a website, a brochure and a small exhibition in a public place in the village of Langenargen were realised. Two further press conferences and several appointments with journalists produced an outcome of more than 200 contributions in newspapers, websites, radio and TV in four countries.

### First results of project »Tiefenschärfe«

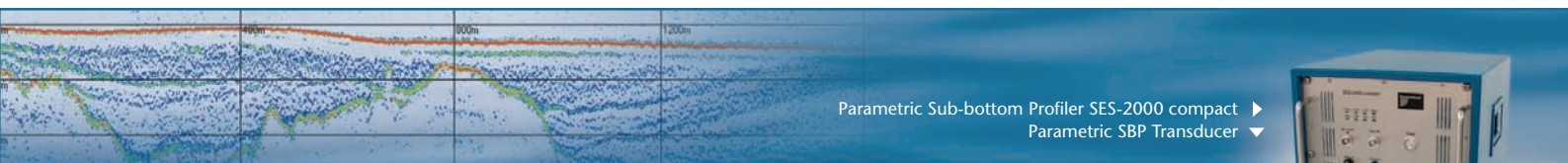
A lot of fascinating lake-floor features were already recognised during the surveys and later on refined during processing of data. Only few examples will be presented here as further evaluation will take

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## Call for Projects

### Innomar supports science

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#### What projects can apply?

Any research project at postgraduate level (MSc, PhD) with a hydrographic component can apply. Applications include hydrography, dredging, oil & gas, ports & harbours, renewables, environmental studies, underwater archaeology and geo-sciences. Field work should not exceed 2 weeks and must be performed in Europe. The project and report must be finished by 30 September 2015.

#### Who can apply?

Any student at postgraduate level enrolled at a European university or scientific institute can submit a proposal.

#### How to apply?

Please send your proposal to [project2015@innomar.com](mailto:project2015@innomar.com) (max. one A4 page). The final date for submission is 31 March 2015.

#### What can you expect?

Apart from active support with equipment and training we will invite the student with the most successful project to present the results during the 7<sup>th</sup> workshop "Seabed Acoustics" in Rostock, Germany in November 2015. The winning project will be published in Hydro International to bring your work closer to a wide audience in the hydrographic community.

#### What do we expect?

A final report in English must be submitted at the end of the project (max. four A4 pages). Innovation, commitment and submission on time are imperative.

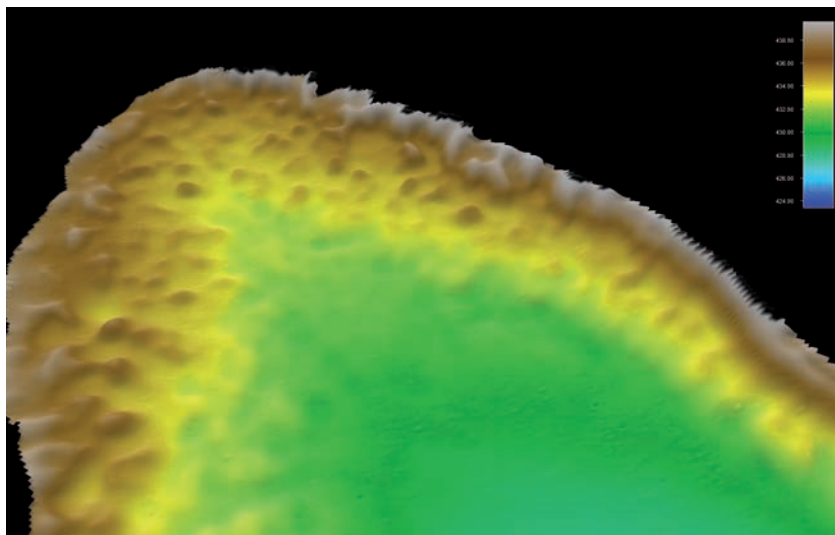
#### Important dates:

- ▶ submission of proposal 31/03/2015
- ▶ end of fieldwork 30/06/2015
- ▶ submission of report 30/09/2015

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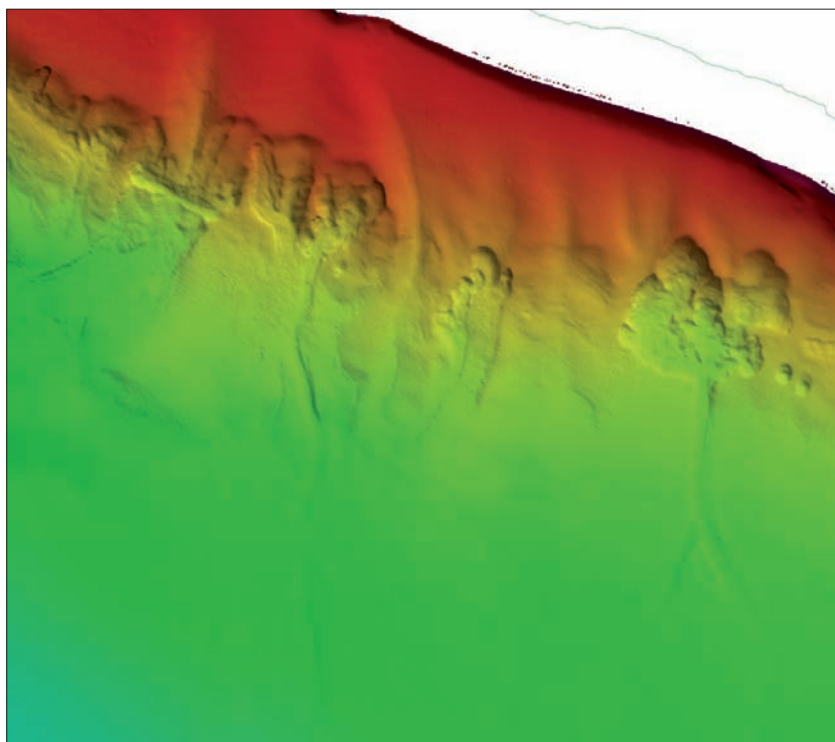
**Fig. 3:** Shallow areas of Gnadensee, a small isolated and protected basin part of Lower Lake Constance have a hummocky structure, probably a remnant of the retreating Late Glacial ice sheet

some while and final processing of the data is not yet completed. Thus, results and images presented here are still preliminary.

### Morphology in the shallow-water zone

One of the unexpected results is the morphology in the shallow-water zone of Lake Gnadensee, an isolated and somewhat protected basin of Lower Lake Constance. Here, large portions offshore the shorelines have a hummocky structure or are covered with large but shallow depressions (ca 10 to 50 m diameter, 0.2 to 0.5 m deep, Fig. 3). This was never observed before in any other part of the lake. So far, we speculate, that this protected part of the lake preserved some of the late glacial surface, when the Rhine glacier retreated from the Lake Constance basin. All other shorelines of the lake are much more exposed towards winds and waves, which probably levelled all of these structures at the shoreline. This interpretation is sup-

**Fig. 4:** Depressions along the slope give hints for groundwater intrusions into Lake Überlingen



ported by sub-bottom profiling data that show in other parts of the lake the morphology of the shallow-water zone being strongly homogenised since the Late Glacial.

### Indicators for lake-groundwater interactions

In deeper waters (about 80 to 100 m) of Lake Überlingen, the fjord-like northwestern arm of the main basin of Upper Lake Constance, large and irregular depressions with sharp upslope edges and smoother lake ward boundaries occur (Fig. 4). These depressions lack any hints for rock slides or mass movements and are currently interpreted as caused by groundwater discharge into the lake. In a new project, we will investigate if indeed groundwater-sources (e.g. from nearby molasse-rocks) may contribute to the water budget of Lake Constance. Even though springs within the molasse are often observed, their contribution to the overall water budget of the lake is unknown. These features are in particular interesting as they may contribute to significant boundary conditions regarding the discussion of fracking technologies in the vicinity of the lake.

### Topobathymetry in the shallow-water zone

Water levels of Lake Constance usually differ about 1.5 m (max. 3 m) with maximum wave height of up to 2.5 m. This results in a high degree of erosion and accumulation which is increased by ship waves and strongly endangering cultural heritage like pile settlements. Despite these forces which tend to equalise morphology, our new data show a high degree of morphological patterns in the shallow-water zone (e.g. megaripples near the mouth of the River Rhine, Fig. 5). These of course were known (and visible in orthophotos) but with dimensions never investigated in detail in a lake. Thus, the new data will strongly help to understand the functioning of the shallow-water zone in a large lake.

### Flight into the lake

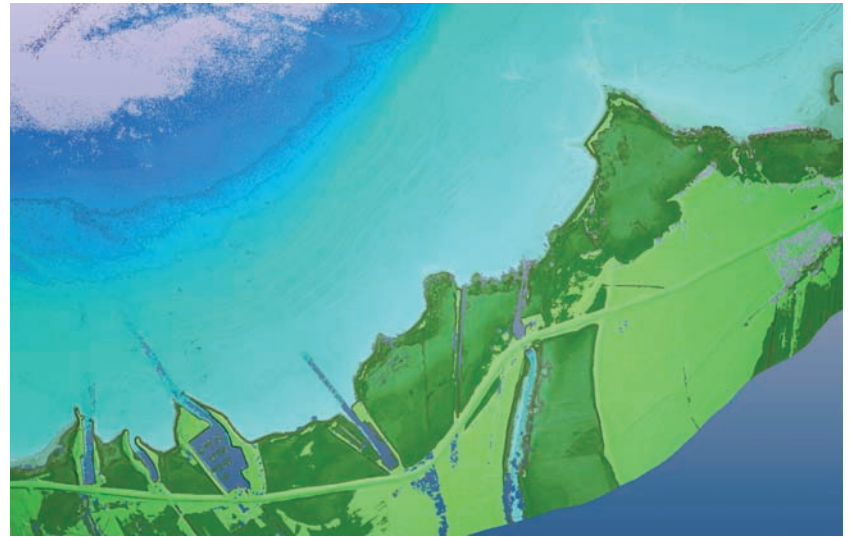
Besides the above mentioned basic technologies, a number of existing data sets have to be handled. To visualise the bathymetry, a virtual flight from the surrounding region into the lake is anticipated, fuelling the high degree of enthusiasm of the public for the rich underwater landscape, which eventually will help to protect the entire lake. This flight should visualise the existing data (on land) and the new underwater data (from LiDAR and multibeam) for the public. For that flight, digital orthophotos (DOP) with a resolution of up to 20 cm and DTMs with 1 m grid size were transformed from four national grids into a unique coordinate system. Errors occurring when combining the data sets of different origin were corrected manually with software solutions that are able to handle the large image files. Once this product is finished, the visualisation is done using two different resolutions: in a first step, DTMs with 10 cm resolution will be covered

with a 4 m DOP. LiDAR and multibeam data from the lake will then be integrated in a second, high-resolution level, so that, when flying into the lake, the visualisation automatically switches into the relevant level.

### Experiences and challenges

Our project resulted in a number of lessons and experiences in addition to the lake-floor data. Technically, a project of this size is really difficult to handle, as small freshwater bodies are much more variable compared with fully marine systems. Especially in nearshore regions, water bodies strongly differ spatially and temporally, in particular in spring and early summer, when the lake is rapidly warming. So far, also advanced processing software packages (Caris HIPS and SIPS) still lacks a proper handling of the high numbers of sound velocity profiles in a satisfactory way (we measured 602 profiles). Also, possibilities to handle and classify data which should not be visible in the final products (mainly inlets for drinking water supply and relevant archeological objects) are limited so far.

When processing LiDAR topobathymetric data, there is no solution to achieve lake-floor data in densely vegetated areas. Further, the methods presented will have limitations when used e.g. for vegetational studies with submerged macrophytes.



**Fig. 5:** Airborne LiDAR data of the Rohrspitz impressively show the rich morphology in the shallow-water zone with long megaripples parallel to the shoreline

Experiences from our trans-boundary cooperation of the surveying authorities will help to execute further national surveys, as boundary conditions (e.g. coverage of multibeam swaths) can be well defined and evaluated, and data processing and handling can be better planned. In fact, new projects are already anticipated in Switzerland that will also combine topobathymetric LiDAR and multibeam echo sounder data. [↕](#)



Kameras



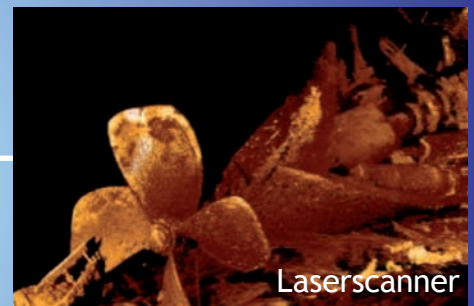
Beleuchtung



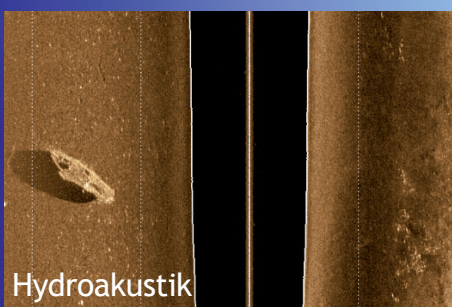
ROV



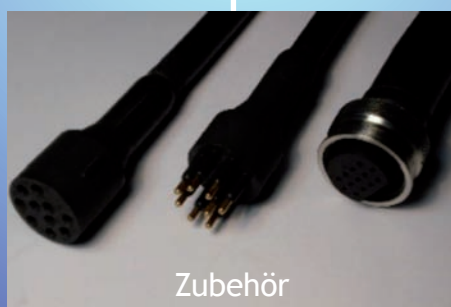
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Laserscanner



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# Extensive sheet pile wall inspection in the Port of Hamburg

An article by ISABELL MÜCKE

In spring 2014 a survey was conducted in the Port of Hamburg to examine the condition of a quay wall. For this purpose Kongsberg Maritime Embient GmbH (KMEMB) introduced a three-stage inspection concept, which provides, according to the current state-of-the-art sonar-techniques, best possible information and analysis of the inspected object, while significantly reducing survey time and costs related to the inspection. On basis of the survey data, a complete picture of the quay wall was created. Several areas of specific interest have been detected, such as bended sheet piles, scouring and distorted steel plates.

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quay wall inspection | underwater inspection | MBES | multi-frequency scanning sonar | 3D modelling

## 1 Introduction

Three-dimensional inspections of underwater structures are a specific survey challenge, requiring specialised techniques and methods. In extreme environments, such as a basin in a port, optical sensors and divers might be limited due to a very high particle load in the water column. Divers also struggle with limitations of their working time under water. Acoustic methods are not affected by these issues, making them an effective, innovative approach for in-port surveys. Methods and techniques are generally customised, depending e.g. on the geometry, the desired resolution and the distance from the investigated object to the transducer. However, the acquisition of high-quality data covering large complex subsea structures in short order, remains a major challenge. Here, a combination of different inspection methods is essential to ensure an optimum coverage of the inspected subsea structure. For this purpose KMEMB introduced a three-stage inspection concept, which provides best possible information and analysis of the inspected object. The concept is based on a cost-efficient overview survey. This data is used to define specific locations of interest, where a more time-consuming high-resolution survey will be performed. The combination of these methods ensures that the most important areas are covered in fine detail, whilst achieving a full overview of the location. In this article, we present the results of a survey conducted by KMEMB in cooperation with Kongsberg Maritime in Germany and Kongsberg Mesotech Ltd., supported by Hamburg Port Authority.

## 2 Three-stage inspection concept of subsea structures

The three-stage inspection concept is based on a multibeam echo sounder survey. Multibeam systems provide coarse, but accurate point cloud data in relatively short time, which makes multibeam mapping an effective and fast method for an overview inspection of underwater structures. The recorded point cloud data delivers quantitative information and can be used in post-processing for three-dimensional measurements and volume calculations. Nevertheless, the method is subject to

some limitations such as acoustic shadow zones, which appear at structures with a complex geometry. Furthermore, the minimum resolution of the systems is limited by the distance from the transducer to the object and the swath opening angle. Thus, the use of multibeam systems alone may not lead to the required resolution when mapping key subsea structures.

Hence, a scanning sonar is used for a more detailed examination of the subsea structure during the second stage of the inspection. Opposed to multibeam echo sounders, scanning sonars provide, depending on the mode settings, either high-resolution profiling data (profiling mode) or imaging data (imaging mode). Imaging data provides high-resolution qualitative information, which can be used for precise visual analysis and two-dimensional measurements. In contrast, high-resolution three-dimensional point cloud data, revealed in profiling mode, achieves better data precision and density, as well as reduced shadow zones in comparison to multibeam point cloud data. Furthermore, profiling data is very useful for modelling. Nevertheless, due to the high time expenditure of profiling measurements (one high-resolution scan can take up to several hours), it is only efficient and economical to conduct these measurements in specific locations of interest. These locations are defined after the analysis of the previously recorded multibeam and imaging data.

In the third stage of the inspection concept, quantitative (imaging data) and qualitative (multibeam and profiling data) information are processed and combined, before the data set is analysed and interpreted.

## 3 The Amsterdamer quay wall survey

For running the three-stage inspection concept, the Amsterdamer Kai, located in the Dradenauhafen in the Port of Hamburg, was selected as the survey site in spring 2014. The investigated quay wall is about 500 m in length and is used as a docking place for freighters and barges. The main task of the project was to examine the condition of the quay wall, which is made up of several fixed sheet piles. Particular attention was paid to the steel plates, which

were welded on the sheet pile wall to repair former damage. The shape of the investigated sheet wall is an isosceles trapezoid, with the wide side facing outwards, which makes it susceptible to the formation of shadow zones in sonar data. This had to be considered during planning and measuring. Furthermore, KMEMB had to deliver precise, high-resolution data to determine possible areas of interest (e.g. deformations) and the corresponding location (exact position and depth). In order to meet these requirements, KMEMB used the three-stage inspection concept as a guideline for the survey.

### 3.1 Method

Following the three-stage inspection concept, a multibeam overview survey was conducted, followed by a high-resolution survey and the final processing, analysis and interpretation of the combined data set.

#### Project phase I: Overview measurement and extensive recording of qualitative data

During the first phase an overview measurement of the sheet pile wall and the adjacent sea-floor was conducted using a Kongsberg EM2040 multi-beam system. The system operates at a frequency of 400 kHz with a beam width of  $0.4^\circ \times 0.7^\circ$ . During survey the transducer was mounted at a pole on the side of the survey vessel and orientated towards the quay wall. Motion data was acquired by a Kongsberg Seapath 330 Inertial Navigation System, and VRS (Virtual Reference Station) corrections were received via GSM modem. The measurement was repeated several times. During the individual measurements, the vessel was sailing along various profiles with respect to the quay wall, which resulted into varying positions and sizes of shadow zones in the multibeam data. Through the combination of these individual data sets, the shadow zones could be reduced during post-processing.

#### Project phase II: High-resolution survey

The multibeam survey was followed by a high-resolution survey, conducted with a Kongsberg Mesotech 1171-Series high-resolution, multi-frequency, Fan/Conical Beam Transducer Scanning Sonar (MS 1171). This sonar supports two different modes of operation. It was first used in imaging mode and then in profiling mode. During imaging survey, a fan-shaped acoustic beam is produced to scan a specified area or feature, while during profiling survey a narrow, conically shaped beam generates a single point for each ping.

#### Project phase II: Imaging survey

For imaging survey, the scanning sonar was deployed on a pole, which was adapted to a mobile working platform (man lift). The platform was operated on shore, illustrated in Fig. 1. The sonar head was in approximately 1 m water depth during measurement. The sonar was operated with linear frequency modulated (LFM) pulses using a fre-

quency of 1,100 kHz and producing a beam width of  $0.6^\circ \times 45^\circ$ . Every ten metres, scans with range settings of 15 m were performed to ensure good overlap coverage between scans (Fig. 2), whereby the scanning time was approximately 1 minute per scan. The whole quay wall was recorded this way. A data example (screenshot) during imaging survey is shown in Fig. 3. The distances between the individual scans were selected deliberately, in order to produce an image overlap to eliminate in later processing the typical data gaps in the centre of rotation of the sonar head (Fig. 1 and Fig. 2).

#### Project phase II: Profiling survey

After a short data analysis of the recorded multi-beam and imaging data, a profiling survey was per-

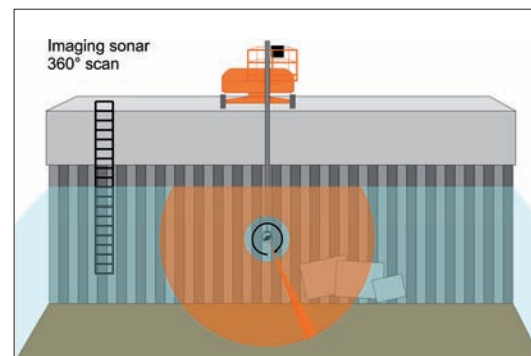


Fig. 1: Survey configuration in imaging mode

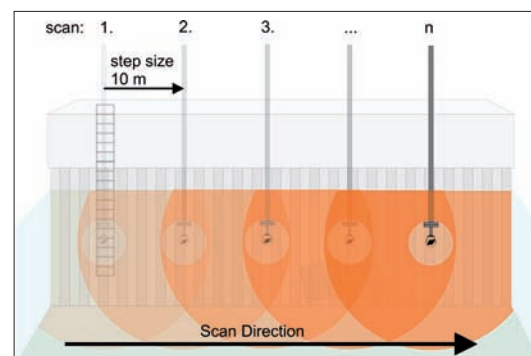


Fig. 2: Scanning positions and procedure in imaging mode

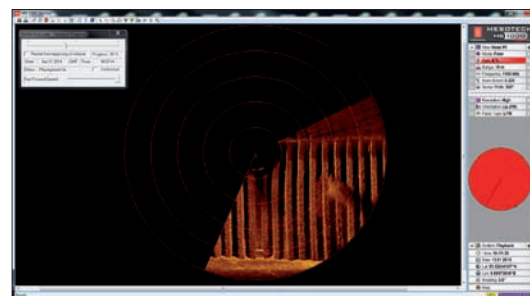


Fig. 3: Screenshot of a data example during imaging survey

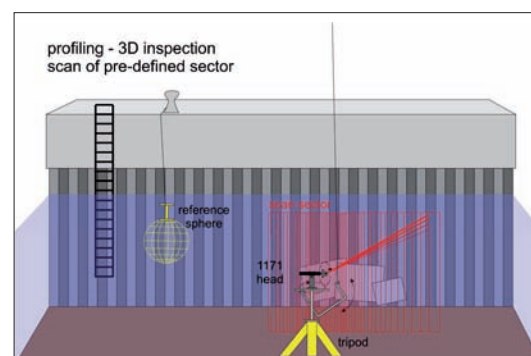
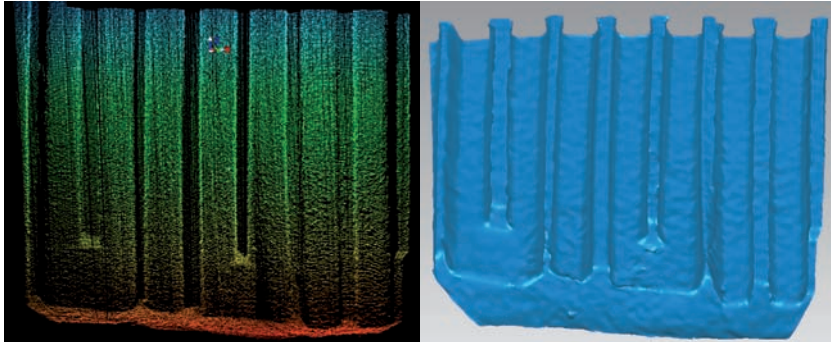


Fig. 4: Survey configuration and procedure in profiling mode



**Fig. 5:** Data example of high-resolution profiling data (left), and a 3D-model based on high-resolution profiling data

formed in areas where features (e.g. welded steel plates) were identified. For this purpose the single-axis profiling head was integrated with a Kongsberg Mesotech Heavy Duty Rotator (mechanical second axis drive), which was mounted on a tripod assembly. The tripod was placed on the sea-floor with the sonar adjusted parallel to the quay wall, displayed in Fig. 4. This method provides high-resolution three-dimensional profiles. After collecting the single axis profile, the head rotates by the second axis drive through preset increments and the scan process repeats. This generates a grid of profile points from a single position, after which the processed data generates a three-dimensional point cloud. During measurement the operating frequency of the sonar was set to 1,100 kHz with beam width of  $1^\circ \times 1^\circ$  and the pulse type to LFM. The step size of the rotator was set to maximum resolution (0.225°). Thereby a point resolution of 1–2 cm was achieved. The time needed for one 45° scan was approximately two hours, whereby about 130,000 data points were collected. Due to the tripod deployment method, the

survey was conducted using relative positioning. The resulting point cloud data was co-registered and geo-referenced in the post-processing phase, using the multibeam data from project phase I.

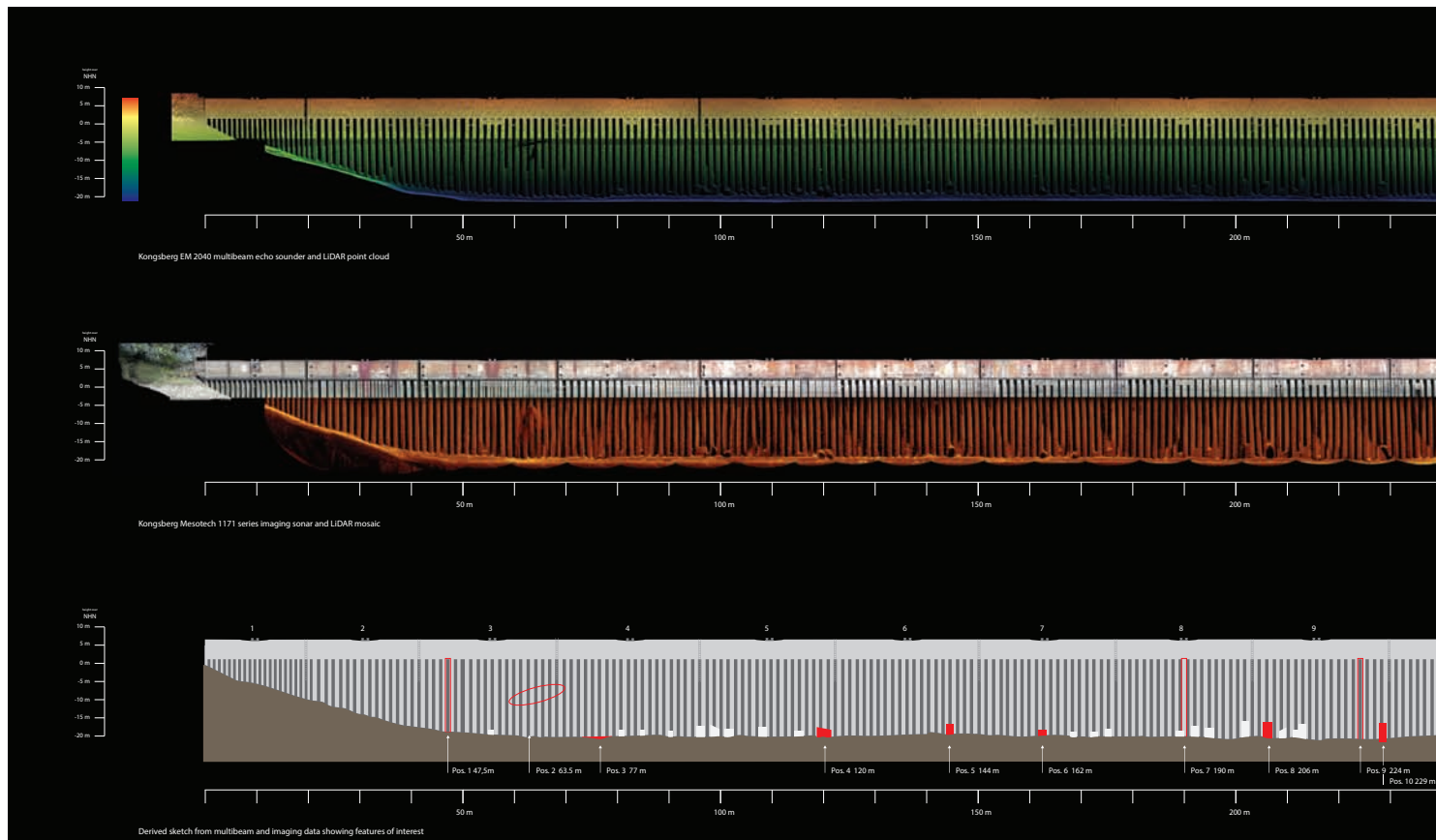
### Project Phase III: Processing

After finishing the data recording, the third stage was devoted to several processing steps to combine the recorded quantitative (imaging data) and qualitative (multibeam and profiling data) information. The single imaging scans on the one side and the multibeam profiles on the other side were merged to overview pictures and geo-referenced in relation to the quay wall. In addition, the multibeam data were supplemented by laserscan data, which were provided by the Hamburg Port Authority and show the part of the quay wall that is above sea level. Besides that, 3D models were generated using both multibeam data and point cloud data from the high-resolution profiling survey (for high-resolution model see Fig. 5). On this data basis, a complete picture was created and the condition of the quay wall could be analysed.

### 3.2 Result

The full picture of the quay wall after data processing is illustrated in Fig. 6. Several features have been detected, such as bended sheet piles, scouring and distorted steel plates. Larger features were identified in the multibeam data, while smaller features were identified in the imaging data. For instance, after analysing the imaging data, small deformations (2–10 cm) have been detected on the lower part of the sheet piles, which have not been

**Fig. 6:** Result of the Amsterdamer quay wall survey: imaging data of the wall (upper panel); multibeam and laserscan data of the wall (centre panel); 2D-model of the wall, showing identified features (lower panel)



**Multibeam survey**

| Pro  | Con   |
|--|---|
| <ul style="list-style-type: none"> <li>• Good survey coverage in short time, providing a geo-referenced overview for future detail scans (profiling)</li> <li>• Good positioning accuracy</li> </ul> | <ul style="list-style-type: none"> <li>• Small anomalies cannot be identified</li> <li>• Shadows due to the shape of the structure</li> </ul> |

**Imaging survey**

| Pro   | Con   |
|---|---|
| <ul style="list-style-type: none"> <li>• Very short timed survey per single scan location</li> <li>• Small anomalies can be resolved</li> </ul> | <ul style="list-style-type: none"> <li>• Scan results are very dependent of scanning head stability (mounting is important)</li> <li>• Only 2D measurements are possible</li> <li>• Slant range distortion</li> </ul> |

**Profiling survey**

| Pro  | Con  |
|--|--|
| <ul style="list-style-type: none"> <li>• Best achievable resolution</li> <li>• Minimal development of shadow zones</li> <li>• Generation of exact 3D model possible</li> </ul> | <ul style="list-style-type: none"> <li>• Scan results are very dependent of scanning head stability (mounting is important)</li> <li>• Scan duration may be very time consuming</li> </ul> |

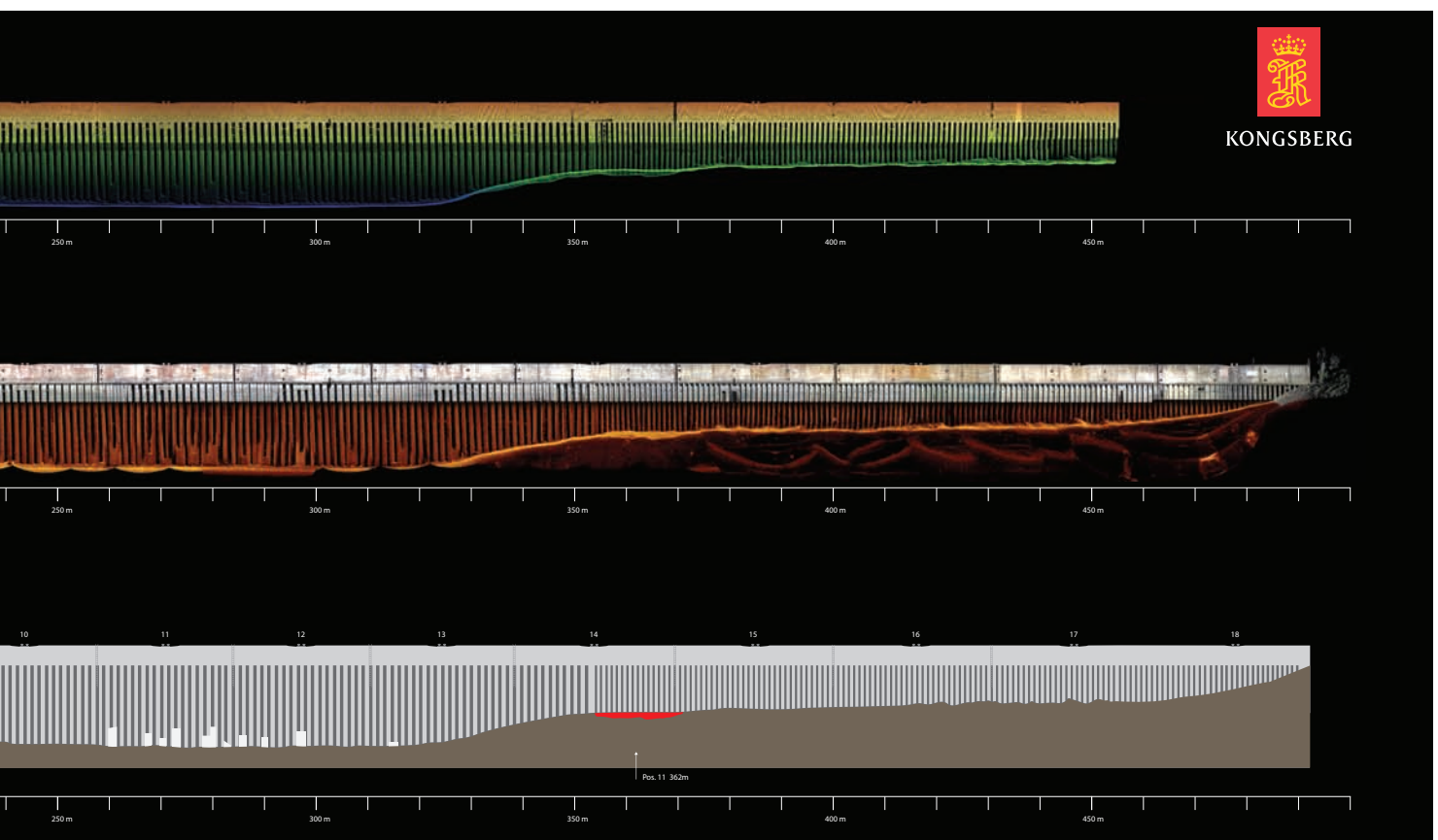
noticed in the multibeam data. In contrast, the recorded point cloud multibeam data allowed the identification of the direction and shape of the deformation of sheet piles, which cannot be derived from the imaging data. As a final result, the quay wall is illustrated as a 2D-model (see Fig. 6, lower panel) with all identified features. This is used as the basis for the required upcoming work, where for instance divers can be sent directly to the surveyed features. Finally, the high-resolution point cloud, derived from the profiling survey, as well as the multibeam data were used for the generation of 3D-models. Due to the limited point cloud density and accuracy, the multibeam data model shows different artefacts and uncertainties. Compared to that, the high-resolution profiling model, displayed in Fig. 5, shows significantly less shadow zones and fewer distortions.

#### 4 Conclusion

The three-stage inspection concept offers a wide range of information that is crucial for a complete analysis of an investigated subsea structure. The combination of individual data sets of different sonar systems involving differing time commit-

ments and different resolutions make it possible to ensure an optimum coverage of the investigated subsea structure in the shortest time possible. The concept has been structured in such a way that the different restrictions of the individual devices are neutralised when applying these in the overall concept, which is demonstrated in Fig. 7. The final result exhibits both qualitative and quantitative information. The quantitative information is provided by high-resolution imaging data, while qualitative information is provided by multibeam and high-resolution profiling data. The initial inspection of a quay wall in size of the conducted survey, including the baseline survey with post-processing and identification of features, the detailed high-resolution survey with post-processing, and the final reporting and documentation, will last about 20 days. The final result will be an illustration like in Fig. 6, without being at risk to miss any feature. Based on this full picture baseline survey, repeated surveys of the identified critical features only utilising the scanning sonar, can be conducted at longer intervals. A repeated survey is estimated to be in the area of 2–3 days only, including post-processing and documentation. [↕](#)

**Fig. 7:** Summary of the three inspection methods with pros and cons



# How deep is deep enough?

## Anchor penetration tests in the German Bight to optimise burial depth for subsea power cables

An article by CHRISTIAN MAUSHAKE

»How deep does an anchor penetrate the sea-floor?« This question has been examined by a team of scientists and technicians in Germany. The motivation for this large-scale fieldwork was the use of sea cables for shore connections to offshore wind farms in the German Bight. The current regulations prescribe a burial depth of 3 m when sea cables cross shipping channels. The reason for this increase is to guard against the risk factors arising from anchor manoeuvres in emergency and disaster situations. Conversely, implementing a burial depth of 3 m is technically very ambitious as well as being very cost-intensive.

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subsea power cable | grid connection | anchor penetration test | hydrographic survey | German Bight

### Introduction

There are currently 1,500 km of subsea power cables installed in the North Sea and some 1,800 km more are planned. Many of them underlying major shipping channels like the Traffic Separation Scheme (TSS) »Terschelling – German Bight«, which is part of the German Exclusive Economic Zone (EEZ) and one of the busiest waterways worldwide. In areas like this, the goal is to define an optimal burial depth for the subsea power cables transferring energy from the offshore wind farms to the shore. Criteria are (among others):

- Protection of the subsea power cable itself;
- Reduction of time and costs for laying and maintenance;
- Protection of the marine environment;
- Requirements of fisheries and shipping.

One of the issues in this context is to determine the depth, to which ship anchors can endanger buried subsea power cables. To guard against the risk factor arising from anchor manoeuvres in emergency and disaster situations the regulations for the TSS »Terschelling – German Bight« prescribe a burial depth of 3 m below the seabed. Outside this area subsea power cables are buried generally at 1.5 m below the seabed. Due to locally difficult

soil conditions in the German Bight the implementation of a burial depth of 3 m is ambitious from a technical point of view as well as being very cost-intensive. Hence, a discussion between the transmission system operator and the approving authorities about the possibility to reduce the prescribed burial depth has been initiated.

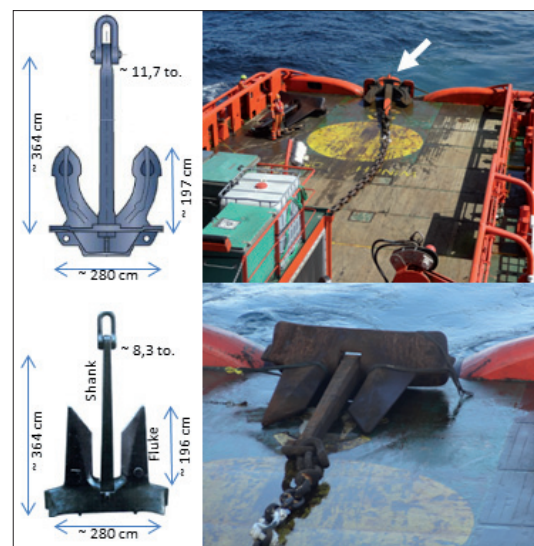
To gain more information on the level of risk involved in a possible reduction of the burial depth, a consortium of stakeholders embarked upon a field measurement programme in order to determine the real penetration depths of anchors into the sea-floor. Alongside the transmission system operator TenneT and the approving authority (Waterways and Shipping Administration of the Federal Government, GDWS), the Federal Maritime and Hydrographic Agency (BSH), the Dutch research institute Deltares and the Federal Waterways Engineering and Research Institute (BAW) have been involved in the field measurement programme, its documentation and the scientific evaluation of the results. The results of the experiment will potentially support and substantiate the enhancement of the regulations for the burial depth of subsea power cables in the TSS. The most relevant regulations are formulated in the »Spatial Offshore Grid Plan« which is issued and updated by the BSH for the German EEZ. The plan is being coordinated in consent with other federal agencies like the GDWS for nautical concerns.

### Anchor penetration tests

One 8.3 tons AC14 anchor and one 11.7 tons Hall anchor have been selected for the implementation of the anchor penetration tests (Fig. 1). These were accepted to be representative for a 294 m long container vessel of 80,000 dwt, which has been chosen as the design vessel after traffic analysis in the TSS. The anchor equipment like chain, shackles and forerunners gave another 8.7 tons of weight and the total length measured from the anchor to the stern of the vessel is about 140 m.

In process of planning the experimental setup the strong interaction between the behaviour of

**Fig. 1:** Anchors used for the trials with dimensions: Hall anchor (top), AC14 anchor





a ships' anchor and the sea-floor has to be considered as well. Therefore, three different test-sites (»BSH Nord«, »BSH Süd« and »VTG« in Fig. 2) have been designated where geotechnical data are available and the soil conditions are representative for the area of the German Bight. They range from loose, fine sand and relatively dense sand to densely packed sand layers over consolidated stiff clay in the TSS (VTG) (Fig. 2).

The field measurement programme required four vessels, including an offshore support vessel, the »Esvagt Connector« (Fig. 3) to handle, drop and pull the anchors, and two survey vessels, the »Guardian« and the »Wega« (Fig. 3) to carry out surveying and ROV operation, and a guard vessel to keep other vessels clear during operations carried out in the TSS »Terschelling – German Bight«.

Within each of the three test-sites the anchor drop positions were predefined and every test-site was initially surveyed using side-scan sonar (SSS) and sediment echo sounder (SES) to check the seabed characteristics and detect possible obstacles.

Three trials with each of the two anchors were carried out in each of three test-sites. That gives a total number of 18 trials following a precisely specified procedure. One of the trials failed so that in the end 17 data sets are available for analysis.

The anchor drops were carried out by lowering the anchor slowly to a level of 10 m above the seabed, then releasing the winch. The winch brake was applied after approximately 15 m of chain payout. Once the anchor had been set a ROV was launched to make a video check of the anchors position and location on the seabed. If necessary the anchor was then orientated in line with the chain before the pull starts. This ensured maximal anchor performance, what means maximal penetration depths for the purpose of a worst-case scenario. The anchor handling vessel »Esvagt Connector« then moved ahead while paying out all chain and a further 100 m of wire. Pulling tests were then carried out, stopping at anchor break-out or when a pulling force of 800 kN was reached as a safety precaution. In fact the maximum measured pull during the trials was ~950 kN. The maximum bollard pull of the anchor handling vessel »Esvagt Connector« is specified with ~1050 kN (10 kN ≈ 1 ton).

After completion of the pull the final anchor position was again located and inspected by ROV video before being recovered to deck. The track and the final position of the anchor then were surveyed by a multibeam echo sounder (MBES), a side-scan sonar (SSS) and a sediment echo sounder (SES).

### Hydrographic survey

MBES and SSS have been used to identify and map the anchor tracks on the seabed. These systems are capable to sweep large swaths of the seabed, but they are not able to penetrate it. Only the sur-

face of the sea-floor is being detected. In contrast to that an SES is able to penetrate the seabed – although in a line not in a swath – and to visualise vertical sediment structures and layers as well as e.g. embedded objects. Therefore, the SES played the key role in the detection of the anchor penetration depth because it has to be assumed that the anchor track refills with sediment quickly after the pull and the spot of maximum influence depth lies underneath »fresh« sediment.

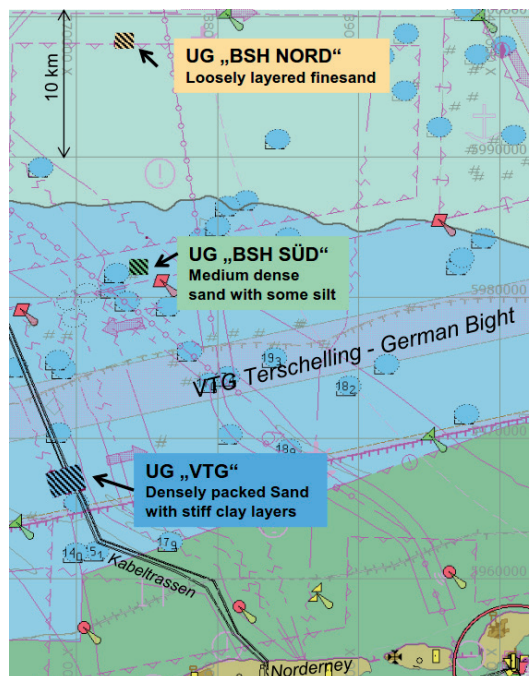
The survey of the anchor tracks was conducted in two steps. First an SSS sweep identifies the anchors track and the start and ending position of the anchor pull. This gave the baseline for the second step: A cross-sectional SES survey perpendicular to the anchor track. The distance between the survey lines was kept as small as possible. Depending on the length between 2 and 13 crossings of an anchor track could be achieved (Fig. 4 and 5).

The impact of the anchor could clearly be identified for all of the 17 processed trials. Goal of the analysis was the detection of the »deepest point of influence« in the seabed. The dragging of an anchor through the seabed generates local changes in the sediment structures, like loosening, compression or displacing. These changes in sediment properties can be detected with an SES as a transition e.g. from a loose to a dense state which is caused by dragging the anchors' flukes through the seabed. This »deepest point of influence« can be digitised as a depth value and was compared

### Spatial Offshore Grid Plan

In the Federal Energy Act the German Federal Maritime and Hydrographic Agency (BSH) was given the legal task to issue and annually update a »Spatial Offshore Grid Plan« for the German Exclusive Economic Zone (EEZ). The plan is being developed in consultation with other governmental agencies like the Waterways and Shipping Administration of the Federal Government (GDWS) for the nautical concerns. Its aim is to ensure coordinated and consistent spatial planning of grid infrastructure and grid topology, particularly for the grid connections of offshore wind farms in the German EEZ of the North and Baltic Sea up to the 12 nautical mile border of the territorial waters.

More information:  
[www.bsh.de/en/Marine\\_uses/BFO/index.jsp](http://www.bsh.de/en/Marine_uses/BFO/index.jsp)

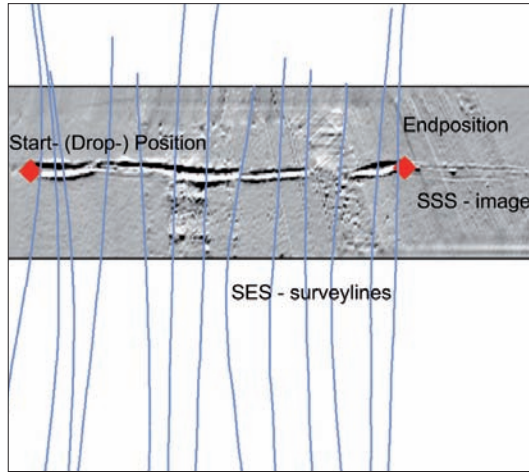


**Fig. 2:** Test-sites in the German Bight with a brief description of the sediments

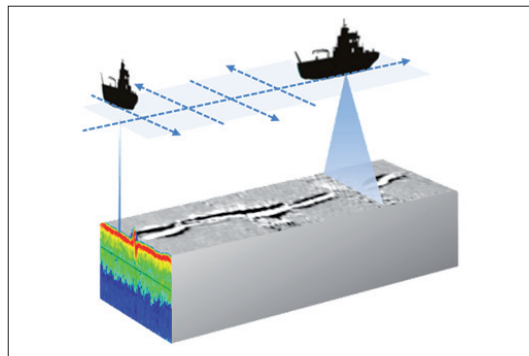


**Fig. 3:** Anchor handling vessel »Esvagt Connector« (left); survey vessels »Guardian« and »Wega«

**Fig. 4:** SES survey lines (blue) on top of an SSS image with anchor track

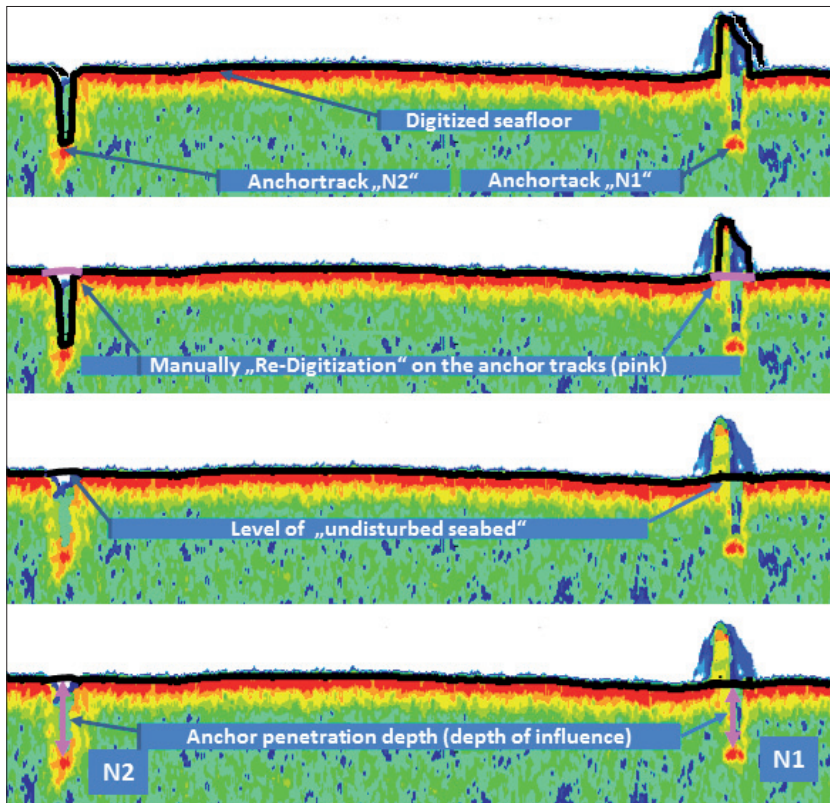


**Fig. 5:** Schematic illustration of a combined SES/SSS survey



to the level which can be assumed as »undisturbed seabed«, like it has been before the anchor was dragged through. The difference between these two levels (»undisturbed seabed« – »deepest point of influence«) gives the maximum penetration depth of the anchor into the seabed. In Fig. 6 the procedure for the analysis of the anchor penetration depth is shown. There are two anchor tracks

**Fig. 6:** Derivation of the anchor penetration depth out of SES echo plots



and the corresponding survey lines. Data were processed using the ISE software which is part of the used Innomar SES system.

The error budget of this method is mainly given by two sources:

- Errors in digitising the targets (»maximum depth of influence« and »undisturbed seabed«);
- Error due to variation in the sound velocity of the echo sounder signals (sound velocity through water ~ 1,500 m/s, sound velocity through sand ~ 1,600 m/s).

With conservative estimate the maximum error could be accounted for approximately 0.11 m.

The crossing points between anchor track and survey line can be connected to depth profiles of the anchor through the sea-floor. Fig. 7 shows an example of a complete processed trial, including SES cross sections, SSS image, and depth profile.

The overall result is put together in the table.

| Pos. | Type | Number of pulls | Length of pulls [m] | Max. force [t] | Max. depth [m] |
|------|------|-----------------|---------------------|----------------|----------------|
| N1   | AC14 | 1               | 67                  | 62             | 0,65           |
| N2   | Hall | 2               | 92                  | 64             | 0,70           |
| N3   | AC14 | 1               | 57                  | 82             | 0,69           |
| N5   | Hall | 2               | 87                  | 58             | 0,88           |
| N6   | Hall | 2               | 92                  | 65             | 0,78           |
| S1   | AC14 | 1               | 63                  | 86             | 0,33           |
| S2   | AC14 | 1               | 20                  | 95             | 0,28           |
| S3   | AC14 | 1               | 102                 | 64             | 0,34           |
| S4   | Hall | 1               | 23                  | 76             | 0,28           |
| S5   | Hall | 1               | 27                  | 72             | 0,28           |
| S6   | Hall | 1               | 22                  | 80             | 0,26           |
| V1   | AC14 | 3               | 107                 | 73             | 0,33           |
| V2   | Hall | 1               | 27                  | 75             | 0,34           |
| V3   | AC14 | 1               | 20                  | 78             | 0,19           |
| V4   | Hall | 1               | 24                  | 79             | 0,26           |
| V5   | AC14 | 1               | 31                  | 80             | 0,67           |
| V6   | Hall | 1               | 26                  | 80             | 0,67           |

The first column is labelling the position and the test site (N = BSH North, S = BSH South, V = TSS). Subsequently, anchor type and the number of pulls are listed. On some position the anchor handling vessels has pulled more than one time to ensure maximum performance of the anchor. Then the parameters of the pulls are specified: length of the entire pulls, maximum pulling force as recorded by the anchor handling vessel and the maximum penetration depth as processed out of the SES survey.

As expected the deepest anchor penetration was recorded at the test-site »BSH Nord« with its loosely layered fine sand. Due to soil conditions the other two test-sites are showing significantly less penetration. None of the overall 17 trials, which have been processed, showed an anchor penetration depth of more than 1 m including possible er-

rors. In the crucial area of the TSS this value could even be detected as only 0.8 m.

## Discussion

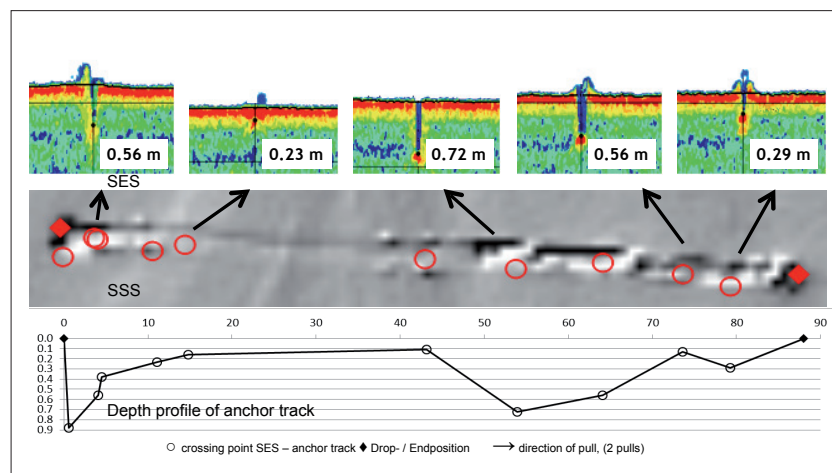
Generally, the behaviour of an anchor depends on a wide range of parameters during the anchoring manoeuvre, such as: soil conditions of the sea-floor, geometry and weight of the anchor, position and orientation of the anchor in relation to chain and vessel, and the catenary (inclined chain). The currently valid depth requirements for laying cables resulted from safety values that had been determined in a general or worst-case manner. Regarding the penetration of an anchor into the seabed international recommendations gave a reference value of 1.0 for the relation between the depth of penetration and the length of the anchors' fluke. Typical ship anchors, like the ones which have been used for this experiment, have a fluke length of 2 m. When taken into account that there are also bigger anchors in use, this value reflects the prescribed burial depth of 3 m which is given in the regulations at that time.

In contrast to this, it was concluded that for none of the 17 trials of the field measurement programme more than 1.0 m penetration below the seabed could be detected (including measurement uncertainties). That means that the relation between the penetration depth and the length of the fluke is only  $\sim 0.5$ , based on the results of an experiment under realistic conditions. This gave a significantly reduced penetration compared to the reference value. The main reason for that is, that it can be expected under the site specific soil conditions that the anchors' shank always lies on top of the sea-floor and does not penetrate it. This can be completely different in areas with soft (= muddy) sediment structures at the seabed.

A correction of the processed anchor penetration depth has to be applied due to an inclination angle of the chain. Maximum anchor performance is given when the shank is orientated horizontally on the seabed. Any inclination of the chain will cause a rotation of the anchor around its crown in the direction of the chain. This has implications for the holding capacity of the anchor (which is not discussed here) as well as for the penetration of the anchor (Fig. 8).

Another issue is the extrapolation of the test results to other ships and anchor types. According to the studies of the involved research institute Deltares an extrapolation of the test results gives a maximum penetration depth of  $\sim 1.25$  m from a 22.5 ton anchor as used by the 188,000 dwt »Marco Polo« – one of the world's largest container vessels.

The penetrations that were recorded showed a good correlation with the soil conditions at the three test areas (loose to medium dense and dense sand, partly underlying firm clay). This suggests that the tests are a reliable basis for the assessment of penetration depth of anchors in such



**Fig. 7:** Result of an anchor track survey: SES echo plots at the crossing point with the anchor track (top); SSS image of an anchor track, red dots: crossing points with SES survey lines (centre); depth profile of the anchor track

areas. Extrapolation to silts (mud) or coarser material (gravels) cannot be justified without further study.

The results of the field measurement programme in the area of the TSS »Terschelling – German Bight« have been stated as confident and robust by the involved research institutes BAW and Deltares.

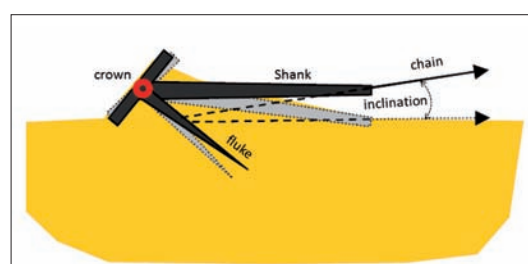
Furthermore, it has to be considered that the presented approach is deterministic. However, for a final evaluation of anchor risk to a buried cable, also probabilistic aspects have to be taken into account. Much more information is needed about the distribution of anchor masses, anchor types, soil conditions, frequency of emergency anchoring operations, human errors, etc.

## Conclusion

The results of the field measurement programme have been carefully discussed and evaluated among all stakeholders. In conclusion of the reports published by the involved research institutes BAW and Deltares the recommendation was given for a reduction of the prescribed burial depth for subsea power cables to 1.5 m below seabed – within and outside the TSS »Terschelling – German Bight«.

This proposal was picked up by the responsible authority (BSH). After coordinating with the Waterways and Shipping Administration of the Federal Government (GDWS) this regulation was accepted for the Revised Draft of the »Spatial Offshore Grid Plan«, July 2014 (§ 5.3.2.7 and § 5.4.2.7).

This will result in considerable reduction of costs, maintenance time and disturbance to traffic, but without comprising the safety of either vessel traffic or undersea infrastructure. ⚓



**Fig. 8:** Rotation of the anchor around the crown due to chain inclination

# Ems-Dollart estuary

Did Germany and the Netherlands really agree on the disputed boundary recently?

An article by THOMAS DEHLING

»Germany and the Netherlands settled a dispute regarding the border in the Ems estuary which endured for centuries. The Ministers of Foreign Affairs Frank-Walter Steinmeier and Bert Koenders signed the respective treaty.« This or similar headlines could be read in the newspapers in autumn 2014. It gives the impression that finally a border between the two countries has been agreed upon in that area. In fact, the treaty consolidates the contrary. But although both partners agree that they don't agree on that boundary, they found another pragmatic solution which fits in the line of treaties in the Ems-Dollart area and which fixes substantial and for practical matters particularly important aspects. This solution is yet another example of the excellent and pragmatic cooperation between the Netherlands and Germany.

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Ems-Dollart estuary | boundary delineation | UNCLOS | Law of the Sea | talweg | EEZ | Borkum Riffgat

**Historical background**

To understand the special case of the common boundaries between the Netherlands and Germany in the estuary of the river Ems, it is necessary to shortly explain the historical background first. The different positions about the boundary in that area go centuries back. The German position is that the low-water line at the western shore of the Ems estuary constitutes the border and refers mainly to a letter of enfeoffment (German: Lehnsbrief) from the year 1464. The Netherlands state that the border should be drawn according to the general rules in international law and refer to the principle of the talweg, which is defined as the line joining the lowest points of a valley throughout its length (*IHO Hydrographic Dictionary, S-32*).

**Ems-Dollart Treaty**

In the 20th century both countries agreed that they don't agree in this regard, and in the light of the traditionally good relationship both coun-

tries found a status-quo agreement that led to the Ems-Dollart Treaty in 1960. Several supplementary treaties have been signed and the Ems-Dollart-Commission has been constituted. This framework guarantees that all practical issues in the disputed area are being dealt with amicably. Thus, the unsolved case of the boundary became quite irrelevant.

Fig. 1 shows the area of the Ems-Dollart Treaty in red (attachment to the supplementary agreement from 14 May 1962). As can be seen on the chart, the area comprises the territorial sea in the estuary at the time the treaties were signed as well. The seaward limits of the territorial sea from both countries were drawn in a distance of three nautical miles from the normal baseline.

In 1964 both countries also agreed on the limits of the continental shelf adjacent to that area. Fig. 2 shows that line in blue. This treaty distinctly excluded the question of the common territorial border. The continental shelf comprises the sea-

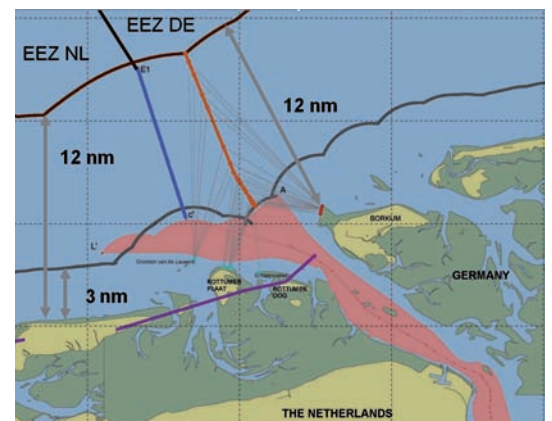
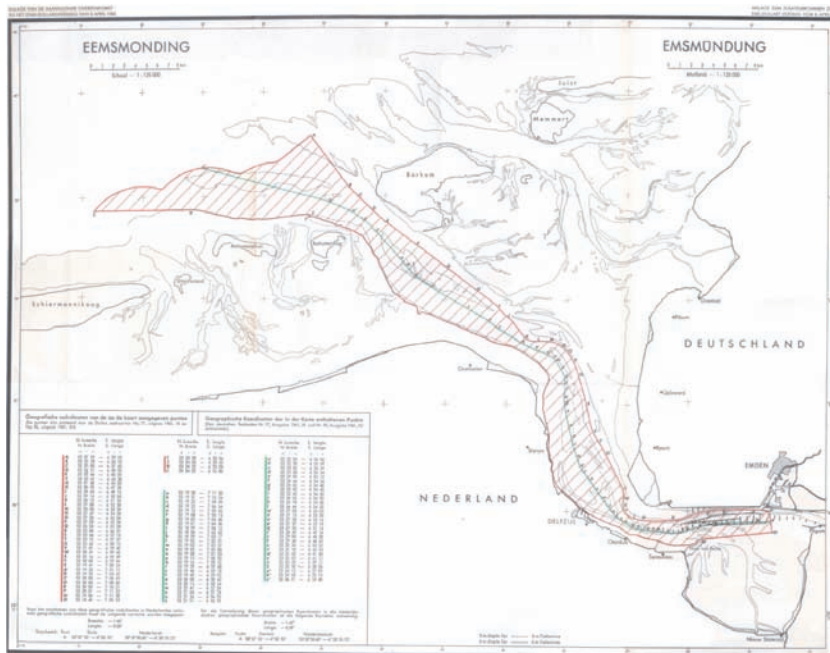


Fig. 2: Sketch showing the area between 3 and 12 nm

Fig. 1: Chart showing the area of the Ems-Dollart Treaty

bed and subsoil of the submarine areas that extend beyond its territorial sea to the outer edge of the continental margin. The coastal state exercises over the continental shelf sovereign rights for the purpose of exploring it and exploiting its natural resources.

## UNCLOS

In 1982 the United Nations Convention on the Law of the Sea (UNCLOS) was concluded and replaced four treaties of 1958. UNCLOS came into force in 1994, a year after Guyana became the 60th nation to sign the treaty. One mayor development was the extension of the territorial sea beyond three nautical miles (nm) up to 12 nautical miles. Both the Netherlands (in 1985) and Germany (in 1994) extended their territorial waters to that limit.

In the sketch of Fig. 2 the area of the Ems-Dollart Treaty can be seen in red, the 3 nm in grey, the 12 nm in brown, the limit of the continental shelf in blue and the equidistance line in orange.

The limits of the Ems-Dollart Treaty were not adjusted to that extension accordingly. Both countries stated that the lateral limits of the territorial sea between 3 and 12 nm have to be defined by a later agreement. Thus, the extension in the Ems-Dollart estuary has led to an area of unclear legislation. Even the limits of that area were unclear.

One question discussed by lawyers is, whether through the extension to 12 nm and the former agreement on the limits of the continental shelf a »de facto« border of the territorial sea has been defined (cf. König and tho Pesch). At least it seems to be clear that continental shelf and territorial sea can't exist in the same area simultaneously and that the extension of the territorial sea from both sides were only possible to the limits of the continental shelf.

## Extended use of the area beyond 3 nm – »Windpark Borkum Riffgat«

The practical impact of that unclear legal status was marginal in the beginning and could generally be solved by the Ems-Dollart-Commission. But with the growing importance of that area for economic use and environmental protection the need for a new regulation became more and more obvious.

The excerpt of the nautical chart (Fig. 3) shows the wind farm »Riffgat« in green, the continental shelf limit in red and the equidistance line in blue.

The plans for the wind farm »Riffgat« put even more pressure on the legal questions. As can be seen on the chart the wind farm is intersected by the equidistance line. The equidistance line is composed of points that have the same distance from the baseline of neighbouring countries. The Netherlands state that this line should be the basis for the border between 3 and 12 nm. From the German point of view the whole wind farm is without doubt completely inside their territorial

sea and that view was supported by an expertise from Prof. Rainer Lagoni (Lagoni 2012). The legal process of approving the construction of the wind farm was accomplished according to German law in 2011. But still the legal situation remained unclear and there will surely be more cases to come in practice, where approvals will be requested and second »approval chains« need to be avoided. Thus, it became evident that this uncertainty had to be eliminated.

## Consultations and negotiations

Already in the 1980s consultations offered a solution. There were proposals for a definition of the boundary of the territorial sea itself and various ideas for an extension of the Ems-Dollart Treaty area. One general question was how far seawards the basic dispute can be legally extended and whether or not an equidistance line could be applicable.

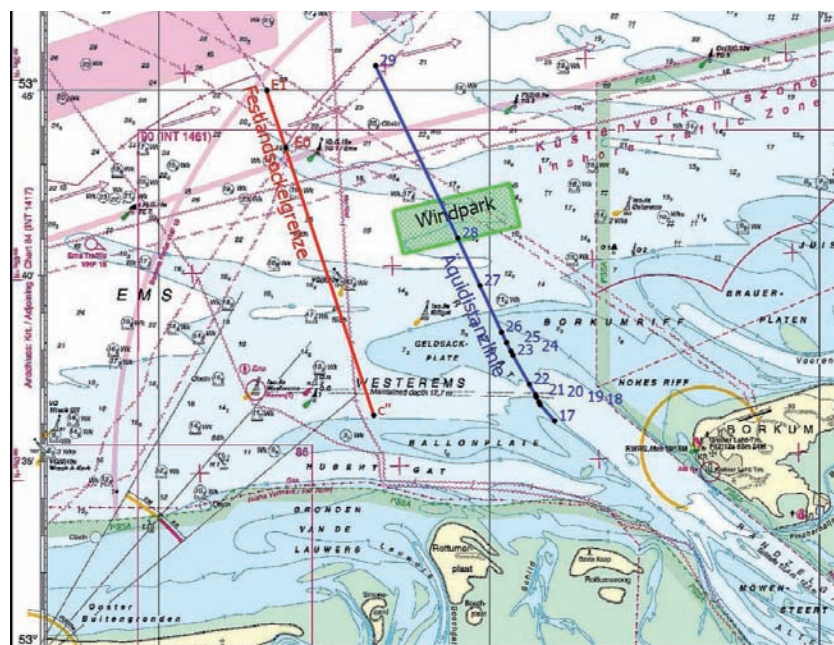
There were different views of both countries regarding formal negotiations. Especially the question whether negotiations could be started without the necessity of reaching a solution of a border as such. In 2012 this question was answered positively from both countries and the formal process started in 2013. Already in the same year the general outline of a treaty was settled. The agreement was reached in June 2014 and the formal signing of the treaty was done in October 2014.

## Signing of the treaty

The treaty was signed on board the vessel »Neuwerk« on its passage from Emden in Germany to Delfzijl in the Netherlands on the 24 October 2014 by the Ministers of Foreign Affairs of the Federal Republic of Germany, Frank-Walter Steinmeier, and of the Netherlands, Bert Koenders (Fig. 4). The »Neuwerk« is a multi-purpose vessel, operated by the German Water and Shipping Administration and is part of the German Coast Guard.

## References

- König, Doris; Sebastian tho Pesch (2013): Der Festlandsockelvertrag von 1964 und seine Auswirkungen auf die deutsch-niederländische Küstenmeergrenze; ZaöRV, Vol. 73, pp. 483–508
- Lagoni, Rainer (2012): Die Abgrenzung des Küstenmeeres außerhalb der Emsmündung; Archiv des Völkerrechts, Vol. 50, pp. 348–375



**Fig. 3:** Excerpt of the nautical chart showing the wind farm »Riffgat« (green), the continental shelf limit (red) and the equidistance line (blue)



Fig. 4: The Ministers of Foreign Affairs of the Federal Republic of Germany, Frank-Walter Steinmeier (right), and of the Netherlands, Bert Koenders

### Result

»Vertrag zwischen der Bundesrepublik Deutschland und dem Königreich der Niederlande über die Nutzung und Verwaltung des Küstenmeeres zwischen 3 und 12 Seemeilen«

»Verdrag tussen de Bondsrepubliek Duitsland en het Koninkrijk der Nederlanden betreffende het gebruik en beheer van de territoriale zee van 3 tot 12 zeemijlen«

The treaty »on the use and administration of the territorial sea between 3 and 12 nautical miles« fixes the substantial and for practice particularly important aspects:

- The construction of the wind farm »Riffgat« is being based on an assured basis of international law;
- The delimitation of responsibilities for marine cables, pipelines, wind farms, rights for exploitation and uses is being done along the line of the German-Dutch treaty of the continental shelf from 1964;
- The access to the high sea from the harbours of Emden, Delfzijl and Eemshaven remains without hindrance;

- The whole marine traffic management in that area will be concentrated in one joint vessel traffic service centre.

Although stated in the media repeatedly, this treaty is not an agreement about the boundary in the Ems-Dollart estuary. It explicitly does not include a border between the two countries, but it provides legal certainty on both sides with a pragmatic solution. This is important for further investments and the administration of the Ems-Dollart estuary, which becomes more and more important due to the growing importance of the coastal seas economically and ecologically.

### Role of hydrography

The international law, especially the Law of Sea, is not only a legal issue where lawyers and politicians are engaged in. The example described above shows many tasks that are closely related to hydrography. One prerequisite is of course the provision of a topography of the sea-floor and the wadden sea. Decisions have to be based as well on up-to-date and quality assured information of the coastline, the 0 m contour line and the talweg. Description of estuaries and their limits have to be based on scientific research. Calculations have to be accomplished regarding coordinates and transformations, equidistance lines and other delimitations. And all these calculations and results have to be presented in digital and analogue cartographic products and in presentations which are understandable for non-hydrographers.

The hydrographers probably still can do more to make their contributions in all marine fields and aspects known to the public and to other professions. They should be more self-confident and more visible. [↕](#)

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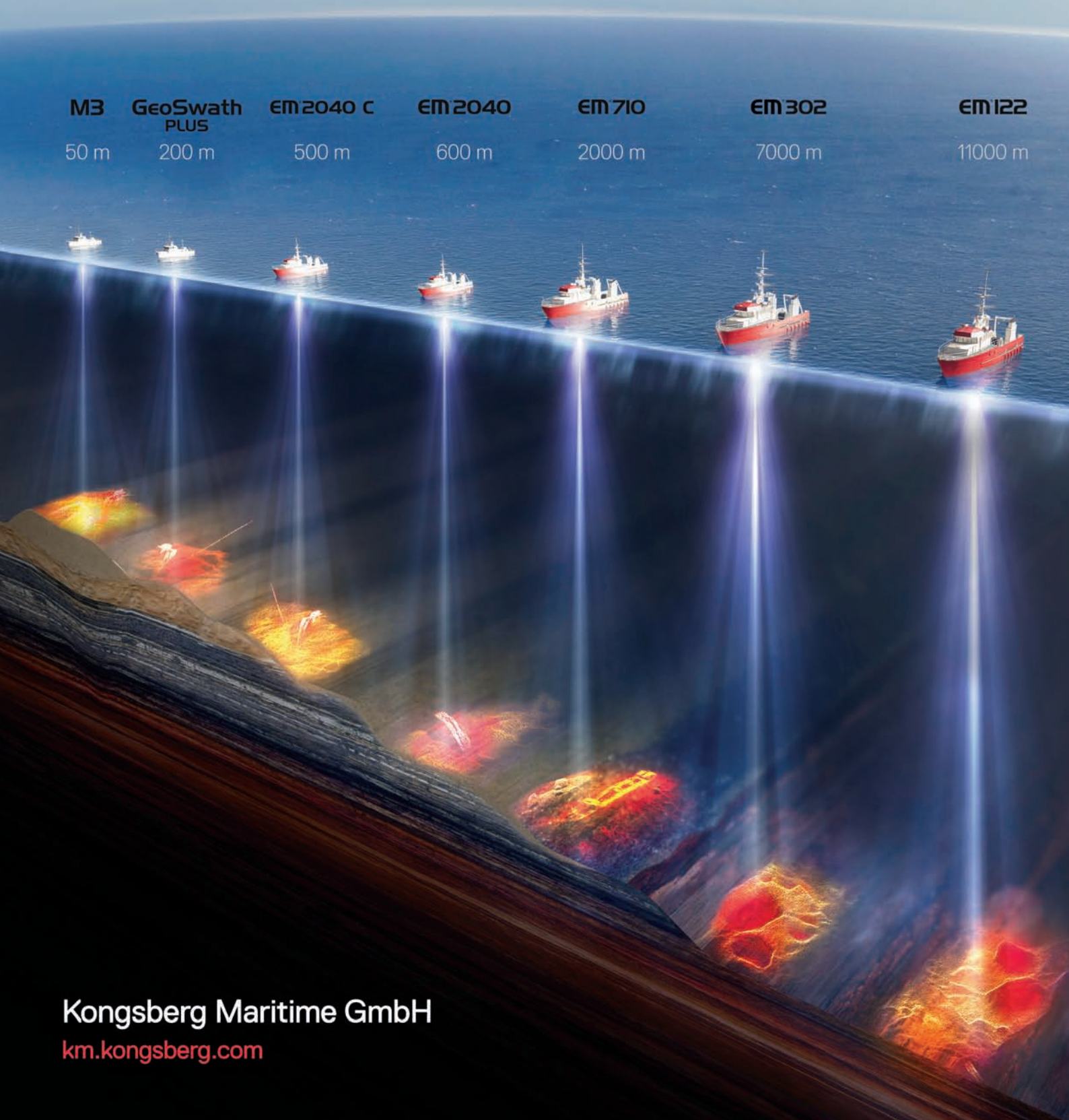


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# Big Data

## The challenges of large-area bathymetric surveys

An article by KLAUS MICHELS

According to the IHO's »Status Report on Hydrography and Mapping of the World's Seas, Oceans and Coastal Waters« (IHO 2013) a large percentage of the world's seas and oceans are still unsurveyed. Even areas covered by nautical charts need to be resurveyed since, in the absence of any other data, many of today's charts contain significant amounts of information derived from non-systematic observations and survey data dating back up to 200 years (IHO 2013). The demand for hydrographic and bathymetric data for a broad range of offshore activities was never higher than it is today. Advances in multibeam echo sounder (MBES) and airborne LiDAR bathymetry (ALB) technology allow safe hydrographic and bathymetric survey of large areas at a speed and accuracy previously unknown. However, increasing sizes of survey areas and improving resolutions of survey systems come with larger data volumes and greater requirements related to management and operations. Big Data\* need to be managed.

### Author

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**Fig. 1:** A typical modern dedicated survey vessel for hydrographic data acquisition (MV »Fugro Helmert«) and a typical airborne LiDAR bathymetry aircraft



Big Data | Blue Economy | large-area survey | data management | project management | tender | deliverables

### Introduction

»We know less of the oceans at our feet, where we came from, than we do of the sky above our heads« (US President John F. Kennedy, 1963).

President Kennedy made this statement 42 years after the foundation of the International Hydrographic Organization (IHO) whose principal aim – to ensure that all the world's seas, oceans and navigable waters are surveyed and charted – still persists. According to the Committee of Experts on Global Geospatial Information Management of the IHO and its »Status Report on Hydrography and Mapping of the World's Seas, Oceans and Coastal Waters« this aim remains far from being met. Contrasting the knowledge about the oceans and the planets it states that »there are higher resolution maps of the Moon and Mars than most of the world's sea and ocean areas« (IHO 2013).

IHO Publication C-55 – »Status of hydrographic surveying and charting worldwide« (IHO 2015) lists the areas that require a hydrographic (re)survey in somewhat more detail, on a worldwide scale. The largest unsurveyed parts are made up of deep-water areas greater than 200 metres water depth. However, in water depths shallower than 200 metres there are also significant areas that need to be surveyed or resurveyed.

Nevertheless, the recent history of hydrographic surveys shows that numerous projects were carried out to obtain high-quality validated data for

large coastal, shelf and deep-water areas covering hundreds of thousands of square kilometres. A significant number of these surveys were carried out by Fugro. The largest single hydrographic survey contract comprised 110,000 square kilometres, and involved ten MBES survey vessels and launches and three ALB survey aircraft (Fig. 1).

Different hydrographic survey campaigns tendered out by national hydrographic agencies and other governmental institutions, energy providers and exploration and exploitation companies usually fall into one of the following categories:

- Safety of navigation: Surveys and resurveys are covering navigation routes and ports in order to create and update nautical charts and electronic navigation charts.
- Strategic environmental assessments: Hydrographic surveys in this context are related to the appraisal of marine areas with regard to their environmental protection and sustainable development. The results are considered in national and local decisions for the use of marine areas such as oil and gas licensing rounds, offshore renewable energy developments, the designation of environmental protection areas and gas and carbon dioxide storage. The overarching goal is the development of successful and environmentally sustainable human activities in the seas and oceans as part of The Blue Economy\*\*. Hydrography is increasingly being recognised as a fundamental prerequisite for a sustainable, cost-effective and environmentally sensitive development of The Blue Economy.
- Exploration for marine metallic and non-metallic resources (e.g. hydrocarbons and polymetallic nodules): Hydrographic surveys of this type are regarded as an essential basis for the planning and safe execution of further exploration and exploitation activities.



- The determination of the foot of the continental slope by hydrographic methods: This is one of the major features in the establishment of the outer limits of the juridical continental shelf under Article 76 of the United Nations Convention on the Law of the Sea. Potentially it entitles coastal states to an extended continental shelf beyond 200 nautical miles.

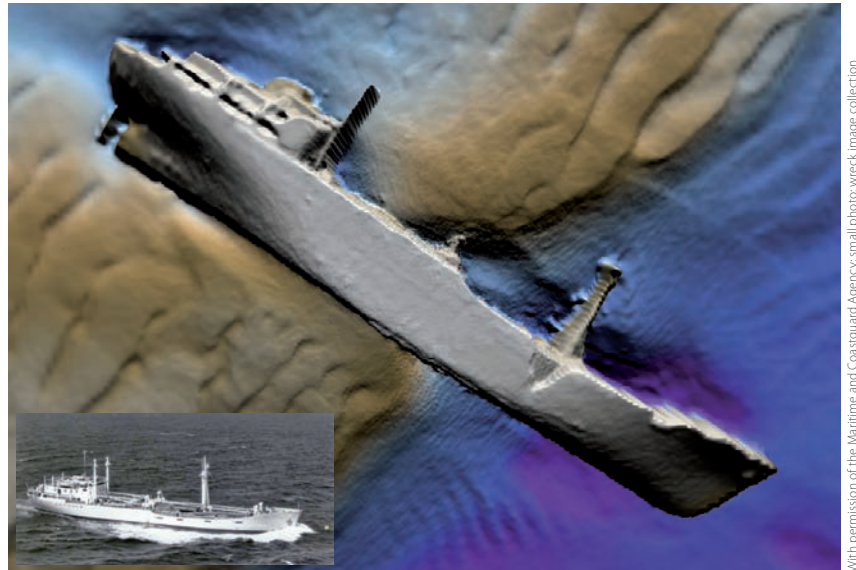
Common to all these hydrographic survey projects are survey specifications in compliance with (or even exceeding) the Standards for Hydrographic Surveys of the IHO (IHO 2008). This basically determines the amount of data to be acquired, the data processing procedures, the quality control process and the deliverables. Given the performance of state-of-the-art multibeam echo sounder bathymetry (an example is given in Fig. 2) and airborne LiDAR bathymetry systems (Fig. 3) the storage capacity requirements for larger projects can easily add up to several hundred terabytes.

Often the time frame for the execution of the survey and the range of water depths in the survey areas demand the deployment of multiple survey sensors. Either the combination of MBES and ALB systems, or several of either sensor may be deployed at the same time in one field campaign.

This framework of requirements is quite demanding for the planning, execution and control of this type of hydrographic survey project. This paper deals with the associated challenges of the projects and describes the approaches chosen by Fugro. It will discuss the requirements and possible approaches by going through the different stages of the projects: tender and planning, survey, processing and delivery.

### Tender phase

Compiling a competitive tender for a large-area hydrographic survey requires the input of many different types of information. The most important – and sometimes most challenging – task is to obtain reliable information about the distribution of water depths in the survey area in order to calculate a realistic length (survey kilometres) to cover the survey area with the quoted MBES or ALB system(s) according to the specifications. Due to the fan-shaped sound signal emitted by MBES systems the coverage increases with increasing water depth (at the cost of resolution and accuracy), which makes water depths the dominant factor when calculating the required survey lines and thus survey duration. Potential sources of bathymetric information of the seabed are nautical charts (although even the latest revision can be based on old data) and free or commercial data sets (e.g. GEBCO, ETOPO for global coverage) based on ship depth soundings and satellite-derived gravity data. Aerial photographs and satellite images can serve to assess the distribution of shallow water areas and map potential shoals, which pose a risk



With permission of the Maritime and Coastguard Agency; small photo: wreck image collection

**Fig. 2:** The wreck of the MV »Höegh Aigrette« depicted by multibeam bathymetry data.

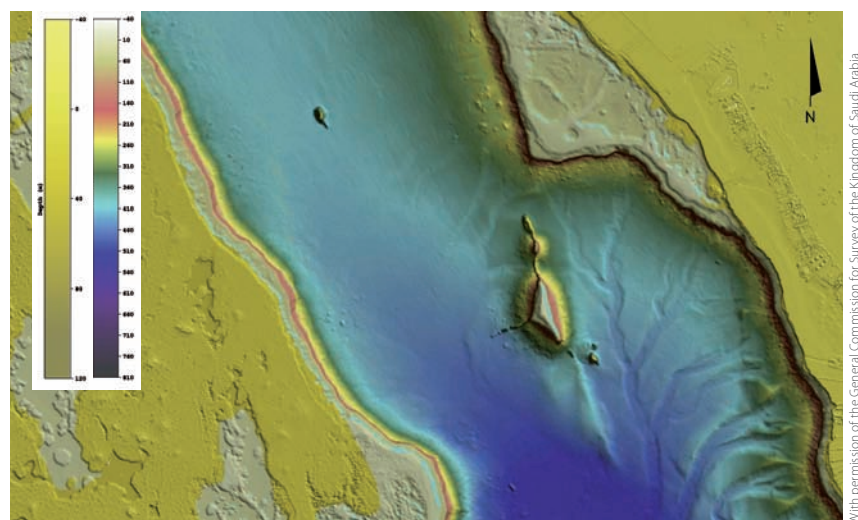
The example shows the capability of modern systems to image even details of objects on the seabed (for comparison the intact vessel is shown).

The wreck clearly shows the notch caused by collision with another vessel, which led to the loss. The length of the vessel is 112 metres, water depths at the wreck site range from 28 metres to 39 metres

to navigation and are specifically important for an estimate of the coverage that can be achieved by ALB. The resulting number of survey line-kilometres and the survey duration, together with the survey specifications, are the basis for estimating the data storage requirements for the vessels and the processing centre. The provision of suitable data storage facilities can contribute significantly to the infrastructure costs of a project.

Other information relevant for compiling a tender for a hydrographic survey in a specific area are the weather and climate conditions; oceanographic restrictions – such as the tidal characteristics, the current and wave climate, the formation of distinct thermohaline layers and strong turbidity in the water column; the legal framework for vessel operations in territorial waters; and furthermore the operational costs for vessels such as permitting costs, port and harbour fees, bunker costs, travel and visa costs for the vessel and survey crew, etc. For surveys with a longer duration even the access to repair and shipyard facilities needs to be considered. When clients stipulate in-country processing of all data (or when in-country processing offers an operational advantage), local facilities and staff accommodation costs can contribute significantly

**Fig. 3:** Example for the seamless integration of multibeam and airborne LiDAR bathymetry data (different data types are distinguished by different colour scales: LiDAR on the left, multibeam on the right side). The area in the east comprises terrestrial LiDAR data; buildings and infrastructure can be recognised. The shallow water areas north of the island and in the west consist of coral reef. The size of the area is 10.6 × 6.4 kilometres



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 Pauli, Gunter (2010): The Blue Economy; Paradigm Publications, Taos NM, USA

to the overall operational expenditure. Altogether these factors and conditions, and the allowance for contingencies, determine the overall survey expense.

**Project planning phase**

Once the contract for a survey project is awarded based on the successful tender, the concrete planning for the project execution will start. The permitting application procedures may take considerable time (often of unknown extent) and therefore are among the first activities when vessels and aircraft are to be mobilised. This guarantees a mobilisation and start-of-survey date as early as possible (which usually is requested by the client).

Based on the project proposal a line plan is developed which makes sure that all survey data will be acquired throughout the survey area at the required quality and density in the most efficient way.

The identification of potential risks to navigation – especially uncharted shoals – is another step in the planning phase which needs to be accomplished before the shallow water vessel operations start. This is best completed using geo-referenced aerial and satellite photographs where shoals can be identified and mapped using remote sensing methods.

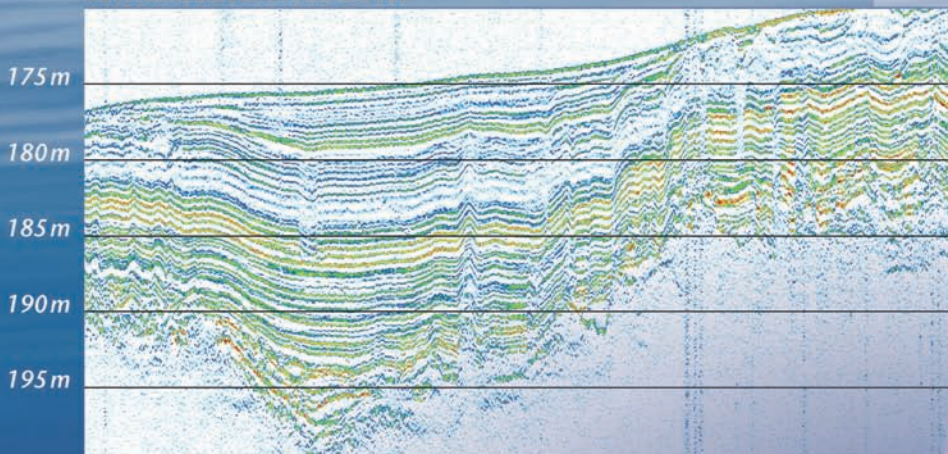
Personnel planning is another important part

of the planning phase. The critical questions that need to be answered are:

- Do we have the right people to fill all key project positions, i.e. a project manager, the party chiefs, a chief surveyor, a processing and reporting manager, etc.?
- Do we have enough qualified personnel to man all vessels and aircraft planned for the project?
- Do we have enough >Category A< certified surveyors to man all key positions dealing with hydrographic data?
- How do we best put together the survey teams and vessel crew on board so that maximum safety for operation is achieved (especially in very shallow waters where the risk of grounding exists)?
- Will all planned staff obtain the required visas in time?
- Is all staff able and permitted to work in the project country (e.g. there might be medical restrictions on working in tropical areas, there are cultural restrictions on working in the Middle East)?

Data management, which involves data storage, backup and transfer, also needs to be thoroughly planned and prepared. All vessels and aircraft need

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to be equipped with storage capacity (including backup) capable of holding all data acquired and processed until transfer to the processing centre storage system (in-country or at the head office) is fully completed. Data transfer can either happen by physically hand-carrying or mailing storage media (e.g. USB flash or hard drives, NAS or RAID systems), or by using electronic transmission methods (e.g. e-mail, Internet or cloud-based transmission, FTP, Aspera, etc.). The total amount of project data is not only defined by the size of the survey area but also by the requirements for data delivery and formats, necessary intermediate formats and products, and the number of different processing facilities.

It might be also part of the contractual obligations to establish a method of correcting the acquired bathymetric data for tidal variations in the survey area, which needs to be planned prior to survey start. Some clients require the collection of comprehensive tidal data even covering seasonal changes by means of tide gauges installed on the coast and offshore. These tide gauges are ideally operational before vessel operations commence and should not finish until all ALB and MBES data are acquired. Tide watches carried out by vessels may complement the tidal observations and help to enhance the vertical control.

Last but not least the mobilisation of the vessels and aircraft according to the specifications of the contract needs to be completed and the transit to the survey area planned and scheduled.

### Survey phase

Safety is the utmost priority during survey operations and it will verify the efficiency of planning. For efficient management of the operation the survey teams on board the vessels and aircraft should make sure that (1) the survey data they acquire are of the required quality and cover the specified area; (2) no gaps are left within the designated survey area, and within the capabilities of vessel and equipment; (3) other vessels and aircraft operating in the same or neighbouring areas receive the information necessary to operate safely, avoid excessive overlaps and close all gaps left by other survey platforms because of limitations in their capabilities. Gaps may be left by a survey platform when waters become too deep for LiDAR sensors or shallow-water MBES systems, or too shallow for larger vessels; alternatively safe navigation may prevent vessels entering a specific area, or survey crews may be inattentive. Generally survey gaps must be closed wherever possible whilst the highest level of safety is maintained.

A great deal of background management is required, both in the head office and on board, to ensure the data flow between the survey platforms and the processing centres and to ascertain the availability of qualified personnel on board. The documentation of the data acquisition procedures and on-board processing and QC is essential

to allow for a problem-free transition from data processing and QC to the processing centre.

The most efficient way to cover areas in a multi-sensor survey operation is usually developed in close cooperation between the project manager, the party chief(s), the chief surveyor(s) and the processing and reporting manager.

### Processing

The processing of hydrographic and bathymetric data needs to be carried out in compliance with the specifications for the relevant survey. Important steps in the processing procedure are

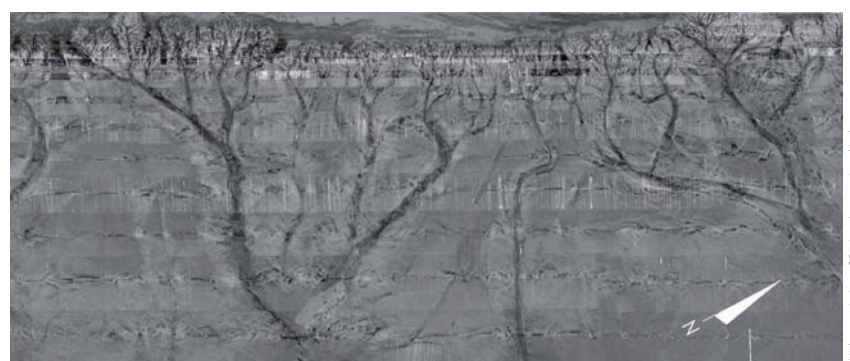
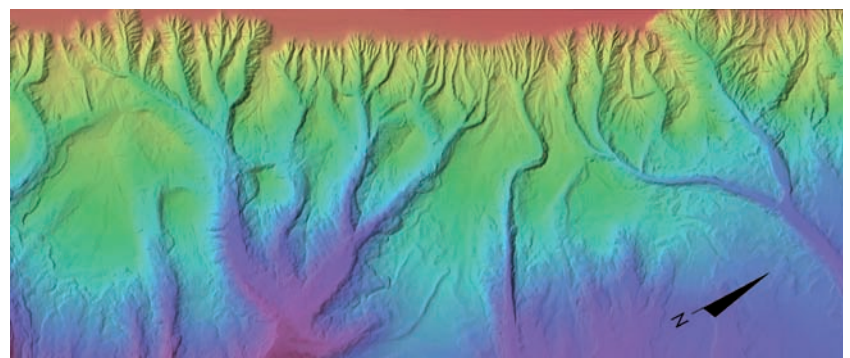
- the filtering and editing of data,
- the integration and merging of data from different platforms and sensors,
- the tidal correction of the final edited data set,
- the shift of bathymetric data to the required datum,
- the systematic check of the data set with regard to compliance with the specifications and finally
- the creation of the deliverables.

The decision whether on-board and in-country processing is established depends on strategic considerations in addition to contractual obligations. On-board processing – which is only possible on larger vessels – happens much closer to data acquisition and therefore identifies issues (such as technical problems, too much or insufficient overlap, or even gaps) much sooner than land-based processing can. On-board processing can also easily take advantage of 24-hour processing to achieve more efficiency and faster processing progress. On the other hand data storage facilities are more difficult to install, operate and maintain on board. Therefore, on-board data processing will most often be limit-

\* The term 'Big Data' here refers to data sets characterised by their very large size, a diversity of data types, and sophisticated processing flows required to analyse them

\*\* The Blue Economy is a design theory which is intended to bring natural ecosystems and economy into harmony and create jobs (cf. Pauli 2010)

**Fig. 4:** Comparison of multibeam bathymetry data and backscatter data from a continental slope with a dendritic channel system. The water depths in this example range from the shelf edge at 100 metres in the northwest to maximum water depths of approximately 2,900 metres in the deepest parts in the southeast (top). The seabed sediments in the channels and on the shelf clearly show a higher acoustic reflectivity, which indicates coarser grain sizes (bottom). The size of the area is approximately 83 × 34 kilometres



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ed to the data acquired by the vessel itself and data from a smaller survey boat – either operated from the vessel or land-based near the survey area.

For large survey projects the data processing ideally is supervised by a dedicated data manager dealing with structuring and apportioning data for the editing, merging and QC process. ALB and MBES data generally have completely different processing requirements and therefore need different processing approaches (usually handled by different processing teams) before being merged.

The integration of data from different survey platforms (Fig. 3) – either multibeam or aircraft – requires specific attention because of different physical measurement methods (i.e. acoustic MBES and laser-optic ALB), different footprints, different resolutions and/or different data densities.

**Fig. 5:** Bathymetric coastal data shown on top of a geological map (top). The strata mapped onshore (in the north) could be identified in the bathymetric data so that a geological map of the seabed could be produced (bottom). The size of the area is approximately 5.0 x 3.5 kilometres

### Delivery

The creation of the specified deliverables is the last step in the project. Deliverables are created based on the final processed data.

Contractually required deliverables can vary considerably from contract to contract and from

client to client. The delivery of the final bathymetric product ranges from ASCII grids of specific resolutions to full delivery of the processing software file structure including raw data. However, not all clients are prepared to store and handle tens or hundreds of terabytes of data so this needs to be discussed with the client early in the project. Often the list of deliverables comprises data which are not directly of hydrographic nature but can be derived from the MBES or ALB data set, e.g. maps or geotiff files of the MBES backscatter (Fig. 4) and ALB reflectivity signals. Using a geologist's knowledge of the seabed and sediment properties or (semi-) automatic seabed classification tools, the bathymetry and backscatter/reflectance information can be used to create so-called bottom texture sheets, which delineate and map areas of the seabed with similar patterns and properties (an example for geological mapping based on hydrographic data is shown in Fig. 5). Often this information is used in addition to the bathymetry to conduct initial habitat mapping and undertake the planning for a dedicated habitat survey and sampling campaign.

A rapidly increasing demand exists for GIS-compatible deliverables from hydrographic and bathymetric surveys. This is regarded as a result of the same hydrographic and bathymetric data being used for several different purposes at the same time.

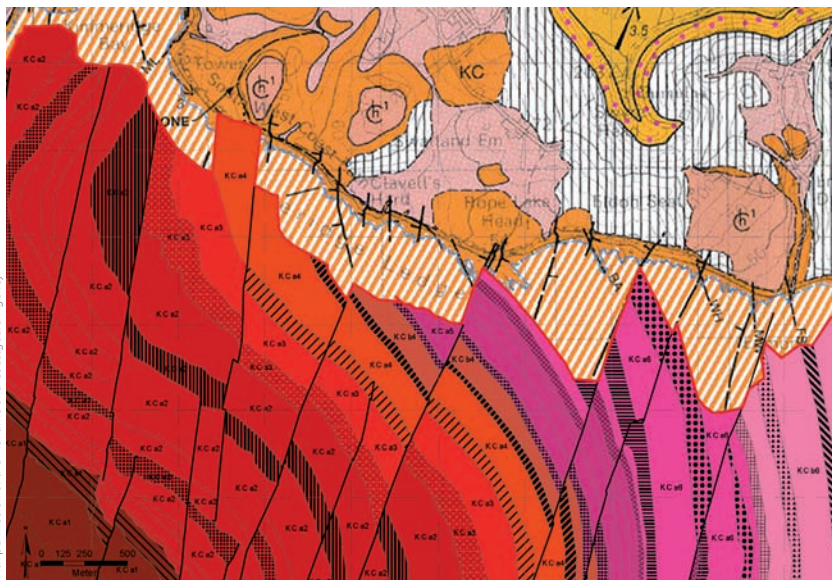
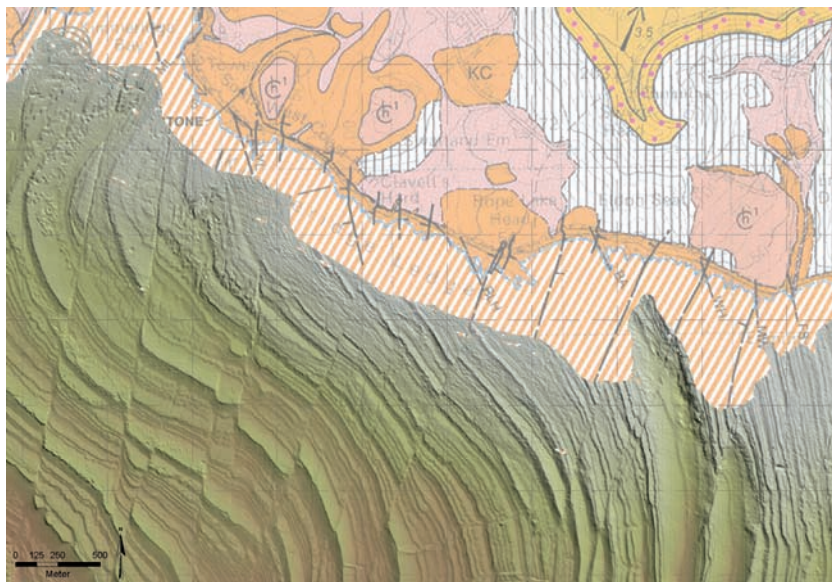
### Summary

Hydrographic and bathymetric data are increasingly being recognised as a fundamental set of information needed to perform an assessment of coastal, nearshore and offshore areas with regard to the safety of navigation, the spatial management of marine areas, the variety of habitats, the environmental status, the effects of natural hazards and climate change, the exploration and exploitation of resources, and the development of renewable energies. Generally speaking the request for hydrographic and bathymetric data increases with an increasing use of the oceans, further powered by the demands of The Blue Economy.

Hydrographic and bathymetric surveys can provide the coverage of large areas within fairly short timeframes. The challenges of such surveys need to be managed in a suitable way especially when multiple survey platforms (vessels, aircraft, launches) and multiple sensor types (MBES, ALB) contribute to data acquisition.

Identifying the main challenges at the different stages of the projects – the tender, planning, survey, processing and delivery phases – and managing their completion in accordance with the available resources and contractual requirements is key to success.

The current survey status of the world's oceans leaves ample room for many more large area hydrographic and bathymetric survey campaigns. Big Data will continue to play an essential role in these campaigns. [↕](#)



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# Hydrographic applications on a Mac

## Public domain software solutions

An article by HARTMUT PIETREK

Since the introduction of iPhone and iPad, Apple products have been in wider use. But – in spite of the huge choice of apps – there is no program yet that can be used for applications in hydrography. With a little effort and some additional software, public

Apple Mac OS X | MB-System | Quantum GIS | Fink | X Window | XQuartz | Xcode | Command Line Tool – CLT

### 1 Introduction

More and more public domain software can be used for applications in hydrography and cartography. However, this software is rarely written for Apple computers. Besides, the standard installation of the Apple operating system is not set up for an installation of public domain software without obstacles. To enable the Mac user to make use of this software, a couple of prerequisites have to be fulfilled. This given, the Mac world can enjoy the benefits of MB-System and Quantum GIS (Fig. 1). MB-System puts almost all tools at your hand that are required for processing multibeam echo sounder data. Quantum GIS can be employed to bring the results into an appropriate context.

### 2 Creating the prerequisites

In order to be able to install public domain software, first of all the Apple Xcode package has to be available. In addition, the software package MB-System requires the X Window libraries. In order to compile the software code, the Command Line Tool (CLT) is required as an add-on component to the Xcode package.

Furthermore, Fink is needed. This package manager takes care that all relevant packages are downloaded and installed on their proper locations.

All packages should be installed together in a designated directory, e.g. under `/Users/$USERNAME/Downloads/fink-install`, where `$USERNAME` is the name of the account on the computer in use.

#### 2.1 Installation of Xcode and CLT

Xcode is a complete development environment with everything that is needed for application development under Mac OS X. This package is available without charge at: <https://itunes.apple.com/en/app/xcode/id497799835?mt=12>.

Upon installation, Xcode should be started in order to post-install the Command Line Tool (CLT). The easiest way to accomplish this is to select Xcode in the Menu Bar and then *Preferences* ... Select the index-tab *Downloads* in the dialogue window that opens up. On the tab select the entry »Command Line Tools«. These are then loaded

and installed automatically. Finally, the C compiler is required which is invoked by the command `cc`. It is included in the Xcode package and can be found in the directory `/usr/bin`.

#### 2.2 Installation of X Window libraries

With XQuartz the X and Open Motif libraries are meant that are provided by Apple within the Open Source Project. These libraries are required for the interactive program parts of MB-System and other public domain software. The X Window libraries are available under <http://xquartz.macosforge.org/landing/>. The file XQuartz-2.7.7.dmg is installed by double-clicking.

#### 2.3 Installation of Fink

The package manager Fink can be obtained at [www.finkproject.org/download/srcdist.php](http://www.finkproject.org/download/srcdist.php).

After downloading, Fink is available as zipped (gz) and archived (tar) file: `fink-0.38.3.tar.gz`.

First this file has to be unzipped. Thereafter a new directory exists with the name `fink-0.38.3` containing various files and subdirectories.

In the next step the program Bootstrap has to be run that is located in the directory just created previously. It may happen that this program does not start or that an error message appears saying

domain software such as GMT, MB-System or Quantum GIS can be made to run under the Apple operating system.

#### Author

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**Fig. 1:** Everything that is necessary to run hydrographic applications like MB-System or Quantum GIS on a Mac



**Useful links**

**Fink**  
[http://pdb.finkproject.org/pdb/package.php/mbsystem?rel\\_id=10.8-x86\\_64-current-stable](http://pdb.finkproject.org/pdb/package.php/mbsystem?rel_id=10.8-x86_64-current-stable)

**MB-System**  
[www.ldeo.columbia.edu/res/pi/MB-System/](http://www.ldeo.columbia.edu/res/pi/MB-System/)

**Quantum GIS**  
[www.kyngchaos.com/software/qgis](http://www.kyngchaos.com/software/qgis)

**GMT**  
<ftp://ftp.geologi.uio.no/pub/gmt/>

**OSU tidal software**  
<http://volkov.oce.orst.edu/tides/>

that it cannot be executed because it is not certified. In this case, the program has to be marked and opened from the context menu, selecting *Open with ...* and then *Terminal*. Upon this, a question appears asking whether the program should be opened. This is confirmed by *Open*. Thereafter the program Terminal starts. Immediately after starting, a window appears prompting for selection of a method. Then a »1« has to be entered and the Return key pressed in order to accept the program's suggestion. Subsequently the password of the root user has to be entered. The program will continue its starting process and make some statements that are recorded rather extensively. Then it will ask for the path where to install Fink. Accept the preset directory path /sw by pressing the Return key. Then Fink will start running. This process takes some time while various states of the system proper are checked, and the relevant files and directories are created as they will be used by Fink for its operation.

for a typical Unix command. A blank character has to be placed between individual options and commands. The options can either be written in full length (with two preceding minus signs) or abbreviated (with only one preceding minus sign).

The Fink call for updates uses `--verbose selfupdate`. With this, a Fink update takes place that displays all commands and feedback messages, taking several minutes.

**3.1 Installation of MB-System**

MB-System is an Open Source software for processing and displaying bathymetric data. Raw data formats of multibeam echo sounders can be processed directly, a property that permits the use of original data, even after several years.

It makes sense to look for the package to be installed on the Fink website [www.finkproject.org](http://www.finkproject.org).

In the area *Sections*, first select *Packages* and then *By Package*. Enter the keyword »mbsystem« in the field *Package Name* of the search mask, and start the search which, in turn, will output two results:

- mbsystem
- mbsystem-dev

Both packages carry the same version number. The package with -dev in its name is the developer version with additional components. It is recommended to select the entry mbsystem. Then an overview page appears showing the package history. For the most recent versions of OS X, there is a »stable« version. Now the essential corner points of the package are known, and the next step is to return to the installation, i.e. to Terminal.

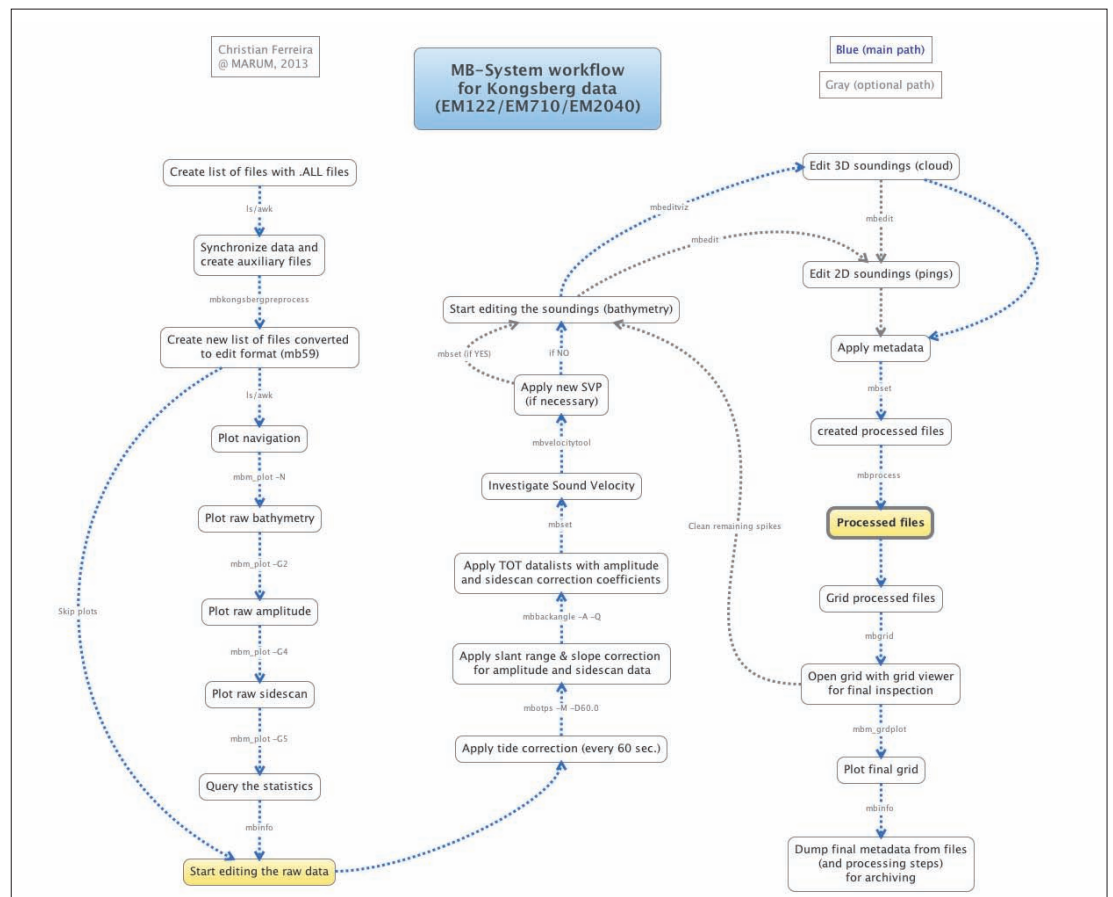
**3 Installation of hydrography software**

Having installed Xcode, CLT, X Window, and Fink, the prerequisites have been established for downloading various software packages from the Fink website.

First the Terminal is required that is located in the folder containing utility programs. Thereafter the package manager Fink should be updated. Typing `/sw/bin/fink` will start the script.

Subsequently, Fink should be updated to the most recent version with `<Option> <Command>`,

**Fig. 2:** A proven workflow for the processing of multibeam echo sounder data with MB-System



The command to install MB-System is:  
*fink -v install mbsystem.*

The installation takes some time. With the option *-v* it is well possible to check if the installation is still continuing or if and where an error occurred. A successful installation is indicated as the system prompt reappears.

In order to verify that the programs work correctly, the X11 environment (XQuartz) can be launched. XQuartz can be found among the utility programs.

As soon as XQuartz has been started, inspect the main menu X11 and select *Programs* and thereafter *xterm*, whereupon an *xterm* window is opened.

Here, the command */sw/bin/mbedit* has to be entered, leading to the display of an X11 window.

Select *About* in the main menu. A window with the version information of MB-System is displayed. Who is able to view this window has done everything right, as far as the installation is concerned, and can start processing multibeam echo sounder data (Fig. 2).

### 3.2 Installation of Quantum GIS

Quantum GIS – also denoted as QGIS – meets nearly all requirements for a geographic information system (GIS). Several public domain database systems are supported, including PostGIS and

SQLite, as well as one or the other commercial database management system. Some properties, such as unrestricted support of the GeoDataBase (GDB) are still missing, but there are workarounds in order to remove or neutralise such deficiencies. QGIS can be obtained from [www.kyngchaos.com/software/qgis](http://www.kyngchaos.com/software/qgis).

QGIS requires some additional libraries that are contained in the GDAL complete 1.10 framework package. This package contains the PROJ library (Cartographic Projections Library), the UnixImageIO library (for processing various image data formats), the GEOS (Geometry Engine Open Source) package with the add-ons of the R-GeoS package, as well as the embedded database system SQLite as framework together with the Spatialite Tools.

First the GDAL package has to be installed; subsequently Quantum GIS. Starting with Version 2.0, the QGIS package also contains the GRASS Toolbox, as well as SAGA-GIS, the ORFEO Toolbox, and also the TauDEM-package (Terrain analysis using Digital Elevation Models). Since then the possibility is also offered to check the installation. At any rate, it pays to start each package for a short while in order to see the program logo appearing. Who can view the logo has done everything right in the installation process. [Ⓡ](#)

#### Hint

This solution was tested successfully under Mac OS X 10.8 (Mountain Lion). Validated solutions are not yet available for more recent versions of this operating system

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# Modern multibeam technology

## Beyond accurate depth measurements

An article by PETER GIMPEL and CHRISTIAN ZWANZIG

Every 50 years there are new developments in hydroacoustics. Hundred years ago, Alexander Behm invented the echo sounder, round about fifty years ago General Instruments developed a Sonar Array Sounding System. Today everyone talks about high-resolution Water Column Imaging. The aim is to detect all objects in the water column. However, it's a hard job for the survey operator to observe the screen. The question is: What is the next big thing? The industry works on an Automatic Object Detector. The article gives an insight in the stage of development and points out the challenges.

### Authors

Dr. Peter Gimpel is Director Survey Systems and Dr. Christian Zwanzig is Senior Systems Engineer, both at L-3 Communications ELAC Nautik GmbH in Kiel, Germany

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Alexander Behm | Bernard Mills | SeaBeam | BOMAS-1 | multibeam echo sounder | WCI – water column imaging | AOD – automatic object detection

### Introduction

We are celebrating the 100th issue of *Hydrographische Nachrichten*, a milestone for the official publication of the German Hydrographic Society as well as for the German hydrographic community.

Not long ago we celebrated another important date for hydroacoustics as well – 100 years since the invention of the echo sounder by Alexander Behm in Kiel, Germany. On several occasions, amongst others with articles in the *HN* and two exhibitions, supported by the German Hydrographic Society, the birth of modern echo sounding and the ingenious inventor Behm have been honoured.

Inspired by the tragic accident of the »Titanic«, Behm's intention was to develop an apparatus to detect icebergs well ahead of a vessel. After initial thoughts he realised that the echo response of icebergs was very difficult to detect, to measure the reflection of acoustical energy from the sea-floor instead was much more promising. Starting with this idea of using the variation in signal reflections to measure the depth of the sea-floor, Behm quickly realised after first disappointing experiments in Kiel bay, that this approach would not lead to success. Instead, he had to invent an accurate timer in order to measure the echo travel time with sufficient accuracy.

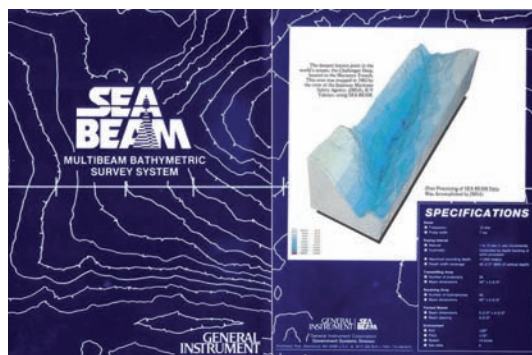
This invention started the age of modern hydrography and revolutionised the depth measurements at sea. Until today, single-beam echo

sounders are the »workhorse« of hydrographic surveying.

Speaking of anniversaries: 1963 – around 50 years ago – the installation of the first multibeam sonar sounding system marked another huge development step ahead. Who would have thought that the downing of the U2 US air force spy plane in May 1960 by Russian forces triggered the development of a new generation of mapping sonars? Here is the answer: At that time engineers of the US company General Instruments were in the planning phase of a new system for radar land mapping for the U2 plane, based on the »Mills Cross Technique« developed by the Australian radio astronomer Bernard Mills. The concept existed, but suddenly no more application on a spy plane. Instead, General Instruments presented this concept as »BOMAS-1« to the US Navy and within shortest time the Sonar Array Sounding System (SASS) was developed. With a frequency of 12 kHz, sixty-one 1 degree preformed beams stabilised for roll and pitch and a swath with of  $\pm 30$  degrees from the vertical, the water depth could be mapped with unprecedented accuracy. This technology was later commercialised as SeaBeam System and used by almost all leading marine research institutes worldwide. Fig. 1 shows the specifications of this system and as an example the mapping of the Mariana trench by the Japanese Research Vessel »Takuyo«.

Today, high-resolution depth charts, »calibrated backscatter strengths« and side-scan images are »standard« results of a multibeam survey. In addition, new applications have been developed by the sonar industry. »Water Column Imaging« (WCI) uses backscatter data from the water column of multibeam sonars. Modern data recording and processing systems allow the storage of raw data for further processing. Fig. 2 shows an example of this integrated data acquisition and processing approach. Data were recorded with a 50 kHz multibeam sonar SeaBeam 3050 installed on RV »Poseidon« (Cruise POS 469 – data provided by Jens Schneider von Deimling, Helmholtz Institute for Marine Science GEOMAR, Kiel).

Fig. 1: Data sheet SeaBeam System (General Instruments, today L-3 Communications ELAC Nautik GmbH)





WCI data as shown in Fig. 2 (c) are of particular interest for researchers today and the processing of these data is described in more detail.

### High-resolution WCI data

The amount of high-resolution WCI data acquired by modern multibeam echo sounders is very huge – within a 12 hour survey, more than a terabyte of WCI data may be stored. In order to support the operator during a survey, modern software packages for the online visualisation of the WCI data are available. They provide sonar displays which include the entire water column information of each ping. However, as the content of such displays completely changes from ping to ping, it is very stressful for the operator to concentrate on the screen all the time and not to miss any possible object within the sonar displays.

Therefore, modern online WCI data visualisation tools like the HydroStar WCI Viewer provide the possibility to display WCI data within a so-called stacked beam history window. In this window, the individual pings are displayed one after the other – similar to an echogram of a single-beam echo sounder which shows not only the current ping information but also a defined ping history.

Objects in the water column can be clearly observed close to the sea-floor.

As a pre-step before displaying the multibeam WCI data in the stacked beam history window (Fig. 3), within each ping a selectable number of beam directions which are oriented to the across-ship direction, are combined by suitable stacking on one vertical line.

### Automatic object detection

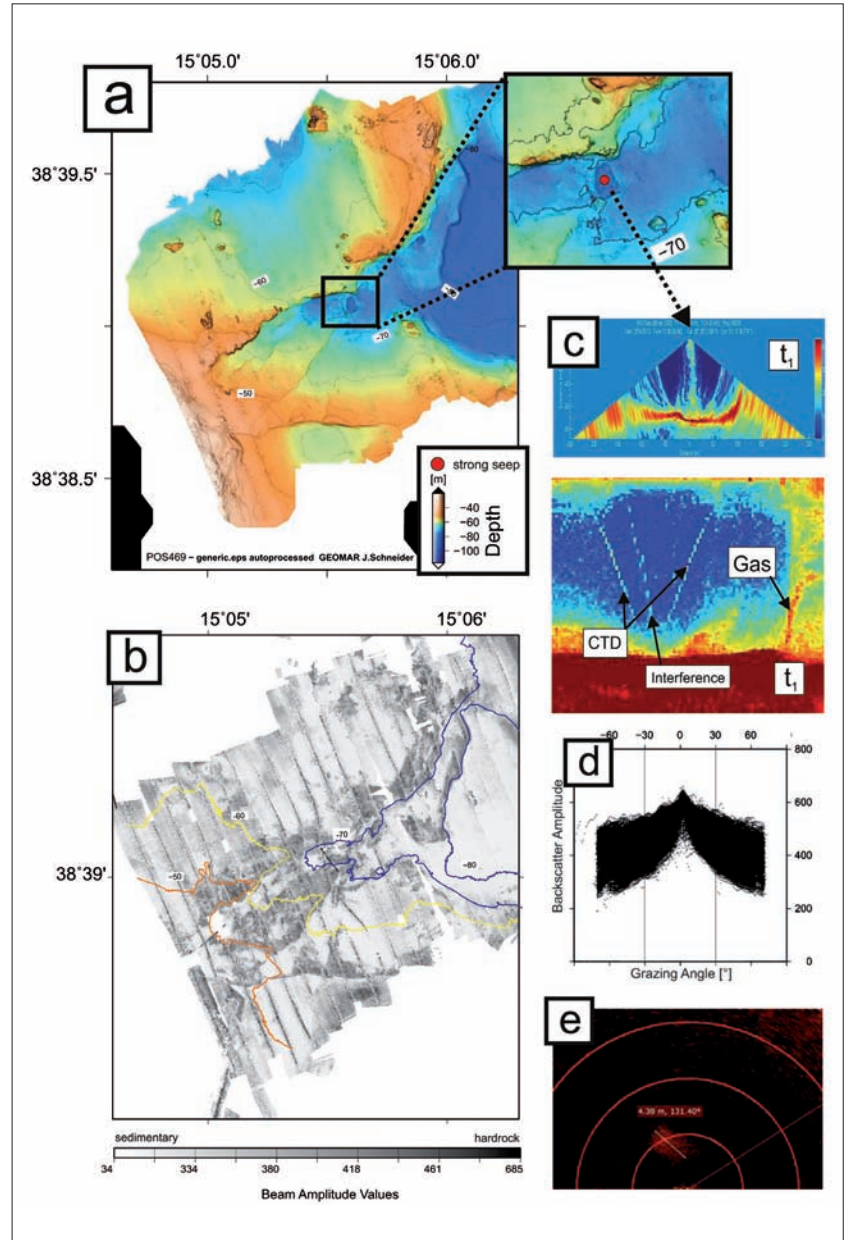
#### Introduction and motivation

Despite helpful aids for the appropriate online visualisation of high-resolution WCI data like the above-mentioned HydroStar WCI Viewer, there is a need for an automatic processing of WCI data with respect to object detection. Such an automatic processing will reduce the workload of survey operators significantly.

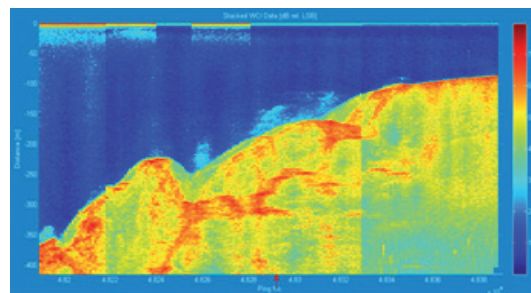
Based upon scientific work of the GEOMAR research centre elaborated within the German SUGAR I and II research projects, which are related to the exploration and exploitation of submarine gas hydrates, L-3 ELAC Nautik develops an initial version of an Automatic Object Detector (AOD) which is dedicated to the automatic detection of larger objects in the water column.

Such objects in the water column are, for example, submarines or gas flares which are indicators for submarine gas hydrate reservoirs. The exploitation of submarine gas hydrates will become an important future business.

Due to the huge data volumes of high-resolution WCI data, the development of an Automatic Object Detector is ambitious and challenging, especially if the detection shall be executed online immediately after data acquisition.



**Fig. 2:** Combined presentation of survey results (POS 469), showing:  
**(a)** Auto-processed bathymetric grid (3 m by 3 m) with histogram equalised colourmap showing volcanic hard rock (brown) and sediment covered areas (blue)  
**(b)** Angular-response corrected beam amplitude data with coloured contour lines  
**(c)** WCI data in temporal fan snapshot and echogram beam stack view with distinct gas release at time  $t_1$ ; CTD down- and upcast is also visible as well as interference echoes from 75 kHz ADCP  
**(d)** Example of beam amplitude grazing angle response pattern that have been used for corrections in (b)  
**(e)** Gas bubbles imaged by the obstacle avoidance sonar MS1000 of the ROV »Phoca«; semi-circle distance is 3 m; ROV depth during this measurement was 16 m



**Fig. 3:** Stacked beam history window (200 consecutive pings)

### Acknowledgements

Parts of the work have been funded by the Federal Ministry for Economic Affairs and Energy (BMWi) in the SUGAR (Submarine Gas Hydrate Reservoirs) project. Data have been provided by GEOMAR, Kiel (Jens Schneider von Deimling and Cord Papenberg)

### Characteristics of objects to be detected

Objects in the water column can be detected by the following characteristics:

- The objects have a certain size and a certain amplitude increase in relation to the surrounding area.
- The objects are located above the seabed.
- The objects are not expanded more or less horizontally over the entire across-ship direction; thus, the objects can be discriminated from the seabed.
- The objects are not covering entirely one or a couple of fixed beam directions within a sequence of pings; thus, the objects can be discriminated from noise spokes which may occur within the sonar electronics.

Gas flares in the water column have a few additional characteristics:

- Gas flares start near the seabed and are more or less expanded vertically.
- The velocity of the individual gas bubbles within a gas flare is directed more or less to the water surface.

### Algorithmic sequence of the AOD

In order to detect objects automatically, a sequence of processing steps has to be applied. Fig. 4 outlines the algorithmic steps of the current version of the AOD.

#### Conversion

WCI data from the SeaBeam medium depth MBES systems are stored as so-called (I, Q) values (I – In-phase; Q – Quadrature), including a real-valued part and an imaginary part. Currently, the algorithms of the AOD do not utilise the phase information included in the (I, Q) data. Therefore, as an initial step the WCI data are converted into absolute values for further processing.

#### Suppression

Using a so-called side lobe suppression algorithm, all echo amplitudes which are identified as acoustical side lobes are eliminated by setting them to zero. The parameters of this algorithm are based upon the characteristics of the reception beamforming within the SeaBeam medium-depth multibeam echo sounders. The side lobe suppression is an optional step which is applied alterna-

tively or in addition to the time slice normalisation within the »Cleaning« block.

As a basis for bottom suppression, a bottom detection algorithm is applied which determines the location of the bottom echo via a so-called boxcar filter. The length of the boxcar filter is based upon the expected length of the bottom echo. As a pre-step to bottom detection, a side lobe suppression algorithm with specific parameters is applied.

In a later step, all amplitude values after the beginning of the bottom echo are eliminated by setting them to zero. The bottom suppression algorithm is still under development.

#### Windowing

The AOD operator has the possibility to define an interesting area in space for object detection. This area is specified by a range interval and a beam interval in the across-ship direction.

All WCI data which are located outside of the interesting area in space are truncated (»windowing«) and not considered in the following algorithmic steps. Thereby, the computing time of the following algorithms is reduced.

#### Cleaning

In order to reduce noise and artefacts in the data and to harmonise the signal amplitudes of different pings, normalisation operations and threshold operations are applied upon the WCI data:

On the one hand, a so-called range normalisation is executed in which individually for each beam direction the mean value is calculated. Afterwards, the amplitude values of all beam directions are divided by the corresponding mean value. Via this operation, for example a noise spoke in the centre area can be eliminated.

On the other hand, a so-called time slice normalisation is executed in which for each time slice the mean value is calculated over all beam directions. Afterwards, the amplitude values of each time slice are divided by the corresponding mean value. This normalisation step has additionally the effect that the side lobes of acoustic echoes are reduced.

After each of the normalisation operations, all amplitude values which are lower than a predefined threshold value are set to zero.

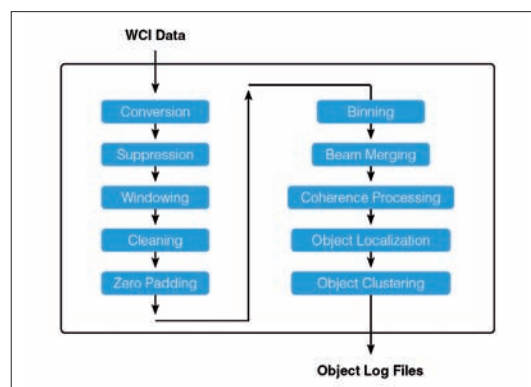
#### Zero padding

If the interesting area in space for the object detection concerning echo travel time and beam angles in the across-ship direction is bigger than the area contained in the WCI data, then the missing WCI data are padded by zeros. This is important for the subsequent binning.

#### Binning

By means of the binning algorithm, all WCI data are transformed to a uniform space grid – resulting in an identical sample interval for the echo

**Fig. 4:** Flow diagram with algorithmic sequence of an Automatic Object Detector



travel time and an identical beam angle pattern in the across-ship direction for the WCI data of all pings.

Depending upon the predefined parameters of the space grid, the binning can include a data reduction in order to reduce the computing time of the subsequent algorithmic steps.

### Beam merging

In order to obtain views of the entire swaths, the WCI data of the inner swath area and the outer swath areas (port and starboard side) are combined via the beam merging algorithm.

The WCI data of the inner swath area and the outer swath areas are overlapping to a certain extent. Therefore, parameters for the beam merging are so-called »merge angles« for the port side and the starboard side, describing the boundaries of the swath sectors within the swath after beam merging.

### Coherence processing

In order to extract larger objects and gas flares in the water column, coherence filters (low-pass filters) are applied subsequently for the different space directions. These filters refer to the echo travel time, the beams in the across-ship direction and the pings in the along-ship direction.

Currently, the coherence processing over the pings (along-ship direction) has not yet been implemented.

After the coherence filtering, all amplitude values which are lower than a predefined threshold value are set to zero.

### Object localisation

The positions of all objects which remain in the WCI data after coherence processing are determined by calculating the balance point of each continuous area with high amplitude values.

### Object clustering

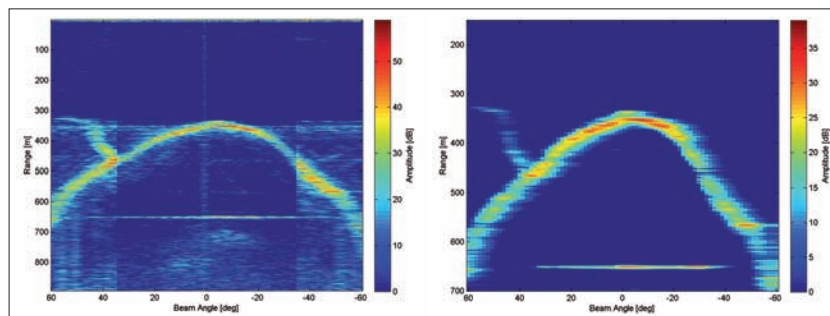
As an optional future step, all identified objects shall be analysed concerning their distances to each other in space. All objects, for which at least one other object is located in the neighbourhood with a distance below a predefined threshold value, shall be summarised as a so-called object cluster.

Afterwards, for each object cluster an associated position has to be determined.

Via object clustering, each aggregation of objects (like a gas flare which is an aggregation of gas bubbles) shall be identified as one (cluster) object, reducing the number of identified objects significantly as each object within an aggregation is not handled individually any more.

### Visualisation of data processing

The subsequent data examples (Fig. 5) are based upon measurement data of the Danube Delta, provided by GEOMAR and acquired by a SeaBeam



**Fig. 5:** One swath ( $\pm 60$  degrees from the vertical) as initial colour-coded WCI data (left); identical swath after application of coherence processing (right)

3050 medium-depth MBES on RV »Poseidon« in December 2010.


After processing, the gas flare at beam angles of approximately 40 degrees can be clearly detected, noise and normalisation problems are greatly reduced and the number of outliers in the automatic object detection process is significantly reduced.

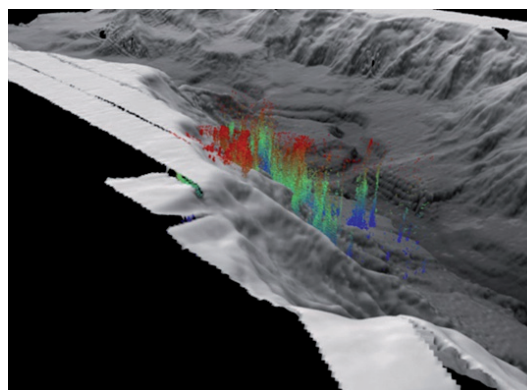
Application of a similar automatic detection algorithm of GEOMAR is shown in Fig. 6. The colour-coded gas flares in the water column are overlaid on a three-dimensional depths map. The correlation of flares with water depth and bottom structures can be clearly noted.

### Summary

The development of an Automatic Object Detector is a challenging task at the front line of technology. Currently, an initial version of the Automatic Object Detector is implemented which has to be further improved within the next years. Among other things, algorithms referring to the specific characteristics of gas flares as indicators for submarine gas hydrate reservoirs shall be included.

Hydroacoustics is still an amazing field of research, increasing requirements as described in the EU regulation No. 2008/56 (European Marine Strategy Framework Directive), which asks for an overall characterisation of the status of the marine environment, need an integrated approach. Protection of the marine environment as a major resource of food and energy requires new technological approaches.

As described in the introduction of this article, the development of new hydrographic systems was realised in part by accident. Every 50 years a quantum leap has taken place – let's see what the next »big thing« in hydroacoustics will be – the time is right. 



**Fig. 6:** Survey of Danube Delta with detected gas flares

# »In development aid Germany should adopt a leading role«

An academic discussion with PETER EHLERS\*

From 1989 till 2008 Prof. Dr. Dr. h. c. Peter Ehlers was president and professor at the Federal Maritime and Hydrographic Agency (BSH). During his term of office he particularly supported the protection of seas and oceans. Prof. Ehlers, a graduate lawyer, was representative in various commissions and an internationally perceived voice. Although he is already retired the 71 year-old's engagement for the ocean is still unbroken. A personal interview about achievements and shortcomings.

Federal Maritime and Hydrographic Agency – BSH | IHO | IMO | hydrography | definition environmental protection | marine economy | ocean engineer | HELCOM | Law of the Sea

**HN:** Mr. Ehlers, you have been retired since 2008. How does it feel when you enter this building, in which you worked as president for more than 20 years?

**Peter Ehlers:** I like being here though the times I come to visit become less. Since 1973 I had worked in this building, at that time in the department Maritime Transport of the Federal Ministry of Transport which for many years was located here in Hamburg. I regard the years as president of the Federal Maritime and Hydrographic Agency as a fulfilled period of life. It makes me happy when former colleagues recognise and greet me, sometimes we have a conversation. I am very satisfied when I look back, yet I know: the time is over. I have no withdrawal symptoms; the only thing I miss is the daily view on the port.

**HN:** Please explain what the title »president and professor« at the Federal Maritime and Hydrographic Agency means.

**Ehlers:** It is a title of official anchored in the Civil Service Remuneration Act. It exists for some positions in federal authorities with a scientific orientation. The idea behind is that scientists at federal

institutions are on eye-level with professors at universities. That is why the title is for example »director and professor«. However, it is only a title of official, which does not entitle teaching at university.

**HN:** However, after the evaluation of the Federal Maritime and Hydrographic Agency a couple of years ago the Scientific Council recommended the enhance-

ment of research activities.

**Ehlers:** That's easier said than done. On the one hand the public sector must save costs, reduce personnel and positions, on the other hand new tasks are coming up. At the same time bureaucracy is steadily growing. You cannot increase scientific work without sufficient personnel, but the

personnel is primarily needed for fulfilling necessary and important tasks demanded by law. The Federal Maritime and Hydrographic Agency fulfils excellent research but less than in former times. How could it be different?

**HN:** After the German Unification you realised the fusion of the Rostock and Hamburg locations. The newly developed Federal Maritime and Hydrographic Agency – till 1990 called German Hydrographic Institute (DHI) – had to be united with the authorities of the German Democratic Republic (GDR). How did that work?

**Ehlers:** When I became president of the German Hydrographic Institute in 1989 the department of maritime transport of the Federal Ministry of Transport was moved to Bonn, the former capital city. At that time, nobody even thought about the fall of the Berlin Wall. As compensation we were to create a central maritime authority by uniting the German Hydrographic Institute and the Federal Agency for Tonnage Measurement. Members of the German Parliament wanted to call the agency »Federal Maritime Agency«. The term was insufficient not only for me. The German Hydrographic Institute already included the term »hydrography« and it should be part of the new agency as well. Fortunately, we were able to convince politicians to adopt the title »Federal Maritime and Hydrographic Agency«.

When the German Unification occurred a few months later we had to integrate the maritime tasks of the GDR – among them those of the Maritime Hydrographical Institute and the Board of Navigation – into the newly created Federal Maritime and Hydrographic Agency. Already before the Unification the directors of the maritime agencies of the former German Federal Republic and the GDR came together and discussed the new structures. Fortunately, we knew each other from former cooperations in international committees. This made it a lot easier. We showed the highest respect for each other. I always wanted that the restructuring would take place unbiased and as equal partners. The West had no reason to show

\* The interview was held by Lars Schiller December 18th, 2014 at the Federal Maritime and Hydrographic Agency (BSH) in Hamburg

Translation by Verena Eismann

*»Hydrography must trust itself more, be more innovative and secure more shares. It is very important to offer not only single components, but overall concepts and solutions which are technically mature and eco-friendly«*

Peter Ehlers

off and be presumptuous as we didn't grow up on the »wrong« side. On the contrary we had utmost respect for our colleagues from the GDR, who had implemented tasks with fewer means.

From October 3rd, 1990 the Federal Maritime and Hydrographic Agency smoothly adopted the respective duties of the GDR agencies; the Federal Maritime and Hydrographic Agency was thus one of the first viable unified German agencies. We opened a branch in Rostock and were able to keep 200 employees.

However, the most difficult part came later when the Commission of Federalism decided to transfer additional 150 posts from Hamburg to Rostock. The idea was to strengthen the Rostock location as symbol for the merging of East and West. This was a difficult situation for many colleagues in Hamburg. The problem was solved along the time frame. At the same time the Federal Maritime and Hydrographic Agency got two headquarters. I commuted between Rostock and Hamburg regularly. It was very important to distribute the tasks clearly between both locations. Parallel structures would have been uneconomically. And that's why we transferred the department of Nautical Hydrography to Rostock.

**HN:** Viewed from a distance of a few years what was one of your greatest achievements as president of the Federal Maritime and Hydrographic Agency?

**Ehlers:** I would say the merging was my most important project because the German Unification was the life's dream of my generation. At the same time we were able to turn the Federal Maritime and Hydrographic Agency into *the* central German maritime authority. I say »we« because it was only made possible thanks to all colleagues.

We also made progress in individual topics. Among them ECDIS licensing, the testing of nautical-technical ship equipment, the authorisation procedures for the offshore wind power plants, and many more, ranging from supporting the German merchant fleet to marine research projects.

**HN:** Can you please tell us about a failure?

**Ehlers:** I was very sad when we had to sell our flagship »Gauss«. Due to the annual cuts in personnel we couldn't keep the ship's crew. So in 2006 we had to reduce our fleet from six to five ships.

I always was ashamed that we weren't able to achieve more in international cooperation for development aid. Regarding the maritime sector Germany isn't very active in technical cooperation. One reason can be found in the fact that those states, which still have to build up a maritime infrastructure, set other priorities. Hydrography, marine science and environmental protection are issues at the very end of the priority list of these countries. I always supported the build-up of maritime infrastructure as we also profit from it. Countries with a developing maritime industry, which are very important for us, are the future markets. Ten years ago, after the disastrous tsunami in Southeast Asia,



**Published up to now:**

Horst Hecht (HN 82),  
 Holger Klindt (HN 83),  
 Joachim Behrens (HN 84),  
 Bernd Jeuken (HN 85),  
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 Werner and Andres Nicola  
 (HN 98),  
 Sören Themann (HN 99)

we were able to give a certain amount of aid, especially in Sri Lanka. Horst Hecht took over international coordinating functions for hydrography, which are continued now by Thomas Dehling, who is very active in the IHO for Capacity Building.

**HN:** German hydrography has »international impact« – these were your words in the festive speech of 2011 for the »150 years of official hydrography in Germany« celebration (published in HN 90). What is Germany's contribution today?

**Ehlers:** From an historic point of view there are quite a few contributions initiated by Germany or at least that we pushed ahead. Especially the International Chart 1 (INT 1), for which the Federal Maritime and Hydrographic Agency was responsible for. Right from the beginning, Germany was also very much involved in developing and introducing the electronic chart. The necessary standards for ECDIS had been elaborated under the supervision of Horst Hecht. And for many years I chaired the WEND Committee of the IHO, which organised the development of ENC data centres. We had initiated the embedding of hydrography into the SOLAS Convention. In former times, there was no obliging international law for states to have a hydrographic office. When the IMO renewed the SOLAS Convention in the 1990s, we took the chance for a German initiative which finally succeeded. Since 2002 SOLAS obligates states to have a hydrographic office. This step strengthened the hydrographic offices for the safety of seafaring. And also the Helsinki Convention for the protection of the Baltic Sea was amplified by hydrographic tasks.

*»I always was ashamed that we weren't able to achieve more international cooperation for development aid. Except ten years ago, after the disastrous tsunami in Southeast Asia, we were able to give a certain amount of aid, especially in Sri Lanka«*

Peter Ehlers

We significantly helped to modernise the organisation of the IHO. To exaggerate a bit, after the revision of the IHO agreement we managed to create a modern international organisation out of a »club«. I regret that the new regulations are still not in force, but I am sure that very soon the necessary numbers of ratification will be reached. Today, we provide important impetus for developing the infrastruc-

ture of marine spatial information. During my active time, we had started that at an international workshop in Rostock. We also care about further developing survey standards. All in all, we are very strong regarding innovations. Maybe we have the advantage that we don't belong to the really big hydrographic offices, we are concerned about the matter itself and not about our own importance.

**HN:** When you were asked to define hydrography your answer was very often: »the description of the oceans and all ocean related issues«. This is a very broad, open and flexible definition. However, I

miss something in the crucial aspect of the subject matter. Why don't you mention the inland waters?  
**Ehlers:** The definition goes back to my pre-predecessor Prof. Roll. I liked it, but you're right. Why not mention inland waters? However, from an historic point of view it is critical. In the meantime, the IHO has decided rather reluctantly to mention inland waters in their new definition of hydrography. It doesn't sound very convincing though because the IHO writes about »marine activities«, which relates very much to the ocean.

Whenever I had used the quoted definition it was from the Federal Maritime and Hydrographic Agency president's perspective, who is responsible for the ocean. (The inland waters are taken care of by the colleagues of the German Hydrological Institute in Koblenz.) My definition goes beyond the traditional nautical hydrography and includes oceanographic tasks and fields of the Federal Maritime and Hydrographic Agency.

**HN:** What's the difference between the German perspective and the international one on hydrography?

**Ehlers:** That's a difficult question. When thinking of actual hydrography, then I must say that I lack detailed information on what is really achieved on international level. However, I have the impression that the science of hydrography is relegated to a niche existence in Germany. This may be different in countries like Great Britain, France, the USA and Canada. Nonetheless, there are technical achievements realised in Germany.

**HN:** What could Germany make better in terms of the ocean?

**Ehlers:** Let me tell you an anecdote. When the United Nations declared the year 1998 as the International Year of the Oceans, US President Bill Clinton held an inauguration speech. In Germany, this was done by the president of the Federal Maritime and Hydrographic Agency. That's exactly the issue. The Germans should devote themselves more to the ocean and recognise its economic importance. We focus on high-tech in many branches for example automotive, aerospace and mechanical engineering and are on eye-level internationally. However, we should emphasise more on marine technologies in order to find eco-friendly solutions.

**HN:** What should be improved in hydrography?

**Ehlers:** Hydrography should extend its service sector for marine spatial information. Detailed information about oceans is asked for everywhere. Hydrographic services are indispensable requirements for most maritime activities, but attracting attention to and entering new fields aren't our strong points.

**HN:** In what way can hydrography profit from changes in the marine economy?

**Ehlers:** Hydrography is part of the marine economy which is a branch with future potential for which alone in Europe the European Commission

has calculated a gross volume of more than 500 billion euros annually. Great potential lies in maritime shipping, aquaculture, offshore wind energy, tourism and innovative marine technology for the environmentally friendly exploitation of nonliving marine resources. This offers several economic chances as well for hydrographic services. Hydrography must trust itself more, be more innovative and secure more shares. There's a lot to do. In marine economy just like in classic hydrography the main issue is the global market. It is very important to offer not only single components, but overall concepts and solutions which are technically mature and eco-friendly. However, companies must position themselves in time on the worldwide market, which brings us to the importance of development aid. Politics must offer more support in this aspect.

**HN:** You describe future tasks which in detail cannot be grasped yet. Who can fulfil them? Oceanographers and hydrographers are not really prepared for that. You once mentioned the profession of ocean engineer.

**Ehlers:** That's right. We should think about a new study programme. The successful education of hydrographers in Hamburg could function as role model for the new profession of ocean engineer. It is important to recognise special requirements.

As a matter of fact, a hydrographer isn't engineer enough, the oceanographer is too much of a physicist. An ocean engineer would have knowledge of both sides, and thanks to the Master study programmes nowadays, it would be easy to offer a respective specialisation.

**HN:** You have once called hydrography a »sleeping beauty« (HN 84). Is she still sleeping? And has she lost some of her beauty?

**Ehlers:** She is as beautiful as ever, but I think she is still sleeping, although I may have missed minor changes during the last few years. We must show how broad the range of hydrography really is and seek contact to neighbouring fields, only in doing so we can give sleeping beauty the »fairy kiss«. All persons involved must convince politicians that we need different conditions and adequate subsidy measures.

**HN:** Can you give concrete examples how hydrography can call more attention? Is the IHO voice loud enough? What can organisations like the DHyG and the IFHS do?

*»The merging of the maritime authorities was my most important project because the German Unification was the life's dream of my generation«*

Peter Ehlers

# Happy Anniversary!

L-3 ELAC Nautik, as supplier of hydroacoustic systems since nearly 100 years, congratulates on the **100th** issue of **Hydrographische Nachrichten** and wishes all the best for the future of this great publication!



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L-3 ELAC Nautik develops and manufactures state-of-the-art units and systems for precise charting of the seafloor topography for customers in the field of hydrography, for survey of harbors, rivers and lakes as well as for oceanography, marine geology and biology.

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**Ehlers:** The IHO does its best. For sure, press work could be better. The question is if the IHO is organised well enough with regard to its importance. Although the IHO is an intergovernmental organisation it doesn't belong to the UN-organisations. I had already asked from time to time if the IHO could be integrated into the IMO. In this way the IHO work would gain importance. When we started reforming the IHO, I could have imagined merging the IHO and the IMO to a powerful maritime organisation, even if that would have meant losing the attractive site in Monaco.

Every effort of trying to make hydrography popular in the public hasn't shown any effects so far. In the past, we always tried to explain hydrography in general terms. But in the meantime, I believe that we need to present it in a more concrete way and present our tasks. I always feared that showing only one aspect would exclude all others, which in a way is true. However, we have no other chance than talking about something concrete. When SHOM found the black box of the Airbus that crashed into the Atlantic in 2009, this could have been a real success story in the public. It offered the possibility to show what hydrographers really can do. And this should also be the duty of the DHyG.

**HN:** During your career you supported the protection of oceans in particular. How should the ideal protection of the marine environment look like?

**Ehlers:** What does ideal mean? One could argue that ideal is leaving the ocean up to itself; however, this isn't feasible because we rely on the manifold

use of the oceans. Effects on the marine environment are definitely the consequences. Every ship makes noises and therefore already has impact on the environment. It must be weighed. One thing is for sure: without protecting the oceans a greater use of them isn't possible. An important aspect is that marine protected areas aren't accessible for further use or only in a restricted way.

**HN:** Like the North Sea which is an industrial park on the one hand and a protected nature reserve on the other hand.

**Ehlers:** That's correct. We cannot restrict the industrial use completely; we need a spatial planning for the sea as well. In view of rising resource consumption we cannot do without raw material from the ocean and marine mining. And it won't be possible to prohibit the recovery of resources in 1,000 metres depth and more. Furthermore, in environment protection there is the consensus to push ahead offshore wind energy. For sure, in fu-

ture other means of energy production from the ocean will play an important part. We must balance responsibly between the economic use of the oceans and their protection.

**HN:** What predominates, pollution through maritime shipping or inputs from land?

**Ehlers:** Definitely landbased inputs, all studies have proven it. Compared to these inputs other sources of pollution play a minor role. Until the beginning of the 1980s we were convinced that pollution comes from ships, especially in form of oil pollution. Since then, there have been great improvements as concerns pollution from ships; nowadays the issue is to reduce ship emissions and the problem of ballast water. Marine pollution is still a very present topic, but mainly because of inputs from land. Worldwide there exist prohibitions for ships; however, compliance has to be controlled even more strictly.

**HN:** Since 40 years HELCOM has been working as intergovernmental organisation for the protection of the marine environment of the Baltic Sea. What has the Helsinki Commission achieved from your point of view?

**Ehlers:** All in all the condition of the Baltic Sea hasn't deteriorated. This alone is already a great success achieved by HELCOM. It was the first time during the Cold War that neighbouring states came together in order to pursue one common concern. Already in 1974 the Helsinki Convention for the protection of the Baltic Sea was adopted. In 1992 it was modernised and the aspect of protecting nature and biodiversity was included. All nine bordering states and the European Union belong to the Helsinki Convention. The Baltic Sea has become cleaner but still there is a lot to do. Eutrophication is the greatest threat and this demands significant efforts.

**HN:** HELCOM demands regular reporting about the effectiveness of protection measures. The basis for this is an extensive environmental monitoring of course. What does environmental protection mean? And what can hydrography contribute?

**Ehlers:** There's no monitoring without hydrography because right from the beginning you need to have a look at the local geographical conditions. Especially flow conditions, tidal range, water exchange and natural nutrient availability determine strongly how much an ocean area is influenced by human impact. Often physics and chemistry are looked at separately not to mention marine biology. You must combine all three in order to obtain well-founded and extensive results.

**HN:** Since 2002 you have been teaching Law of the Sea and Marine Environmental Law at the University of Hamburg. You had to organise that with your regular job for six years. How did you manage that? And does teaching get along with retirement?

**Ehlers:** Since 1991 I had held lectures on a regular basis, even at Rostock University for a couple of years. In 2002 I became honorary professor at

*»When the United Nations declared the year 1998 as the International Year of the Oceans, Bill Clinton held an inauguration speech. In Germany this was done by the president of the Federal Maritime and Hydrographic Agency. That's exactly the issue. The Germans should devote themselves more to the ocean and recognise its economic importance«*

Peter Ehlers



the University of Hamburg. The excursions into university and legal fields were a great enrichment of the practice-oriented management field. In my function as president I had to take one decision after the other on a daily basis. Therefore, an academic duty was a welcome supplement. Law of the Sea was always like a hobby for me and at the same time an indispensable basis for the maritime administrative tasks during my more than 40-year long career. Insofar, holding lectures was compatible with my job, even if I spent numerous weeks preparing them.

I don't lecture anymore at the University of Hamburg so I am more flexible. However, I teach at the World Maritime University in Malmö (Sweden), at the ITLOS we have a summer school every year and I hold lectures regularly on Malta.

**HN:** What fascinates you about Law of the Sea?

**Ehlers:** Since my dissertation about the IMCO, today called IMO, I am fascinated by Law of the Sea because the formulated regulations were always present in my individual professional stages. Most important to me is not only the law in itself but the use of the oceans and their protection. Definitely, this will not be possible without an adequate legal framework. Moreover, the Law of the Sea is still developing and offers many interesting questions.

**HN:** Do you realise that the Wikipedia entry about you isn't up to date?

**Ehlers:** The entry was made for my 65th birthday. I haven't looked at it for a long time because I know my biography, but I can imagine that it is outdated. I don't have the posts which were related to my functions at the Federal Maritime and Hydrographic Agency anymore, but I am still engaged in quite a lot of voluntary commitments in the maritime field.

**HN:** What would you like to do better?

**Ehlers:** At my age you don't want to do many things better. I get along with my imperfections although many times I would have liked to have more knowledge in natural sciences. In school these subjects bored me a lot, but later during my career it would have made things easier sometimes.

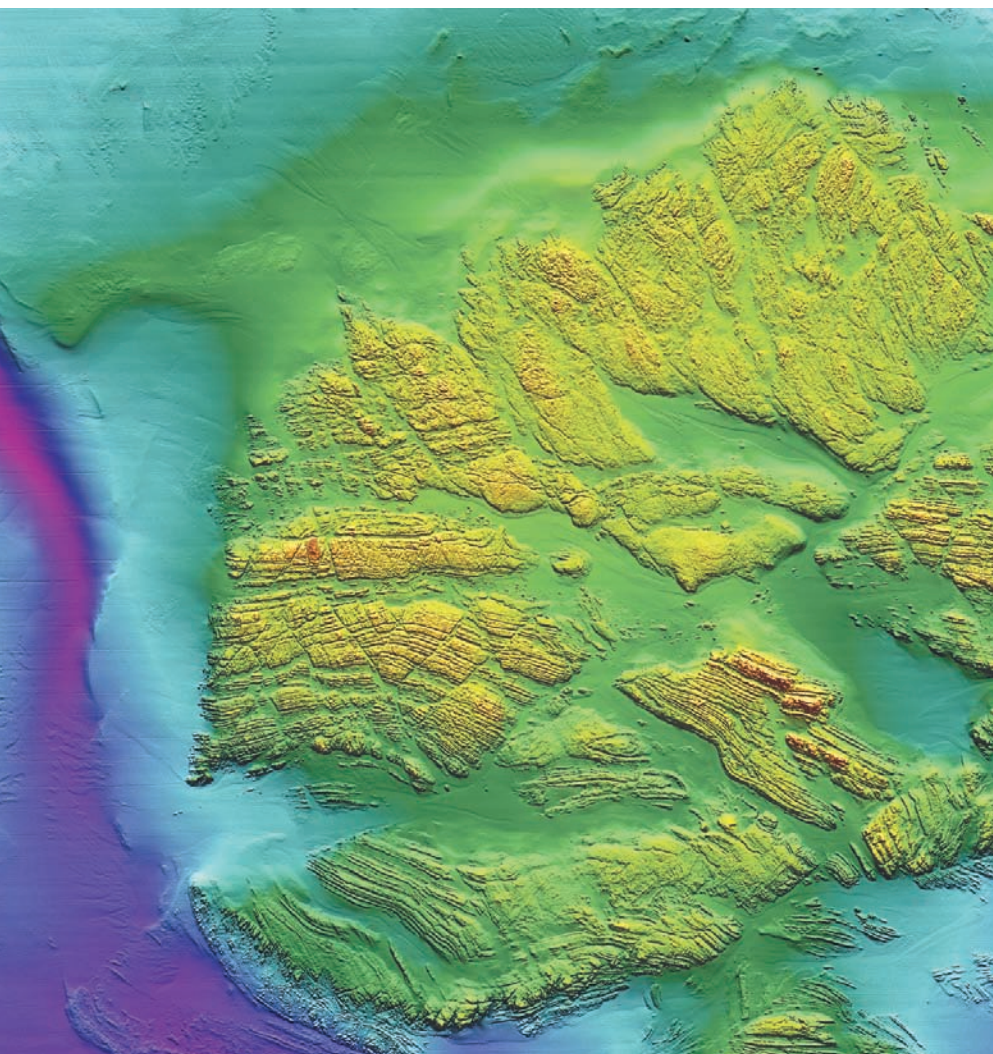
More patience, not only in former times but also today because it doesn't come with age. Many times things don't work as fast as I want them to.

**HN:** The last question: What do you know without being able to proof it?

**Ehlers:** That we need the oceans for our lives and survival. ⚓

*»One thing is for sure: without protecting the oceans a greater use of them isn't possible«*

Peter Ehlers



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# Hydro 2014

## Energy & Enterprise in Aberdeen

A report by *HOLGER KLINDT* and *IAN HOLDEN*

Hydro 2014 took place in the energy capital of Europe. The 22nd Hydro conference of the International Federation of Hydrographic Societies (IFHS) comprised everything the over 300 delegates could expect from such a three day event: a technical programme featuring keynote and paper presentations, workshops and technical visits, an exhibition and a social programme including the ice-breaker party and the conference dinner. Hydro 2014 also saw the introduction of two new regular features to the Hydro conference programme: An IHO-led session and a student presentation session.

Over 300 participants and nearly 60 exhibiting industry partners from over 20 countries had come to enjoy and take part in, what the professional and experienced organising team of the UK Hydrographic Society had prepared, Hydro 2014.

The three day conference and exhibition took place at the Aberdeen Exhibition & Convention Centre in the Bridge of Don area of Aberdeen from the 28th to 30th October 2014.

Aberdeen, the third largest city in Scotland, situated between the rivers Dee and Don and since the discovery of North Sea oil & gas in the 1970s been acknowledged as the Energy Capital of Europe, made a perfect environment for the annual gathering of the worldwide hydrographic community.

Hydro 2014 was opened at the Aberdeen Exhibition & Convention Centre on the 28th of October – by the honourable chairmen of the Hydrographic Society UK, the International Federation of Hydrographic Societies and the director of the International Hydrographic Organization Mr. Gilles Bessero. In his welcome address the Lord Provost of Aberdeen, Councillor George Adam, underpinned the importance of the maritime industry and hydrography in particular, not only for the wealth and development of Aberdeen but for the global energy markets.

**Fig. 1:** The winner of the *IFHS Student Award*, Oliver Kumpel (in the middle), Rob van Ree (IFHS chairman, left), Lilian Lieber (University of Aberdeen), Katrina Murphy (University of Aberdeen), Holger Klindt (former IFHS chairman)



Under the conference theme »Energy & Enterprise«, the host committee had compiled an ambitious programme with 30 well-known experts to provide in-depth knowledge and experience in a wide range of application such as:

- Data Management and Integration,
- Tidal and Sea Level Monitoring,
- Low Impact Offshore Exploration,
- Hydrographic Standards,
- Data Quality and Resilience,
- Subsea Engineering Surveying.

In his keynote address Monty Mountford from Storm Geomarine took the audience back on a route »back-to-basics«. In this world of exponentially growing technology and technical capabilities, Monty strongly promoted an »Intelligent understanding« of the underlying challenges as key for the development of a sustainable Blue Economy.

In the second session, chaired by the vice chair of the International Federation of Hydrographic Societies Rob van Ree (HSB), the audience followed the first-time presentations of students and junior hydrographers, geared up to give their first appearance and presentations to an international auditorium; amongst them Oliver Kumpel from HCU (now Fugro OSAE), the 2014 winner of the newly implemented international *IFHS Student Award* (Fig. 1).

Further student papers gave interesting insights into a wide band of topics ranging from »the use of imaging multibeam sonars to track basking sharks« to the »technology impact of ROVs and AUVs for the development of the Blue Economy«.

It was a pleasure for everyone to see a new generation of young and enthusiastic hydrographers taking a fresh and innovative stand to drive hydrography towards new horizons.

In session three, the subject that underpins all of our data, Tidal and Sea Level Monitoring was covered. The subjects included: GNSS-derived tidal information for PPP (precise point positioning) and the interaction with the various datum models and a particular focus on comparing BATHYELLI

vertical reference surface derived PPP tide and a conventional tide gauge in the Bay of Brest. The session moved onto a practical paper on the installation of a new tide gauge network on the Thames estuary for the Port of London authority. The final paper covered the effect on our coastline with techniques for sustainable coastal management. The land sea interface or the intertidal area is a primary focus. Thanks goes to Aubrey Price (HSSA) for chairing the session.

The evening reception was held at the Maritime Museum. When you enter the building there is a scale model of a North Sea platform rising from the entrance to the roof over three floors. The venue enabled a truly excellent networking opportunity and thanks go to Atlas Professionals for sponsoring the evening.

The Wednesday morning session, chaired by Walter Jardine, begun with Low Impact Offshore Exploration. The first paper on AUVs in the Arctic, an efficient and safe method for surveying under the ice. As confidence increased over the years with better technology, so does the terrain these vehicles are able to operate in. The future will be an exciting field for all AUVs. The second paper discussed the safety aspects of offshore infrastructure, in particular the interaction with fishing vessels. The FishSAFE uses the P5/94 data format to create a database for use on fishing vessels. The final paper in the session discussed error budgets for AUVs. There is a need for standards for AUVs, as the systems are not like a vessel mounted system where S-44 is used. This paper lead onto session 5 where the topic was Standards, chaired by Gordon Johnston.

The first paper was on »e-Navigation: Do we need the IMO SIP?« The answer was yes, but when will it arrive? The international nature of the IMO results in a committee agreement process, with the result that technology is overtaking the agreements. In the near future we will need to switch over to S-101 from S-57. The second paper discussed leveraging more business value from data, with an »observe once use many times« approach. Thus, using standard specifications to give a SSDM (sea-bed survey data model) for use in GIS data bases should be a goal. The next paper discussed standards for data management. We are in the »Big Data« era where a pipeline survey can easily generate terabytes of data. How do we manage and present this data? New hardware will help, though we also need new methods. The final paper of the session »Harmonising survey deliverables – Emerging standards and smart data exchange« was a well chosen closing paper. There are S-100, S-101, S-102, S-121 and OGP (oil and gas producers) standards; we need to harmonise these for data use in CAD, charts, SSDM and ENCs. This will give »Big Data« value.

The workshop session on Wednesday afternoon saw 13 opportunities for site visits and supplier technical presentations on their solutions for topics covered in the sessions and out with. Site visits were held at the Aberdeen Harbour Board Marine Operations Centre and to the Shell GIS Visualisation Centre. Whilst the workshops ranged from standards, to digital video, to GNSS tides, to errors and quality.

The conference dinner on Wednesday evening, held at the Elphinstone Hall, was a real treat; excellent food, inspiring location and great service. During dinner the awards for best student presentation and paper were awarded with the appreciation of all. A superb musician of the bagpipes gave a concert during which some dinner guests demonstrated how difficult the bagpipes are to play (Fig. 2). Thanks to ESRI for the sponsorship of the event.

Session 7, chaired by Ian Douglas, on Thursday morning began with Data Quality and Resilience. The opening paper was pipeline inspection in the Caspian Sea combining both bathymetric data and »pig« data. The GVI inspection does not look at the pipeline wall integrity, unless the coating has significant disturbance. Using a PODS GIS compliant database enables the data to be verified and a time series to be developed. The next paper covered if real-time estimate of uncertainty is possible and could this be used to aid automatic processing. The results showed real-time uncertainty was possible and the estimates could be applied to processing. The third paper presented discussed if the number of beams in MBES matters. Essentially yes, though look at the application and use of the data. More beams will give a finer result when targets are present or greater density in deeper water. The final paper presented was »Automatic 3D boresight estimation of IMU and multibeam echo sounder systems«. The mathematics in the presentation tested most of us; however, the author's in-



**Fig. 2:** A superb musician of the bagpipes gave a concert

terpretation is the boresight calibration is achieved through analysing the best fit for two surfaces. The geometric transformation will give the calibration figures with quality estimates. One note is that we will no longer need to search for significant seabed features, in fact they should be avoided in this method.

Session 8. During Hydro 2006 in Antwerp the International Hydrographic Organization and the IFHS jointly signed a memorandum-of-understanding to deepen the level of their cooperation. Various joint conferences and workshops resulted from this mutual understanding with the conference »Digital Hydrography on the Maritime Web« (Plymouth 2013) as the latest successful gathering addressing the future needs of hydrography as seen by the various stakeholders. At Hydro 2014 Gilles Bessero, Director of the International Hydrographic Organization, together with his fellow panellists Mathias Jonas (BSH GER), David Parker (representative for Duncan Mallace, MMT UK), Ian Holden (representative for Will Primavesi, Survey Services UK), Nicolas Seube (CIDCO CA) and Rob Spillard (Fugro UK) further exploited ideas and proposals on how to improve and intensify the two-way interaction between the IHO and our industry (Fig. 3).

The penultimate session, chaired by David Green, of the programme discussed a topic that defines our industries future: Education and Training. During this session we learnt how industry is tackling the topic in the Fugro Academy, the Institute for Hydrography in Antwerp for higher education training and the Hydrographic Academy in Plymouth for vocational training. All courses lead to higher quality surveyors, able to identify and understand possible sources of error. Thus resulting in benefits to our profession. The second two courses result in IHO Cat B or A qualification respectfully.

The final session was titled Subsea Engineering Survey beginning with a review of LBL INS and the lessons learnt. The conclusion was planning is paramount, only installation time is saved and training is paramount. The final paper was »Using close range photogrammetry to meet offshore platform construction and installation requirements«. This method gives rapid collection removing significant logistical challenges and provides sub-millimetre accuracy. The session was chaired by Colin Cameron.

The closing ceremony gave the opportunity for the conference series to be handed over to the South Africans for Hydro 2015 due to held in Capetown between the 23rd to 25th November, 2015. Keep up to date with the latest news at [www.hydro2015.org](http://www.hydro2015.org). The finale saw a return visit by the bagpipes and a rendition of the Scottish Poet's Robert Burns *Auld Lang Syne*, 1788. A traditional song which is sang to bid farewell to the old year at mid-night and by extension for the ending of other occasions.

The success of Hydro 2014 comes from a multitude of different stakeholders: manufacturers, service and information providers, agencies and commercial users who had come to Hydro 2014. Inspiring presentations, in-depth discussions and lots of tech talks at the exhibition offered everything todays hydrographers could ask for: information, experience and contacts.

In the coming months many of the presentations will be available on the IFHS website (a link will be e-mailed to delegates prior to public release).

Our thanks go to The Hydrographic Society UK, the THSiS (The Hydrographic Society in Scotland) and its organising team, which had done a fantastic job by organising a great Hydro 2014. [📍](#)

**Fig. 3:** IHO-led stakeholder forum with (from left to right) David Parker, Nicolas Seube, Ian Holden, Mathias Jonas, Rob Spillard and Gilles Bessero



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# Flight into freedom

A review by LARS SCHILLER

Alfred Andersch' first novel *Flight to Afar* (*Sansibar oder der letzte Grund* – »Zanzibar or the last reason«) tells a story about flight into freedom. A Jewish young woman and an object of art are being rescued from the imminent Nazi fascist arrest. The flight from Rerik across the Baltic Sea to Sweden succeeds thanks to the knowledge of waterways, shoals and currents.

Nowadays, leaving Germany is very easy, you can just go whenever you want to. Times were different though; you had to flee across the border in order to find freedom. Until 1989, even the inner German border was closed. More than 5,000 GDR citizens tried to escape, either swimming or in rowing boats – across the Baltic Sea to the West. Only few of them succeeded, others failed and were taken to prison. Half a century ago, Jewish people in Germany suffered even more; they were faced with the internment into extermination camps. This is exactly the topic of Alfred Andersch' first novel *Flight to Afar*. He describes two days in the autumn of 1937.

In the small Baltic town of Rerik four people meet with the aim of leaving the country out of political or personal reasons. Judith, a young Jewish woman from Hamburg, needs to escape from the Nazis. Her mother, old and not healthy enough due to a walking disability, committed suicide days before, so that Judith would have the chance of escaping from danger. In Rerik she hopes to find a ship that will take her to a neutral country. And indeed, at midday there is a Swedish steamship in the port ...

In Rerik, Judith gets acquainted with the communist instructor Gregor, who has to accomplish a Party order. He knows immediately that Judith is Jewish and that she desperately wants to flee abroad.

Gregor came to Rerik to contact the fisherman Knudsen, the last active comrade in town. However, Gregor has lost faith in the Communist Party, from his point of view it had failed when the Party left the power to the Nazis in 1933 without showing any resistance. Knudsen as well wants to leave the Party because he cannot see any perspective in its underground activities.

Knudsen employs a 15-year old young sailor who is bored by the anguish of daily life in the small town and annoyed by his mother's moaning. He dreams of a flight as described in one of his adventure books. »The right thing was to go away but you had to have somewhere to go to. You couldn't act like Father, who simply sailed aimlessly out into the open sea. If you had no other goal than the open sea, you always have to come back again. You'd have only got away, thought the boy, when you reached land beyond the open sea« (pp. 1–2).

Then there is another figure: the »Studying Monk«, an object of art by Ernst Barlach installed in

the church of Rerik. The Nazis regard it as »degenerate art« to be taken away and destroyed the following day. The priest asks the fisherman Knudsen to take the figure to Sweden into safety. Knudsen rejects because he doesn't want to get into a dangerous situation himself.

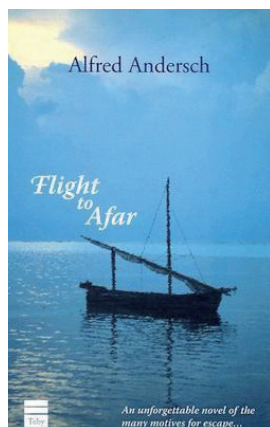
When Gregor meets Knudsen in the church to give him the instructions of the Central Committee, he sees the figure and likes it at once. The tenderness and concentrated reading posture fascinate him. Gregor proposes a joint escape to Sweden. However, the fisherman refuses; he cannot stand Gregor, a man who seemingly shirks away from the Central Committee, while he himself is only a common comrade who cannot escape.

Nonetheless, Gregor can convince the reluctant fisherman to save the figure. They agree on a nocturnal meeting point at a hidden spot on the coast. Knudsen shall leave the port with his boat as usual for everyone to see that he goes out fishing. Gregor will take the »Studying Monk« and sneak completely unnoticed to the meeting point at the headland. There, Knudsen's young sailor will pick him up with the rowing boat.

Everything happens accordingly, only that Gregor doesn't come alone with the statue, but brings Judith, whose only hope to escape with the Swedish ship, had faded desperately. The young sailor is astonished as he was only told about the strange man. When Knudsen had explained about the plan, he thought that a passenger on board would surely be brought to the other side of the Baltic Sea and not be left on this part of the coast. He would never have imagined that Knudsen were capable of such an action.

For the young sailor a story begins similar to one in his adventure books. How many times had he imagined the escape, how many times had he been waiting for such an opportunity? How many times had he thought: »If Knudsen knew how well I know the chart! (...) I've got the sea between Rerik and Fehmarn and Falster and east as far as Darss and over to Moen at my fingertips. I could take the smack across the Baltic with my eyes shut. Where to? Oh, anywhere, he thought« (p. 29).

Although they row diligently through the dark they get into trouble. A patrol boat crosses their way. They are almost detected by the control searchlights. Knudsen had warned them exactly



Cover: © The Toby Press

Alfred Andersch  
*Flight to Afar*;  
172 pp., The Toby Press,  
New Milford 2004,  
US\$ 14.95

against that situation, but he had also mentioned that the coastguards wouldn't be able to stop them on open water because their boat would need to stay in the navigable channels. The young sailor, who is very familiar with the area, steers the boat carefully across the waves. Where they row it is too shallow for the coastguard boat. »Gregor noted with surprise how shallow the bay was. They were rowing across a single extended shoal and frequently struck the bottom with their oars, at many points the water could not have been more than eighteen inches deep« (p. 142).

Finally, they reach the cutter where Knudsen is already waiting. When the fisherman sees the young woman he feels cheated by Gregor. They start arguing. If he would take Judith on board then there wouldn't be a reason not to take Gregor as well. That was definitely a situation which Knudsen wanted to avoid. The ex-communists begin to fight. In the end, Gregor refrains from his own flight, but he can convince Knudsen to take Judith and the »Studying Monk« to Sweden. At dawn Gregor returns to the small coastal town.

The priest observes Gregor's return and knows that the rescue action had been success-

ful. When officers come to arrest him for the disappearance of the figure the priest takes a gun and shoots the first henchman. Then he turns around, looks out of the window and feels the bullets hit his back.

Meanwhile the flight comes to a successful end. At midday the young sailor and Knudsen take their passengers safely to the southern coast of Sweden. While Knudsen accompanies Judith to the shore, the young sailor was ordered to wait in the boat. Instead he runs into the forest and hides. Finally I am free, he thinks by himself. When he finds an abandoned cottage, he decides to stay forever. He, who had always dreamt of »Zanzibar far away« is happy to be in Sweden.

Helping to realise the flight was already an important act for Gregor and the hesitating Knudsen. Their actions had nothing to do with the Communist Party anymore; it was a symbol for the just acquired freedom. The boy, who had always dreamt of flight and freedom, understands that his behaviour would harm others and returns to Germany with Knudsen. Judith escapes the concentration camp and the »Studying Monk« – an object of art, symbol for freedom of thought – is being rescued. Thanks to all the knowledge about waters that is written down in charts. [↕](#)

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# The evolution of the Port of Hamburg from a hydrographic perspective

An article by FRANK KÖSTER and THOMAS THIES

For several hundred years the means of determining the water depth and positioning in the Port of Hamburg have hardly varied. The lead line has played a crucial role for hydrographic measurements. Starting with the introduction of the first echo sounder and the use of satellite navigation the electrotechnics took over the essential part in delivering ever more refined measurement instrumentation for hydrographic surveying. The adoption of computers for data acquisition and processing provides many exciting and seminal prospects. More and more digital products and workflows replace the paper charts opening a new variety of analysis tools that the customers of the Hamburg Port Authority already start to implement. – Part 1\*

## Authors

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**Fig. 1:** An artificial 3D picture created for the Archeological Museum in Hamburg. The scene shows how the *Hammaburg* might have looked like by 845. On the right the *Hammaburg* and on the left the first harbour is depicted. The stream, where the harbour was once situated, no longer exists nowadays



**Fig. 2:** Model of the City of Hamburg showing the status of 1644. This model is situated in the Hamburg Museum. The port area was still limited to the rivers Bille on the right and the dammed Alster. The Elbe river on the bottom had not been utilised for shipping activities by then



Hamburg Port | Hamburg Port Authority – HPA | Elbe | »Deepenschriewer« fleet

## Introduction

The Hydrographic Surveying Department of the Hamburg Port Authority (HPA) and its institutional predecessors have accompanied the development of long periods during the evolution of the Port of Hamburg from a fortified settlement and the birth of the port to the industrial revolution and the port how it is today. For several hundred years the means of determining the water depth and positioning have hardly varied. The lead line has played a crucial role for hydrographic measurements. Starting with the introduction of the first echo sounder used for depth measurements and the use of satellite navigation to a multi-sensor platform the electrotechnics took over the essential part in delivering ever more refined measurement instrumentation for hydrographic surveying. The adoption of computers for data acquisition on board of survey vessels and in the office for data processing provides many exciting and seminal prospects. More and more digital products and workflows replace the paper charts – still widely in

use – opening a new variety of analysis tools that the customers of the Hydrographic Surveying Department already start to implement.

## Historical overview of the development in the Port of Hamburg

At the beginning of the 9th century many fishermen, craftsmen and traders settled in the vicinity of the *Hammaburg*, a wooden missionary base. The first harbour close to this settlement was situated between the rivers Alster and Bille (see Fig. 1).

Despite the destruction of the infrastructure by the Vikings in 850 the city began to prosper. During the following 420 years the city belonged to different dukes and counties while the core around the *Hammaburg* still stayed in the hands of the bishop. On the 7th May of 1189 a charter was issued by Emperor Frederick Barbarossa, that gave Hamburg the privileges for free shipping on the Elbe river and free trade in the area of the county Holstein. The charter was later identified as partly counterfeit. Nevertheless, the date of issue is regarded as the official birth of the Port of Hamburg and is celebrated yearly. In 1270 finally the old Hamburg around the *Hammaburg* and the new Hamburg, that had spread around it, were unified in the so-called »Ordeelbook«, which also contains a description of rules on how ship crews have to navigate in the port area.

By the end of the 15th century the port area had expanded to the Elbe river. After this expansion the development of the port was slowed down. One of the main reasons was the sedimentation of the Elbe river, so that in 1529 two Dutch specialists had to advise Hamburg on dredging. In 1548 the Düpe-Commission was founded. The civil servants of this government agency – the so-called »Fleetenkieker« – were obliged to monitor and maintain the depth (Low German: Düpe) of the port area. During the following two centuries several hydraulic adjustments were made in order to raise the strength of the current for reducing the sedimentation. Besides the technical challenges Hamburg was menaced from the Danish King



Christian IV until 1645 where Denmark and Sweden had signed a peace treaty, that opened a free passage on the Elbe river again. Fig. 2 shows how the port looked like at that time.

In 1715 the depth of the Elbe river and the port area had reached a critical state, so that the *Elbe-deputation* was introduced in order to provide a sufficient water depth. The two heads of the Düpe-Commission belonged to this administration. Depth maintenance was manual work by then. Dry falling shoals were removed with shovels during ebb tide. Scratches were utilised to work with the current. In 1790 a first »Hamburg Dredging Machine« – the *Drehewer* – made this work much easier and reached an effectivity of 6 m<sup>3</sup> per day.

After the French revolution in 1789 Hamburg stayed neutral until 1806 when it was occupied by the French and all administration was restructured. In 1814 the French troops were banished. This gave the possibility to rethink the administration of the port, so that the Düpe-Commission was integrated in the *Hafen- und Schiffahrtsdeputation*. This agency had centralised many responsibilities, like port development, maintenance of navigation aids and depth management. In 1834 the first dredger that was driven by a steam-engine started its work in Hamburg.

In 1842 the City of Hamburg burned down in the Great Fire. On the one hand this catastrophe had a negative economic impact but on the other hand it gave way to a more modern infrastructure. During the following years a fundamental discussion about the direction of port development between the supporters of a wet dock and a tidal port was led, which was decided in 1858 in favour of a tidal port.

The following period saw the creation of the first artificial port – the Sandtorhafen (1866), which is a museum harbour today – and the expansion of

the port area to the southern shore of the Elbe river (see Fig. 3). In 1864 the *Hafen- und Schiffahrtsdeputation* was split into an agency responsible for port construction (Amt für Strom- und Hafenbau) and a separate department, which was responsible for the rest of the administrative tasks. After the accession of Hamburg to the North German Union under the lead and pressure of Prussia (1866) and the following integration into the German Empire (1871) negotiations started for a unified customs policy.

By 1881 Hamburg had lost its status as a free port, but was granted to maintain its own free port area which led to the erection of the warehouse complex *Speicherstadt* (from 1888 to 1914), which is still the largest of its kind in the world. Due to an economic boom the free port area had expanded from the initially planned 426 to around 1,000 hectares by 1910. On the southern shore of the Elbe river the port expanded rapidly with different industries like dockyards (Blohm & Voss), movement of goods for the HAPAG and oil, so that many new harbour basins were constructed on both sides of the Köhlbrand. The Köhlbrand has been the connection between the northern and the southern Elbe streams for centuries. From 1866 until 1908 three contracts between Prussia and Hamburg have been agreed on (Köhlbrandverträge), that regulate different river engineering measures.

Until 1914 Hamburg had become the third largest port after New York and London, but short after the beginning of the First World War trade was nearly fully halted and did not recover until a shortly economic rise from 1924 to 1928, when the global economic crisis started (see Fig. 4).

In 1929 a state treaty between Hamburg and Prussia was concluded, so that a common port expansion of the two Prussian ports (Altona, Hamburg) and Hamburg was agreed on.

In 1933 the National Socialists took over and

\* Part 2 of the article will be published in the next issue where a selection of topical projects is presented



**Fig. 3:** In 1885 on the Grasbrook Island, situated on the northern shore of the Elbe, the Sandtorhafen was already in use since 1866, the Grasbrookhafen followed in 1881. By 1886 also the Baakenhafen and Strandhafen had been finished. The port had spread to the southern shore of the Elbe to the Kleiner Grasbrook and Steinwerder



**Fig. 4:** By 1925 the Port of Hamburg nearly had reached the form how it looks today. The Köhlbrand was relocated, the port areas around the Waltershofer Hafen, the Vorhafen and Hansahafen had been developed. The general layout hardly changed since then

**Fig. 5:** The general layout of the Port of Hamburg was kept as it can be seen here in the port map of 2005. In 2002 the last larger port expansion project – the construction of the Container Terminal Altenwerder was finalised



focused the port on the arms industry. In 1937 Hamburg was united with the industrial cities of Harburg, Altona and Wandsbek, which pushed the industrialisation even more. The handling of cargo collapsed again with the beginning of the Second World War in 1939. The bombing of Hamburg destroyed nearly the whole infrastructure of the port and left several wrecks blocking harbour areas.

Under the direction of the Hamburg Port Authority (HPA), that had been founded by the British occupying forces, the wrecks were removed and the heavily silted harbour basins were dredged. Step by step the British Hamburg Port Authority transferred the control back to the Germans. The HPA was disbanded and the former structure was

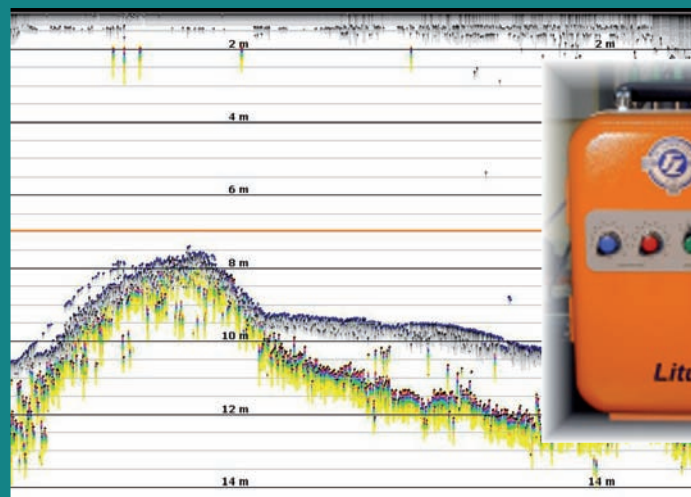
reimplemented, so that the Amt für Strom- und Hafenbau took over the reconstruction.

The economic miracle in the 1950s reproduced the strength of the Port of Hamburg. At the beginning of the 1970s the containerisation demanded another restructuring of the port, so that the container activities were bundled in the Waltershofer Hafen, which is still the most important harbour for container handling in Hamburg.

At the beginning of the 1990s the Eastern Bloc broke. Since then Hamburg has retrieved its importance as the access point to the eastern European countries like Poland, the Czech Republic and Russia. In 2005 the new Hamburg Port Authority was founded and unified all port-related tasks



## Hydrographic Echo Sounders for all Surveying Tasks



and services once again. The extents of the Port of Hamburg can be seen in Fig. 5.

### Historical development of hydrographic surveying in the Port of Hamburg

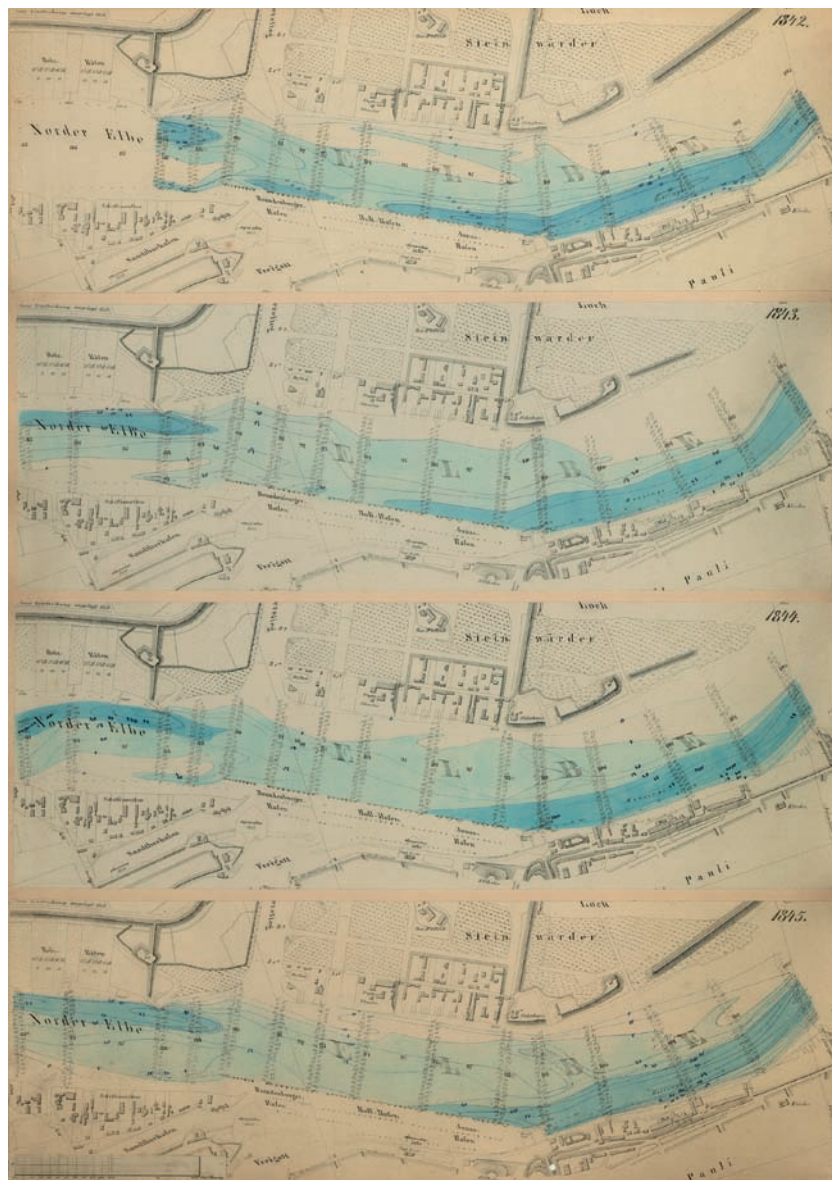
Despite the Port of Hamburg exists for more than 850 years little is known about the development of the depth measurement techniques. It can be assumed, that the means of determining the water depth hardly changed during the centuries. The archive of depth atlases in the Hamburg Port Authority starts in 1842 (see Fig. 6).

By 1938 the atlases were gradually replaced with paper charts until the last atlas was produced in 1940. The general nature of the depth information was not modified. Profiles across the river were measured with depths derived from lead line plumbing.

In the late 1940s when the port administration was returned from the British Hamburg Port Authority to the Amt für Strom- und Hafenaufbau two hand lead line crews consisting of eight or ten persons were installed. The two teams were positioned in two separate areas of the port in order to quickly reach the area to survey. The »Peilmudding« was situated at the pontoon at Neuohof right in the middle of the port. It was used as the office-, store- and common room. The vessel »Peiler« brought the crew to the survey area (see Fig. 7).

For each cross section a pole on one shore was erected. Afterwards the »Set Fast« spanned a wire to the other shore using a winch aboard. The wire had been marked every 2.5 metres. A dinghy staffed with three persons moved from one marking to the next. The first person was responsible for pulling at the rope to keep the dinghy at position, the second was plumbing and the third was noting the measured depth. Additionally another person was placed at the closest tide gauge recording the gauge height (see Fig. 8).

In 1961 the first surveying vessel for Hamburg with an echo sounder was built in the Menzer dockyard, Hamburg-Bergedorf – the »Deepenschriewer I«. It was equipped with an Atlas echo sounder Deso 10 and replaced one of the two hand lead line crews. In 1970 the »Deepenschriewer II« was brought into service. Coming also from the Menzer dockyard the ship was equipped primarily with a Deso 10 echo sounder and in 1974 the innovative multichannel system BOMA 20, introducing the first area based echo sounder to Hamburg and pushing an intensive scientific exchange between the manufacturer and the user in order to get the system fully operational. Together with the new multichannel system an Anschütz-Gyro was introduced in order to determine the heading of the system. In 1983 the third survey vessel »Deepenschriewer III« was introduced – a converted vessel, which had already been built in 1964. This modification soon proved inappropriate, so that a new ship had to be constructed in 1988 at the Buschmann dockyard in Hamburg-



**Fig. 6:** The oldest paper chart from the archive of the Hamburg Port Authority shows a time series of the Norderelbe from 1842 to 1845. The survey area covers where today the HafenCity and the Landungsbrücken are situated

**Fig. 7:** The »Set Fast« behind the »Peilmudding«. The vessel lying at the pontoon is the »Peiler«. This picture is taken in the Magdeburger Hafen. In the background the red buildings of the Speicherstadt are visible





**Fig. 8:** Plumbing a cross section on the Suederelbe in 1950

Wilhelmsburg. This new »Deepenschriewer III« was equipped with a Deso 25 echo sounder and a range bearing system. 1994 saw the introduction of the new hydrographic processing system HydroCAD, that was UNIX based provided by Atlas, and the addition of the »Deepenschriewer IV« to the fleet. The main purpose for this survey vessel was to survey the shallow and narrow parts of the port. During the introduction of the »Deepenschriewer IV« the hand lead line crew was suspended. In 1996 the »Deepenschriewer III« was equipped with the Fansweep 20, the first multibeam echo sounder system used by the port administration supplied together with the first motion sensor Atlas Dynabase in combination with the gyro STD 20 Anschütz. The first surveying projects had to be split into quarters, because the computers were not able to process the full project size at once. The »Deepenschriewer I« was replaced in 1997 with a new construction similar

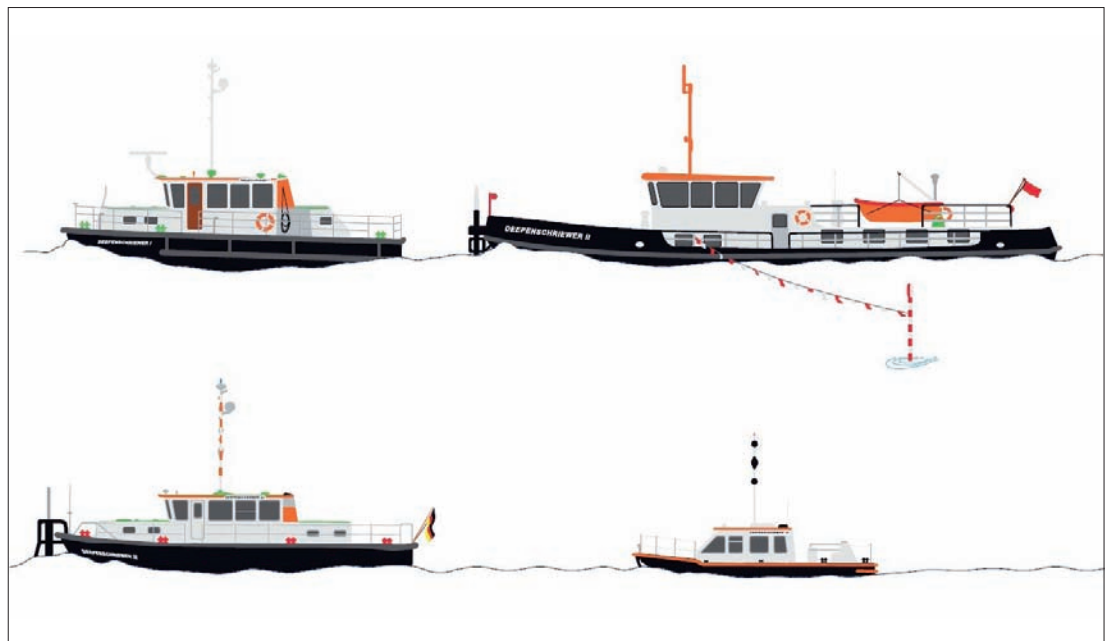
to the »Deepenschriewer III« built at the Grube dockyard in Hamburg-Oortkaten.

In 1999 the »Deepenschriewer II« started into a new era of positioning with the Trimble 4000 SE GPS receiver.

2004 oriented the Hydrographic Surveying Department into a new direction. In the past decades Atlas had been the provider of measurement technique and processing software, but in that year several components were replaced and diversified. HydroCAD was replaced by HydroCAD II from the Canadian software company CARIS, the »Deepenschriewer I and III« were equipped with Reson 8101 multibeam systems and the »Deepenschriewer II« got a new multichannel system MCS2000 also from Reson. All three area based surveying vessels received TSS MAHRS motion sensors and Trimble 5700 GPS receivers. QINSy was introduced on all four survey vessels in 2006 as data acquisition software.

In 2008 all TSS MAHRS had been replaced with inertial navigation systems iXBlue HYDRINS and the »Deepenschriewer IV« was substituted with a new construction from the Barthel dockyard in Derben, so that all four survey vessels had become area-based surveying systems. In 2010 the »Deepenschriewer II« became the last vessel to be equipped with a multibeam sensor. New techniques like the laser-scanner RIEGL VZ-400 on the »Deepenschriewer III« (2011) and the Stema Rheotune on the »Deepenschriewer II« (2013) have been established in order to meet the ever expanding demands on the Hydrographic Surveying Department of the Hamburg Port Authority. Fig. 9 shows the »Deepenschriewer« fleet in use today. All four vessels are equipped with Reson multibeam sonars. Additionally the »Deepenschriewer II« utilises a multichannel system. The positioning is done with Trimble SPS 851 GNSS receivers in combination with INS systems iXBlue HYDRINS. ⚓

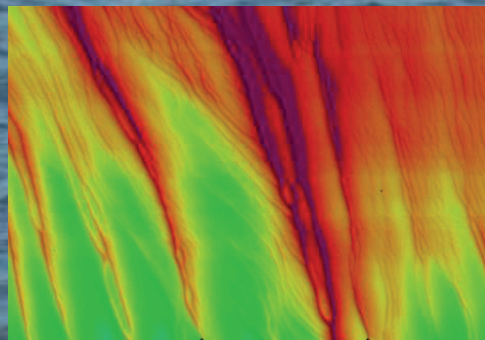
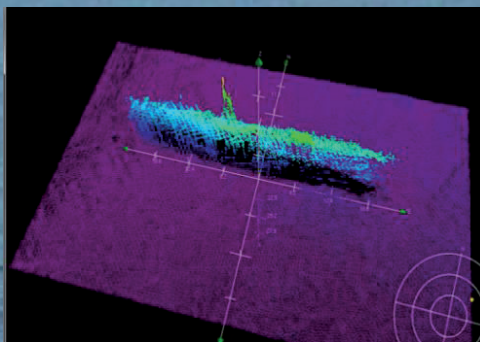
**Fig. 9:** Artist's impression of the »Deepenschriewer« fleet in 2015 drawn by Wiebke Ahrlich



# Hydrography at the HCU

The HafenCity University Hamburg offers as the only German academic institution a full-time course in hydrography (taught in English). It is a specialization within the area of Geomatics and certified as **FIG/IHO/ICA Category A**.

The course is scheduled to last two years and results in a master's thesis and a final examination in a Master of Science (MSc) degree.



The modules include hydrography, higher geodesy, navigation, GIS, marine geology and geophysics, oceanography, tide, maritime environment, data processing, and software technology.



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[www.hcu-hamburg.de/en/master/geomatics](http://www.hcu-hamburg.de/en/master/geomatics)



# New perspectives on indigenous navigation tradition

An article by INGO HENNINGS

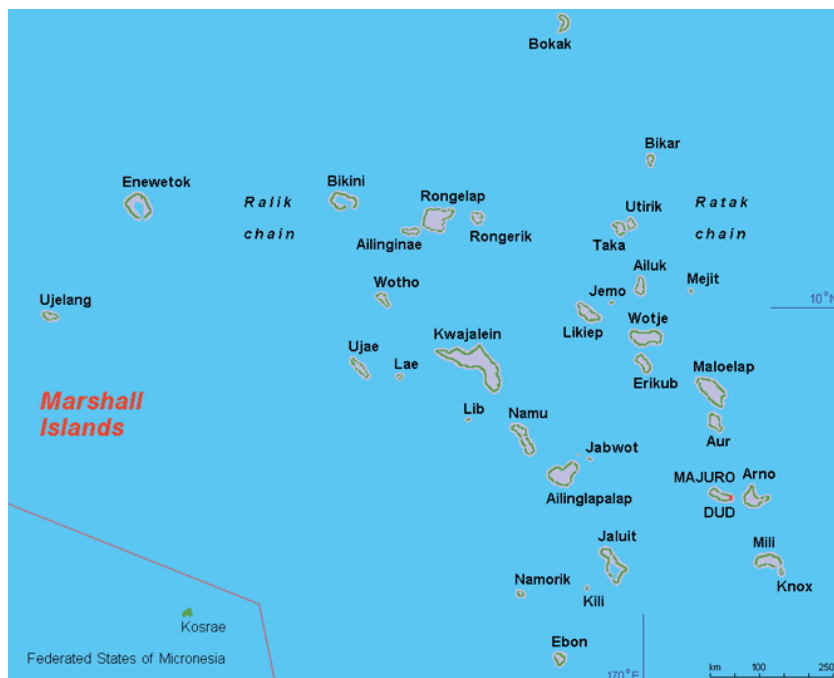
Stick charts are a significant part of the Micronesian Marshallese navigation tradition in the Pacific Ocean. The islanders navigated without instruments just by observing, among others, oceanic phenomena such as swells, currents, and roughness characteristics of the sea surface. For a long time, the explanation of the various sticks of such latticework remained secret and something of a mystery and was only obtained by oral transmission under great difficulties. Old and new interpretations of stick charts are compared and presented. Signatures of different swells manifested on stick charts were identified and proved by satellite remote sensing data. Current research on indigenous navigation is growing to conserve such unique tradition in the Pacific and especially in the sea area of the Marshall Islands. For scientific research on indigenous navigation knowledge collaboration between natural scientists and ethnologists is necessary.

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**Fig. 1:** Map of the Marshall Islands with names of islands and atolls. DUD is the abbreviation for Delap-Uliga-Derrit, a major population centre



Marshall Islands | stick charts | swell diffraction | neutron diffraction | CHRIS satellite image

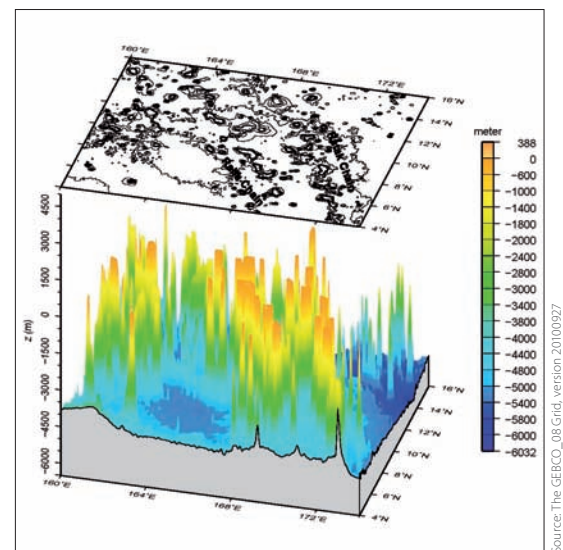
**1 Introduction**

Many small island nations worldwide are vulnerable to sea level rise due to global climate change. An accelerated rise in sea level would further threaten human and natural resources with inundation, coastal erosion, increasing flooding, loss of fresh water and arable land. Environmental disasters, such as typhoons, generate wave fields with significant wave heights of more than 10 m washing across an entire islet, swamping groundwater lenses with salt water, causing enhanced salinity concentration and thus imperilling human survival (Spennemann 2006). Climate change could result in major lifestyle changes, threatening or losing a nation's cultural identity and economic growth potential.

The article focusses on the Republic of the Marshall Islands (RMI) in the north-west equatorial Pacific Ocean. This small atoll nation is comprised of

29 atolls and five islands, with an average elevation of less than 2.4 m. The Marshall Islands are aligned in two island chains running roughly NNW to SSE: the western Ralik Chain and the eastern Ratak Chain. A geographical map of the Marshall Islands with the names of islands and atolls is shown in Fig. 1. Different newspaper articles and television contributions in 2009 reported about the loss of atoll ground of up to 40 m on the Likiep atoll of the Ratak Chain since 1995. If the Marshallese people were to be resettled not only the islands but also their traditional way of life would vanish subsequently.

Two- and three-dimensional bathymetric charts of the sea area around the Marshall Islands of Micronesia in the Pacific Ocean are shown in Fig. 2. The source of the data set is »The GEBCO\_08 Grid«, version 20100927 (GEBCO is the abbreviation for General Bathymetric Chart of the Oceans). The

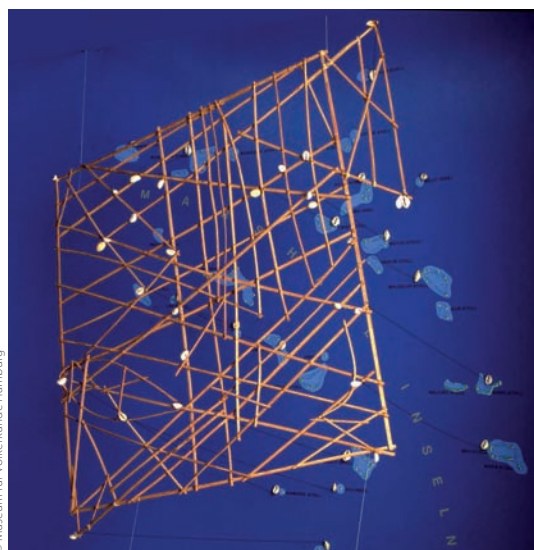


**Fig. 2:** Two- and three-dimensional bathymetric charts of the sea area around the Marshall Islands of Micronesia in the Pacific Ocean

data were visualised by using the Generic Mapping Tools (GMT) software. Fig. 2 shows that the islands and atolls arise almost vertically upwards like needles from the deep ocean basins. Such morphological features cannot be detected by repeated vertical soundings for navigation and a boatman could not be warned in time when entering shallow sea areas. This could be one reason why sounder techniques are not known and used by the islanders of the Marshall Islands when approaching an atoll from the deep open ocean. Therefore, the islanders navigated, among others, by using oceanic phenomena such as swells, currents, and roughness characteristics of the sea surface. On the other hand the draft of an outrigger canoe is small, which implies that sounder techniques are not relevant and not used for navigation purposes.

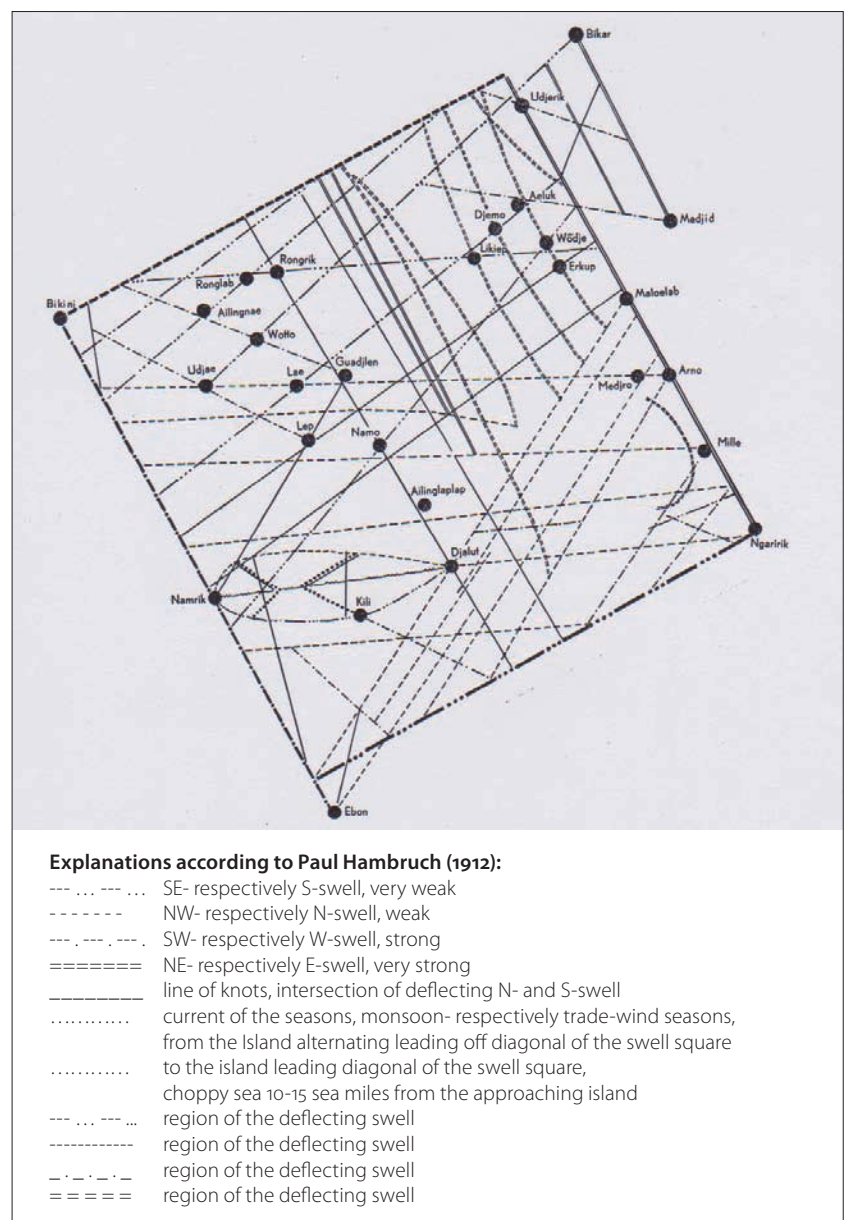
The islanders of the Micronesian Marshall Islands made simple latticework for the purpose of practical navigation which is known as stick charts. Stick charts are a significant part of the Marshallese navigation tradition. An example of a RMI stick chart, a so-called group chart or *rebbelib*, is shown in Fig. 3 (Krämer and Nevermann 1938). The original of this stick chart (No. 393:10) is presented at the Museum für Völkerkunde (Museum of Ethnology) Hamburg. The general chart (*rebbelib*) shown in Fig. 3 based on explanations given by Paul Hambruch (1912) is presented in Fig. 4 (Krämer and Nevermann 1938). The registered sailing instructions are valid for journeys starting from Djalut (Jaluit).

The widespread corpus of stick chart illustrations was published by Marcia Ascher (1995). She studied models and maps from the Marshall Islands and also wave dynamics that they incorporate. It turned out that the collaboration between natural science and ethnology is necessary especially for the interpretation of indigenous navigation using stick charts. One early example of a natural sci-



**Fig. 3:** Stick chart of the Marshall Islands represented as a group chart or *rebbelib*. The original of this stick chart (393:10) is present at the Museum für Völkerkunde Hamburg

tist as well as ethnologist was the German Paul Hambruch (1882–1933). He was a participant of the second part of the Hamburg South Sea expedition 1909–1910 and first head of the South Sea department at the Museum für Völkerkunde (Museum of Ethnology) Hamburg, Germany (Fischer 1981). During life he kept the connection between natural science and ethnology. At that time, ethnologists and natural scientists took a long time to find explanations for the interpretation of stick charts used on the Marshall Islands as one important nautical aid to sail from one atoll to another. Today, again ethnologists, oceanographers, and natural scientists take time to understand and describe the effect of global climate change, also possibly responsible for the disappearing of the Marshall Islands beneath the ocean with all their unique cultures. Fortu-



**Fig. 4:** General chart (*rebbelib*) shown in Fig. 3 with explanations (Hamburg, No. 393:10, scaled down (Krämer and Nevermann 1938)). The registered sailing instructions are valid for journeys starting from Djalut (Jaluit)

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**Fig. 5:** Stick chart (*rebbelib*) of the Marshall Islands obtained by the American missionary Luther H. Gulick in 1860

nately, museums of natural history and ethnology worldwide will show influences, effects, and interactions on atoll cultures of Oceania due to global climate change. For example, the Grassi Museum für Völkerkunde zu Leipzig (Museum of Ethnology) and the Linden-Museum Stuttgart, both located in Germany, are planning to show effects and interactions between atoll cultures in the Pacific Ocean and global climate change. Some of these new exhibition conceptions are already partly realised. The Museum für Völkerkunde (Museum of Ethnology) Hamburg presents unique objects collected during the Hamburger Südsee-Expedition 1908–1910 which could also be the starting point of a new view on traditional navigation in Micronesia.

Old traditions of the Marshall Islands are revived presently. Genz and Finney (2006) described how cultural anthropologists and other professionals in Oceania can help their host countries in reaching their historic preservation goals for an intangible cultural heritage. They reflect the philosophy of their current research on indigenous navigation in the Republic of the Marshall Islands. Similarities and differences between indigenous and Western scientific knowledge in the sea area of the Marshall Islands have been shown by Genz et al. (2009). Their oceanographic perspective conformed strongly with one indigenous concept of a lee-wave crossing pattern resulting from refraction of the easterly trade wind swell.

The aim of this article is the remembrance of such unique navigation traditions in the light of new perspectives so that they do not fall into oblivion and will be preserved. A brief description and interpretation of stick charts are given in section 2. In sections 3 to 5 three examples are presented, in which western scientific and traditional ecological knowledge is combined having benefits beyond

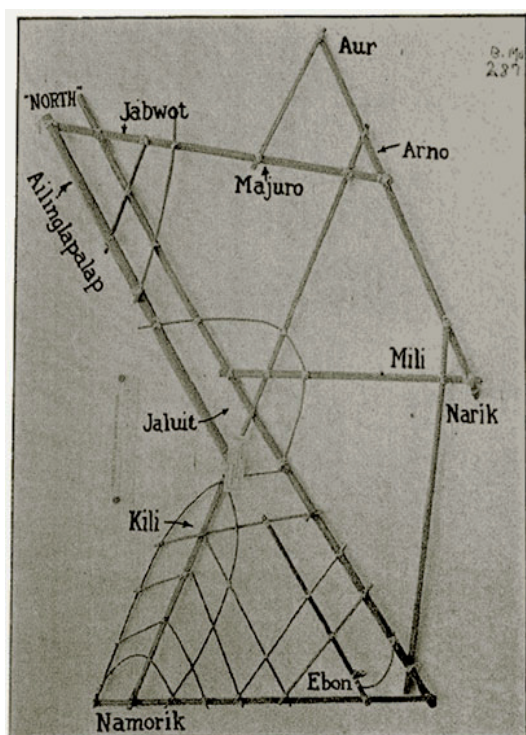
simply relying on one or the other, for reasons, to make atolls and atolls visible, to superimpose two different swells by using their trajectories, and to identify signatures of different swells on satellite images. Finally, the summary is given in section 6.

## 2 Interpretation of stick charts

A brief paragraph of stick charts of the Marshall Islands was published by the American missionary Luther H. Gulick and first caught public attention in 1862 (Gulick 1862). Gulick obtained two stick charts in 1860, possibly from the Ebon atoll, which are now exhibited in the Bernice Pauahi Bishop Museum, Honolulu, Hawaiian Islands, USA. One of the two stick charts, so-called group charts or *rebbelib*, is shown in Fig. 5. The Marshall Islanders sailed with outrigger canoes between the atolls and on the open sea. An impression of Marshall Islands canoes from Jaluit is presented in Fig. 6 (Hernsheim 1883). A short description of navigation and utilisation of stick charts was published by Friedrich Ratzel (1886). Captain Raimund Winkler, commander of the German wooden sheathed light cruiser »S.M.S. Bussard« received first information of the interpretation of stick charts in 1896/97 on Jaluit of the Marshall Islands (Winkler 1901). The counterpart of European naval sea going vessels at that time is demonstrated by the picture of »S.M.S. Bussard« built for German colonial service shown in Fig. 7. Thomas A. Joyce (1908) reported that the English translation of Winkler's German article (Winkler 1898) was not very polished and in parts almost grotesque. However, Joyce had to confess that he had no current information on that subject and referred to the papers of Winkler (1901) and Albert Schück (1902), which, in general, are valid until today and were often cited. Some details of other five stick charts have been presented by Henry Lyons (1928). Later on, principles and problems presented by the stick charts have been published by William Davenport (1960, 1964) and Kjell Åkerblom (1968).

Here, a brief description of stick charts is given according to the interpretations published by Winkler (1898), Winkler (1901), Schück (1902), Hambruch (1912), Krämer and Nevermann (1938), Davenport (1960), and summarised by The Metropolitan Museum of Art (2008), New York, USA. Stick charts consist of numerous narrow strips of centre-ribs of palm leaves lashed together in a rude latticework and are arranged in certain forms and positions. Cowrie snails, small shells, and small pieces of corals are often fixed with lengths of coconut fibre to the sticks in order to represent the atolls of the archipelago. Coconut fibre was obtained from the fibrous husk (*mesocarp*) of the coconut (*Coco nucifera*) from the coconut palm, which belongs to the palm family (*Palmae*).

In the Marshall Islands, navigation was and remains an essential skill, on which the lives of the navigators and all other passengers depended. In the past, knowledge of the art of navigation was a closely guarded secret handed down within



Source: Gulick 1862; Schück 1902; Fig. 31



certain leading families. To assist in recalling and imparting aspects of navigational knowledge, navigators constructed diagrams representing different portions of the archipelago. Made from the sticklike midribs of coconut palm fronds, these objects were memory aids, created for personal use or to instruct novices, and the significance of each was known only to its maker. The charts were exclusively used on land, prior to a voyage. To carry one at sea would put a navigator's skill in question.

The charts indicate the position of islands, but they primarily record features of the sea. Marshallese navigation was based largely on the detection and interpretation of the patterns of ocean swells. Like as a stone thrown into a pond produces ripples, islands after the orientation of the waves that strike them, create characteristic swell patterns that can be detected and used to guide a vessel to land. It is the presence and intersection of swells and other aquatic phenomena, such as currents, that are primarily marked on stick charts.

### 3 Visibility of invisible atoms and atolls

The content of a stick chart is viewed from a new perspective if the following two responsible physical mechanisms, of how to make atoms and atolls visible, are compared. Swell diffraction due to islands or atolls can be illustrated today by analogical physics like neutron diffraction due to particles (Paul Scherrer Institut 2009). Both mechanisms make invisible atolls and atoms visible. By using the experimental method of neutron diffraction it is possible to make atoms visible, for example in material research. A neutron can also behave like a wave. The interaction of neutrons with atoms is analogous to the interaction of swell waves with atolls of the Marshall Islands. Due to such interactions interference patterns arise. From the interference patterns of neutrons conclusions can be made about the structure and movement of atoms. Analogically to neutron diffraction the inhabitants of the Marshall Islands could find the position of an invisible atoll following the knots (*okar*) of different swell patterns by observing them from on board their outrigger canoes. The concept of neutron and electron diffraction applies in the same manner to Bragg diffraction or Bragg formulation of X-ray diffraction. As a first approximation Bragg scattering is the primary mechanism for describing the backscattering of radar pulses from the sea surface and therefore different oceanographic and meteorological phenomena can be made visible like long waves, internal waves, submarine bottom topography and ocean fronts (Hennings 1999).

### 4 Superposition of swell trajectories

Under the condition that an atoll can be considered here as a homoclinic fixed point in phase space the following example described by Nolte (2010) is presented. The superposition of two different swells by using their wave trajectories looks just like a

lattice-work of knots (*okar*). Henri Poincaré (1854 to 1912) already discovered a comparable counterpart of such lattice-work during his study of the three-body system in phase space. Nolte (2010) summarized this discovery as follows (p. 38):

»In the course of correcting his mistake [of a submitted paper for publication in *Acta Mathematica* (the paper was already through proofs and initial printing late in 1889) from December 1889 to January 1890], Poincaré took a geometric approach in which he visualized the behavior around a special feature of the motion called a homoclinic fixed point – a saddle point where stable and unstable trajectories intersect in phase space. As he studied the solutions, he discovered that the trajectories would cross an infinite number of times. It was that ›tangle‹ (...) that was generating the arbitrarily large response to small changes in initial conditions that he had discovered. He was amazed by his own findings:

»If one seeks to visualize the pattern formed by these two curves and their infinite number of intersections (...), these intersections form a kind of lattice-work, a weave, a chain-link network of infinitely fine mesh; each of the two curves can never cross itself, but it must fold back on itself in a very complicated way so as to recross all the chain-links an infinite number of times.

One will be struck by the complexity of this figure, which I am not even attempting to draw. Nothing can give us a better idea of the intricacy of the three-body problem, and of all the problems of dynamics in general.«

It was clear to him that he had discovered a fundamentally new aspect of dynamical motion. That was the original discovery of what is today known as sensitivity to initial conditions, which is at the heart of chaos theory.«



Source: Hershheim 1883



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**Fig. 6:** Impression of Marshall Islands canoes from Jaluit

**Fig. 7:** Picture of the German light cruiser »S.M.S. Bussard« built for colonial service; launching: 23 January 1890 in Wilhelmshaven, Germany; length: 76 m, displacement: 1570 tons

- ...  
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**Fig. 8:** Modified CHRIS satellite image acquired on 27 March 2006 from on board ESA's Proba spacecraft. Signatures of different interference patterns of swells are visible. The so-called *okar*, the line formed by cabbeling points of two different swells, has been used by Marshall Islanders for navigation from one island to another

## 5 Visibility of swell signatures on satellite images

In fact, the signatures of different swells, which have been manifested on stick charts by the natives on the Marshall Islands, were indeed identified and proved when the National Aeronautics and Space Administration (NASA) of the USA started their satellite observations of the whole earth surface in the 1970s (Goss 1993). The imaging of oceanic surface features on radar satellite scenes already indicated on Micronesian stick charts was published by Hennings (1999). As an example, Fig. 8 shows the sea area around Swains Island, the northernmost island of American Samoa in the southern Pacific Ocean. The satellite image was acquired from on board the European Space Agency's (ESA's) Project for On-Board Autonomy (Proba) spacecraft on 27 March 2006. The sensor on board of Proba is the Compact High Resolution Imaging Spectrometer (CHRIS), achieving a spatial resolution of 18 m in 19 programmable spectral bands. A dominant north-easterly swell direction is present at the acquisition time of the satellite image. Signatures of different interference patterns of swells as indicated on stick charts are visible on this CHRIS image. The line formed by the cabbeling points, called *okar*, of both swell diffraction patterns south-westerly of Swains Island is marked by two arrows in Fig. 8. The mechanism called cabbeling originated from the German nautical term ›Kabbelung‹ meaning a rippled or choppy structure of the sea surface. The expression *okar* is used here to describe a regularly alignment of *bots*, which are increased choppy seas due to the deflection of swells by the islands itself producing

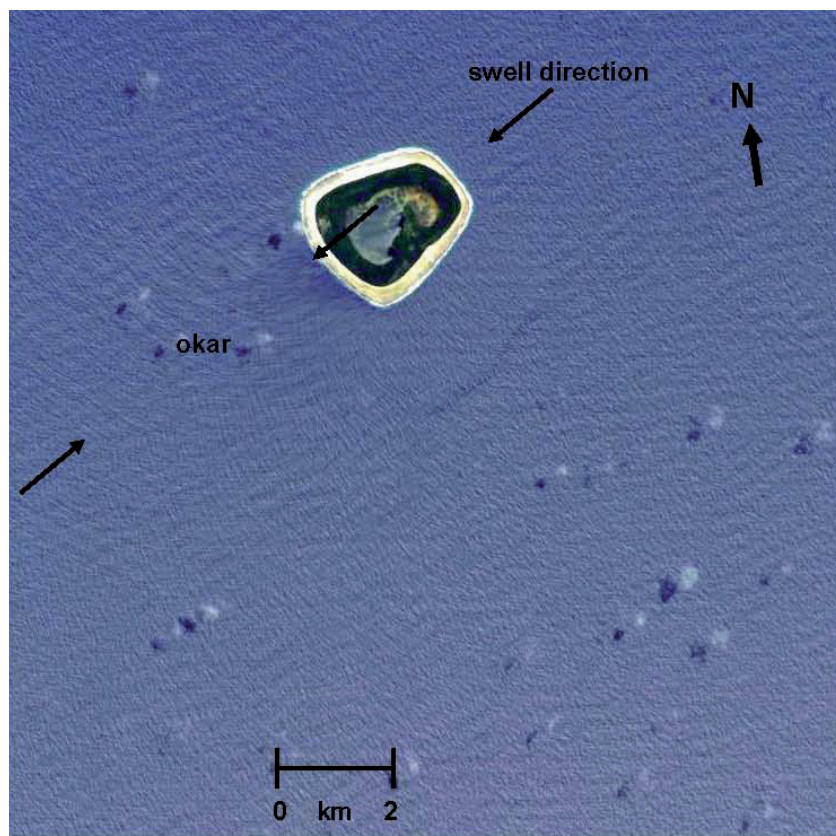
well-defined diffraction patterns. By identifying this *okar* a boatman is able to navigate his outrigger canoe from one island to another if the other island is located in direction of the *okar*. A similar satellite image was presented by Genz et al. (2009) showing an Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) image of Mejit Island from the Marshall Islands. Genz et al. (2009) combined information from a satellite image of the sea area around Mejit Island and results of computer modelling to determine that swell refraction account for that phenomenon. The satellite image and the modelling results indicate how an east swell bifurcates northward and southward around the island due to swell refraction, resulting in a zone of intersecting wave trains in the lee.

## 6 Summary

When Luther H. Gulick published a first note on Marshallese stick charts in 1862 many people did not believe in these different structures of the water surface used for navigation. However, more than 100 years later, photographs, sun glint and radar data from space borne platforms showed synoptic views of the ocean surface with roughness characteristics caused by dynamical processes of the ocean and atmosphere. These remote sensing data confirmed the patterns indicated within stick charts. Especially interference patterns of swells associated with increased choppy seas around islands have been used by the Micronesians on board of outriggers and guided them from one island to another.

It has been shown that Pacific Islanders have a history of navigating without instruments across vast distances over the ocean to reach other atolls and islands. This art is being revived, with voyaging canoes and Pacific voyagers serving as powerful messengers to raise awareness of the imperilled oceans coordinated by the Pacific Voyagers Foundation. *Vaka moanas*, or ocean going canoes, are sailing across the Pacific, *vaka motus*, or inter-island canoes, are designed for sustainable inter-island transport, and the *vaka hapuas* are built for lagoon and short distance travelling.

Today, it is widely accepted that climate change will threaten the whole human living space. Pacific island countries have contributed just 0.06 % to global greenhouse gas emission. Yet now, changing climate and sea level rise due to global warming are affecting Marshallese water supply, food production, fisheries and coastlines. Although the Marshall Islands are located 13,000 km away from Middle Europe their destiny should also be of our interest. It is promising that different museums of natural history and ethnology worldwide have expanded their main objective to maintain cultural resources and will show influences, effects, and interactions on the atoll culture of Oceania due to global climate change. It is hoped that preservation and revitalisation of intangible cultural heritage of Oceania will survive, because the paradise is defenceless. 🚢



# What exactly is hydrography?

The IHO offers an abstract definition only.  
It is high time for more graphicness

An essay by LARS SCHILLER

The term hydrography has different meanings. It describes mainly the science of surveying of waters and of waters-related information, to which the German Hydrographic Society (DHYG) has committed itself to. There are several definitions of the concept depending on the nation and institution. Without doubt, the definition published by the IHO in 2009 has the greatest impact. Still, even this institution hasn't been able to describe comprehensively and convincingly what hydrography is. Most of all, it lacks a vivid description. Therefore, it is about time to point out the weaknesses of the IHO definition and to present a new one. The following definition at least reflects the German understanding of the concept from the DHYG perspective.

hydrography | definition | terminology | lexicography | concept | philosophy of science

## Introduction

Imagine you were asked to give a written answer to the following question: »What exactly is hydrography?«

For sure, you know exactly what it is, otherwise you wouldn't read this journal. But to be honest, are you able to write a couple of professional sentences about it? You are able to talk about it, to tell stories of your everyday work and excel with adventures, but are you really able to describe what the scientific characteristics of hydrography are?

Maybe you come up with the idea of looking into a dictionary or encyclopaedia. Leafing through a printed book nowadays? A searching machine would be today's tool presenting an immediate result. From the amount of given answers you just have to pick the best one, and even that isn't an easy task. A glance into a dictionary would offer you only one definition, a reliable one probably, but perhaps you aren't lucky for the following reason: the term »hydrography« implies more than a science (see Fig. 1).

We often talk about hydrography of rivers, which presumably means the form of the surveyed river bed. There exists also the hydrography of a country meaning the total amount of waters in that country, and all these waters can be found in a list – confusingly this dossier is also called hydrography. And hydrography can even be objects of art (see Fig. 2).

Dictionaries don't tell us that the word »hydrography« has several meanings. A non-hydrographer would be happy with the definition and accept the given answer. In Germany, most people believe that hydrography is, according to the most widely used German dictionary *Duden*, the »descriptive hydrology«. We are experts and see it quite differently, stating that this is true from a hydrologist point of view. German lexicographers don't have a clue what the science of hydrography really is, or maybe they just ignore us. Luckily, this is different in English dictionaries, which

mention mainly the scientific aspect. In the *Oxford Dictionary of English* you can read: »the science of surveying and charting bodies of water, such as seas, lakes, and rivers.«

English dictionaries are on the right track. Still, this sparse sentence isn't very satisfying and that is why we will search for a detailed explanation.

## Search for definition

You begin searching and gathering several definitions from dictionaries, standards and Internet sites of diverse institutions. However, very soon you start wondering: all these definitions are to describe the same concept of hydrography as a science. Well, either they have different focuses or they contradict each other in concrete details. (You don't believe that? Then compare the definition of the IHO of 2009 with the definition of the current DIN standard *18709-3:2012*, which uses parts of the United Nations definition of 1978).

For sure, you stick to the latest and most popular definition which the IHO published in 2009. It was about time to adapt the outdated one published in the 5th edition of the *Hydrographic Dictionary* in 1994. Definitions need to be up to date because science moves on.

## Author

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**Fig. 1:** One term with eleven meanings. This could be an entry in a technical dictionary

**hy•drog•ra•phy** -ies, | hɑɪˈdrɒɡrəfi | noun,

- 1 no pl., science of surveying of bodies of water and waters-related information;
- 2 no pl., **a**) depth measurement of waters (esp. of oceans), bathymetry;  
**b**) surveying of bodies of water;
- 3 no pl., **a**) descriptive hydrology; **b**) characteristic features of bodies of water, descriptive set of waters-related data and information;
- 4 no pl., (register of the) totality of the waters in an area, waters index;
- 5 no pl., **a**) map element; **b**) cartographic depiction of waters;
- 6 shape of the bottom of a water, topography covered by water, morphology;
- 7 **a**) no pl., art technique; **b**) artwork.

**Definition published by the United Nations in 1978**

»Hydrography may be defined as the science of measuring and depicting those parameters that are necessary to describe the precise nature and configuration of the seabed, its geographical relationship to the landmass, and the characteristics and dynamics of the sea. The parameters encompass bathymetry, geology, geophysics, tides, currents, waves and certain other physical properties of sea water« (UN 1978, p. 67)

**Definition in the Hydrographic Dictionary of 1994**

»That branch of applied science which deals with the measurement and description of the physical features of the navigable portion of the EARTH's surface and adjoining coastal areas, with special reference to their use for the purpose of NAVIGATION« (IHO 1994, p. 108)

**Definition in the DIN standard 18709-3:2012**

»Wissenschaft und Praxis der Messung und Darstellung der Parameter, die notwendig sind, um die Beschaffenheit und Gestalt des Bodens der Gewässer, ihre Beziehung zum festen Land und den Zustand und die Dynamik der Gewässer zu beschreiben« (DIN 2012, p. 5)

The definition of 2009 is:

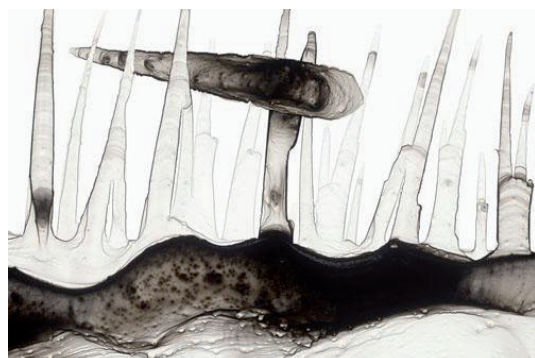
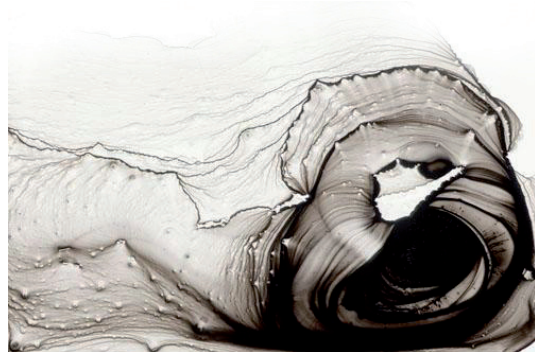
*»Hydrography is the branch of applied sciences which deals with the measurement and description of the physical features of oceans, seas, coastal areas, lakes and rivers, as well as with the prediction of their change over time, for the primary purpose of safety of navigation and in support of all other marine activities, including economic development, security and defence, scientific research, and environmental protection.«*

It may well be that you couldn't grasp the entire meaning of the sentence. No wonder, as linguists say that a sentence shouldn't have more than 25 words in order to grasp it right away. This definition consists of 64 words and all of them in one sentence.

Since the definition was presented on the 4th Extraordinary International Hydrographic Conference in Monaco there was little protest, and even during voting process there were no opposing votes. Nonetheless, I assume that it was difficult to find an unanimous solution which all representatives of IHO member states could accept. In the meantime, criticism was uttered, but whether it reached the IHO is still questionable. I believe it is time to collect the critical comments and to offer a counterproposal.

**Critical aspects of the definition**

To be brief: the definition shows deficits in the content and form. It doesn't reflect the full spectrum of hydrography, nor does it fulfil the requirements of lexicographers. You could argue that a definition doesn't necessarily have to comply with formal aspects and that a reduced definition that only mentions carefully selected aspects is good



**Fig. 2:** Two examples for hydrographies by the German artist Thomas Michel: Capricci Genesis Nr. 25, Cyclus Cerealis Genesis Nr. 130

enough. I would agree, but only if the definition fulfils its duty and that is to explain what hydrography is. I doubt that and I ask you: does this definition really offer an adequate and satisfying answer?

We will find out as we have a closer look at each of the definition's aspects.

**... branch of applied sciences ...**

Hydrography apparently is a »branch of applied sciences«. Is that really true, is hydrography an applied science?

Yes and no. Without doubt hydrography is very practice-oriented, as it should be (for application in the present time), but there are also theoretical components. Just think about research and development (always with regard to the future) or the discussions about hydrography itself (often regarding the past). Of course, hydrography is neither a theory-based nor a mere applied science. So much to the content.

Let's look at the form: including hydrography into applied sciences isn't very useful. Lexicographers recommend to name the hypernym in order to provide a clear position. (Oncology is an applied science as well, but it belongs far more to medicine. The cocker spaniel is a living being, but it makes more sense to call him a dog.)

From the German perspective hydrography is a discipline of the science of surveying and geoinformation.

**... measurement and description ...**

Hydrography deals with measuring and describing waters. That is correct. Measuring includes not only complex surveying, like calculating depths and extents of bodies of water, but also the comparably simple measuring of e.g. water temperature.

»Describing«, what exactly does that mean? Is it sufficient to say »description« or isn't it better to also mention »depiction« as hydrography doesn't only deal with oral or written representation, but also with visualisation? The cartographic aspect is about to disappear in the formulation. And also the information by means of charts, information systems and other media doesn't come through.

**... physical features ...**

Hydrography measures and describes »physical features« of waters, so it is said. Do you have a clear picture of these features? For sure, the statement isn't wrong, but it remains vague and imprecise. Such a basic formulated definition doesn't fulfil its goal. The parameters are of interest.

By the way, the United Nations already talked of »physical properties« in 1978. The expression still remains too abstract, and I presume that it is to »avoid« pointing out the concrete.

Furthermore, the expression seems to be concrete as only the *physical* features are mentioned, but this is too narrow. The chemical parameters (think about salinity or radioactivity) and the bio-

logical characteristics aren't mentioned although »habitat survey« and »biomass detection« have been keywords for quite a while now.

And also the geographical features remain unmentioned, that is the relation of waters to land. The information about water depths is only of value when the coordinates are given as well.

### ... oceans, seas, coastal areas, lakes and rivers ...

Hydrography is concerned about »oceans, seas, coastal areas, lakes and rivers«. The list gives the impression of completeness, but there are gaps. Not all bodies of water are being mentioned, probably on purpose. Why are waters like creeks and channels, wadis (e.g. in Israel) and riviere (e.g. in Namibia) not mentioned? An explanation would be very interesting. If *all* bodies of water are to be included – except maybe underground waters – then it should be expressed quite clearly.

It is surprising that »coastal areas« are listed; such a foreign matter makes us wonder. On the other hand, the question is why shorelines are excluded from the list.

A lexicographer would definitely say: It isn't correct to make a list and not mention everything, but it is even worse to mention a wrong element.

### ... prediction of their change over time ...

The physical parameters are not only measured and described, but the definition courageously offers »the prediction of their change over time«. Very clearly it is about future changes and forecasts. This is a laudable supplement to the previous definition of 1994. Finally, the view is turned towards the future instead of the present time. However, which changes and time span is thought of? Is it only about calculating the water level which depends on the tides? Or the global sea level rise? Probably the formulation is imprecise in order to have both interpretations.

I miss the comparison between past and present although I welcome the view toward future prospects. The analysis of developments plays an enormous role (e.g. after a dredging activity) – the knowledge about changes is the basis for any extrapolation into the future.

### ... primary purpose of safety of navigation ...

We are told that the most important purpose is save navigation. If I may say so, this is a very conservative point of view. What does surveying of the deep sea has to do with navigation? Why should seafaring be interested in the formation of the sea-floor in 50, 1,000 or 4,000 metres depth?

Of course, seafaring profits from the insights of hydrography and captains depend on our nautical charts. However, is it really good to declare that as main issue of a modern definition? Maybe a broader view is better. Waters are used in manifold ways: energy is gained, natural resources are exploited, aqua farming is cultivated. Last but not least, hy-

drography provides epistemological progress by making the invisible visible to the human eye. All humanity profits from it, not only navigation.

Of course, I am aware of the hydrographical roots. Already from an etymological point of view it is obvious that bodies of water are the object of description. Dangerous places or reliable seafaring routes were drawn into charts. But are the roots of such value that hydrography cannot do without safety of navigation? Nevertheless, the IHO decided to mention explicitly other purposes which in 1994 wasn't the case or only implied.

### ... in support of all other marine activities ...

Hydrography supports »all other marine activities«, it is said, followed by some exemplary keywords. Lexicographers would criticise the incompleteness of the list. Moreover, the list remains abstract – so does the entire definition. The keywords are not able to create an image. What is meant with »marine activities«? In what way does hydrography contribute to the economic development? What is the relationship to security and defence? What does the scientific research include? And what is the role of hydrography in environmental protection? There are no answers to these questions, on the contrary: more questions come up.

Bringing together as many broad and vague keywords in order to satisfy all interests, is doomed to fail. Such an approach will not result in a serious definition.


And last but not least: why are only *marine* activities mentioned? What about the activities in inland waters?

### What can be improved?

Enough of criticism, the question remains what can be made better? I come back to my initial question: How would you define hydrography, completely and clearly?

For sure, non-hydrographers and hydrographers would take an interest in the answer. A definition may also be helpful when research funds are at stake and when explaining the difference between hydrography and oceanography for example. It can support us as well by clarifying our profession. And a definition can be of use in public relations.

At this point, I don't want to explain how lexicographers would write a definition nor do I point out the hydrographers' fields of work. The answer can partly be found in this journal, and in the *Manual on Hydrography* or in the *Standards of Competence*, both published by the IHO. Instead I present my idea of a definition that does not stand in contrast to the academic contents, which the IHO demands in the *Standards of Competence*.

Make the practical test! Next time when you are asked to explain what hydrography is then please offer your conversation partner both the IHO definition and the definition on the next page. 

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**hydrography, n.**

Hydrography is a branch of the science of surveying and geoinformation. It investigates the surface waters of the earth and collects the related data and information. Its goal is to expand the knowledge of waters in order to use them responsibly and safely and to protect the habitat.

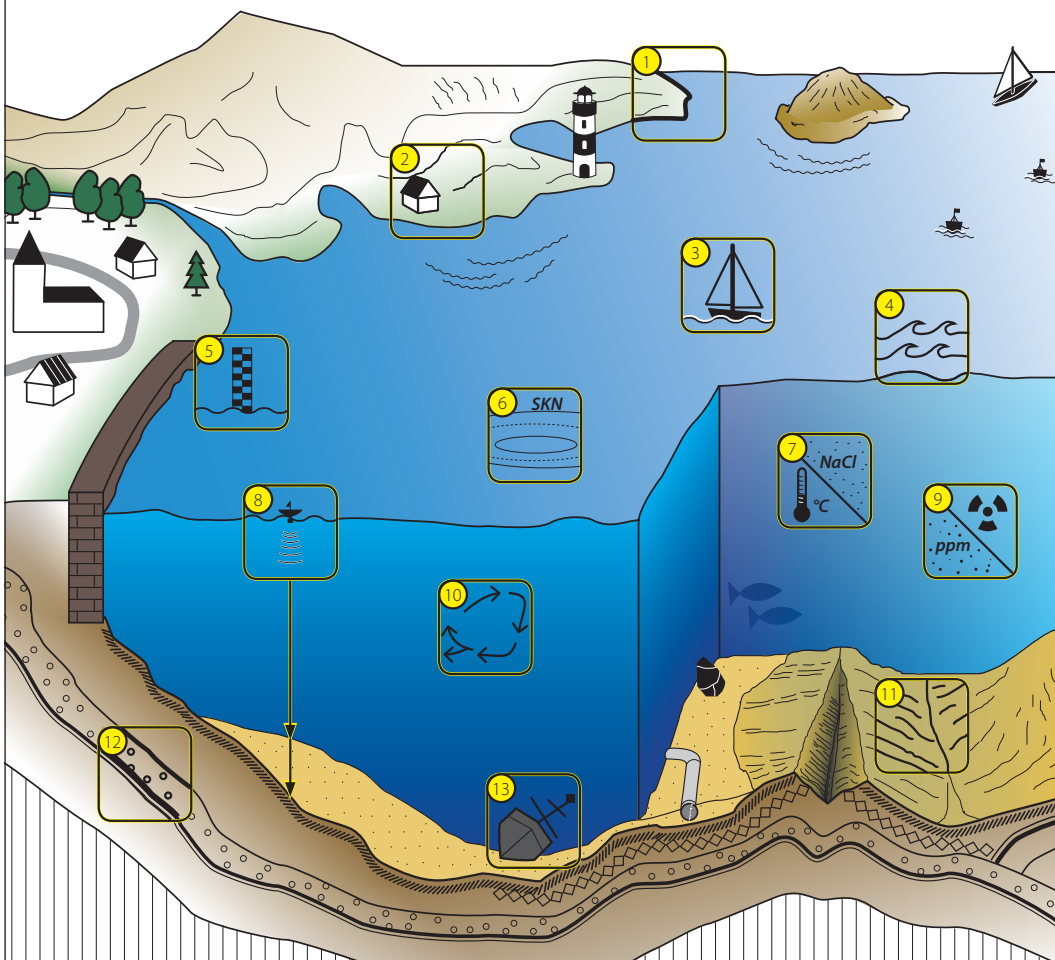
The practical engineering and geoscientific work is divided into three main fields of activity:

1. *Surveying* of waters, and *recording* of aquatic data;
2. *Processing* of the data, *administering* the data in information systems, and *analysing* the total set of data;
3. *Visualising* the waters on charts and in information systems, and *informing* about the waters.

After the examination of a surface water hydrography provides information about its current state and about past and future changes.

Hydrography makes statements about:

- the water depths in relation to a reference horizon,
- the positions of shoals,
- the positions of magnetic anomalies,
- the shape and structure of the bottom,
- the material composition of the bottom,
- the structure of the deeper soil layers,
- the location of deposits,
- the uniform change of the water level (tides),
- the short-term and long-term change of the water level (storm surge, sea level rise),
- the height profile of the water surface (orthometric height),
- the characteristics of waves,
- the characteristics of currents,
- individual parameters of the water column (temperature, salinity),
- the structure of the water body,
- the water quality (particle concentration, radioactivity),
- the natural and artificial objects in and on the waters,
- the traffic situation on the waters,
- the course of the water's limit,
- the course of boundaries within the waters,
- the nature of the adjacent land strip (coastal zone resp. shoreline).



**Object of investigation of hydrography**

- 1 Course of the water's limit
- 2 Nature of the adjacent land strip (coastal zone resp. shoreline)
- 3 Traffic situation on waters
- 4 Characteristics of waves
- 5 Water level
- 6 Height profile of the water's surface
- 7 Individual parameters of the water column (temperature, salinity)
- 8 Water depths
- 9 Water quality (particle concentration, radioactivity)
- 10 Characteristics of currents
- 11 Nature of the bottom
- 12 Structure of the deeper soil layers
- 13 Natural and artificial objects in and on the waters

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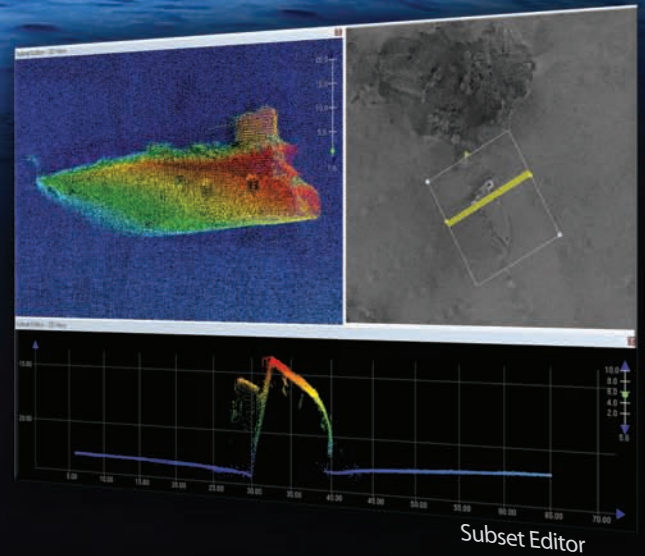
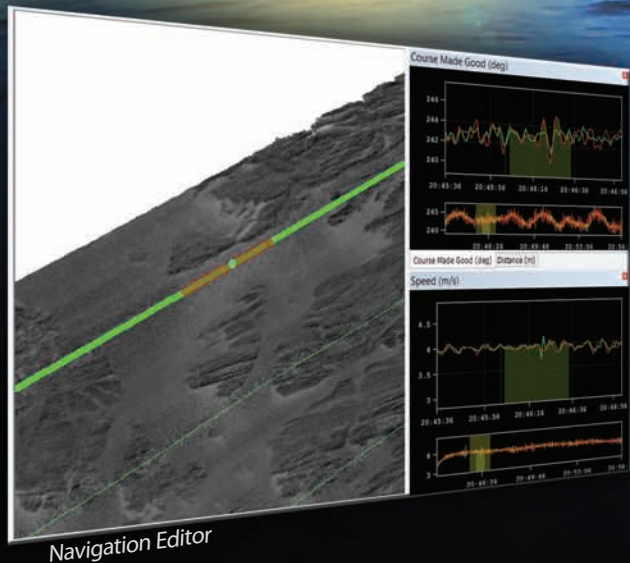


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## OCEAN ENGINEERING IN DEPTH

### HYDROGRAPHIC SYSTEMS



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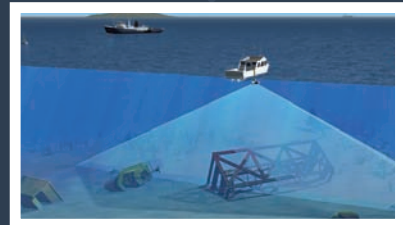
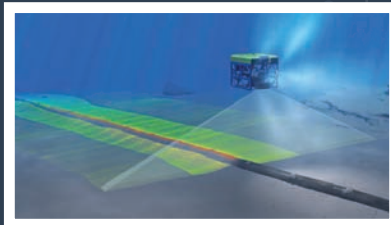
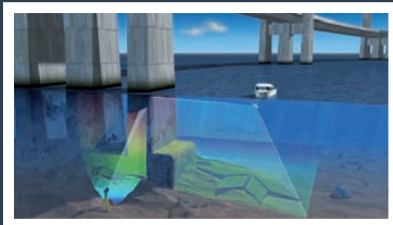
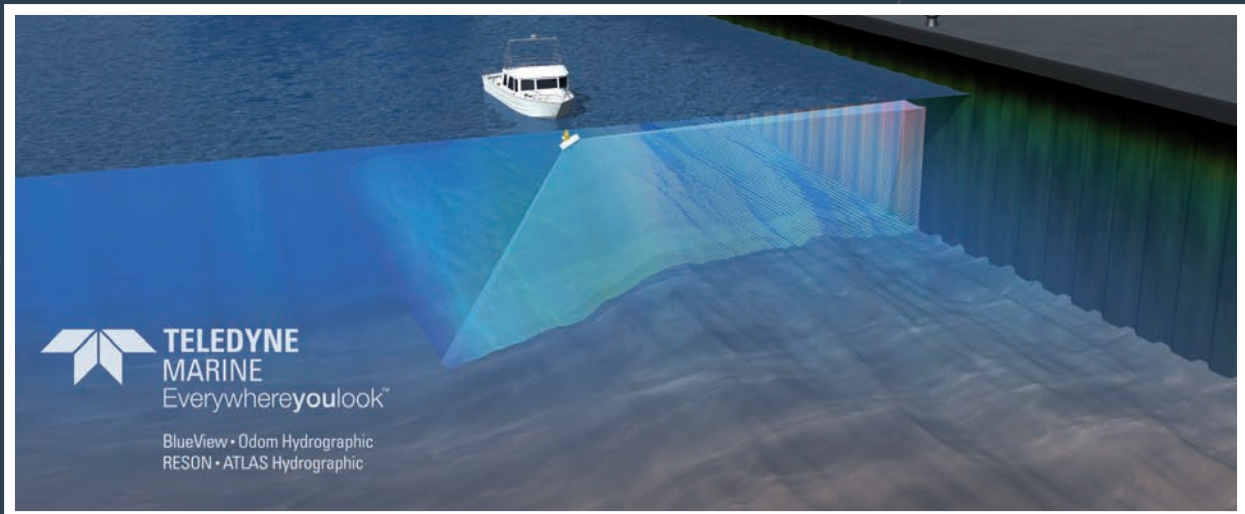
POSITION & MOTION



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