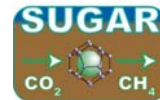


Hydro-Acoustic Gas Bubble Detection for Gas Hydrate Exploration

Ch. Zwanzig
November 04, 2010



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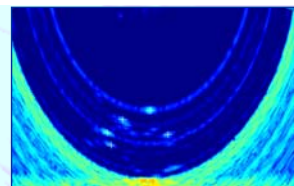
Subproject A1



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Content

- ✓ Introduction
- ✓ Data Compression
- ✓ Multi-Ping Operation
- ✓ High-Resolution WCI Data Storage
 - Data Formats
 - Hardware Components / Firmware
- ✓ High-Resolution WCI Data Visualization
- ✓ Object Detection
- ✓ Results





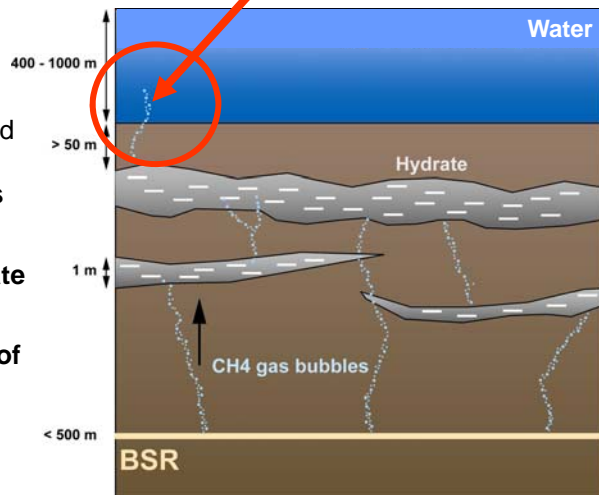
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Introduction Rising Gas Bubbles and Gas Flares

Prospection Target

Rising gas bubbles and gas flares in the water column are **indicators** for:

- Potential gas hydrate reservoirs
- Potential leakages of gas deposits



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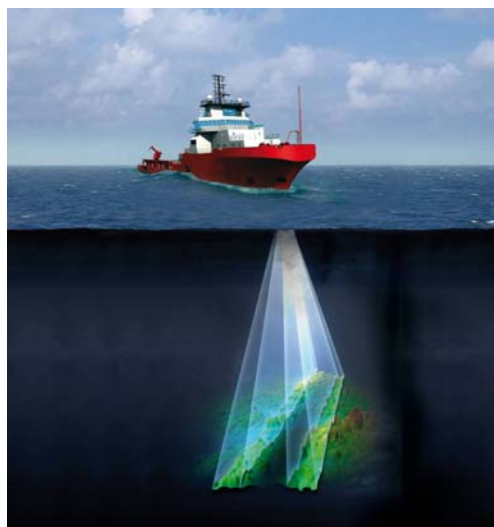
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Introduction Technology for Prospection

VISUALIZATION and DETECTION of Gas Bubbles and Gas Flares in the Water Column with Multibeam Echo Sounders



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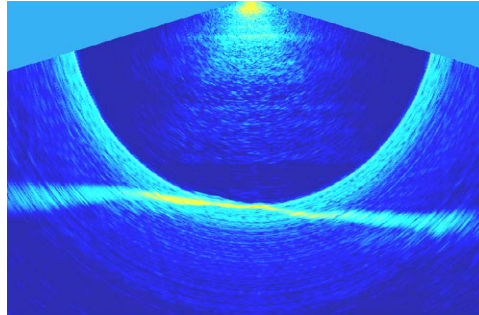
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Introduction

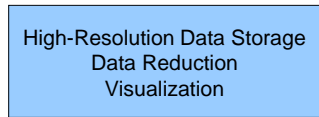
Cooperation of L-3 ELAC Nautik and IFM-GEOMAR



The complete water column trace from each beam is stored in order to provide the full volume.



System Development



Automatic Object Detection



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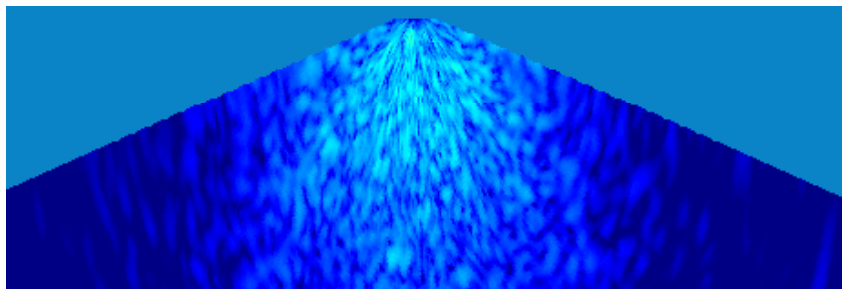


Introduction

Big Technical Challenge

- The ability to detect gas bubbles in the water column online and offline requires **the storage and visualization of high-resolution water column image (WCI) data during surveying.**

This is a big technical challenge.



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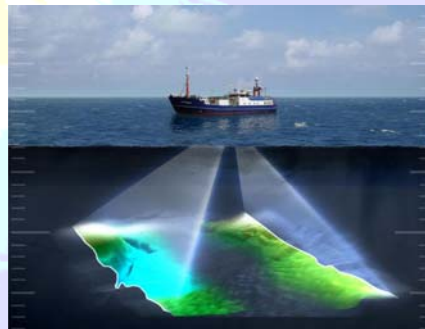


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Data Compression Digital Down Conversion (DDC)

In order to minimize the big data volumes, which are acquired during high-resolution water column imaging (WCI), specific algorithms and software components have been developed, implemented and tested:

- ✓ The carrier signal is eliminated from the digitized measurement data by baseband shift (digital mixer stage).
- ✓ Afterwards, the measurements data are decimated – adapted to the pulse length (i.e. adapted to the wanted signal).
- ✓ This technique is called Digital Down Conversion (DDC).



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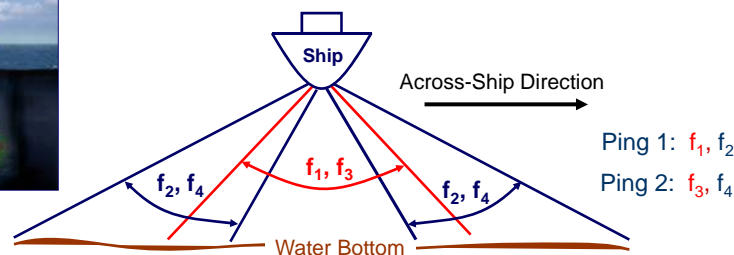
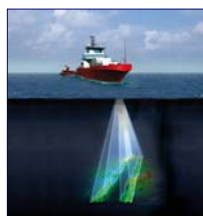
7



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Multi-Ping Operation SeaBeam 3030/3050 MBES

- ✓ Hardware and software components have been developed which make it possible to ensonify the water column quasi-simultaneously with up to four different frequencies (multi-ping functionality of SeaBeam 3030/3050).
- ✓ In order to enable a yaw stabilization during pulse transmission, for each swath the water column is divided into a sector in the center area and two sectors in the outside areas (port und starboard).



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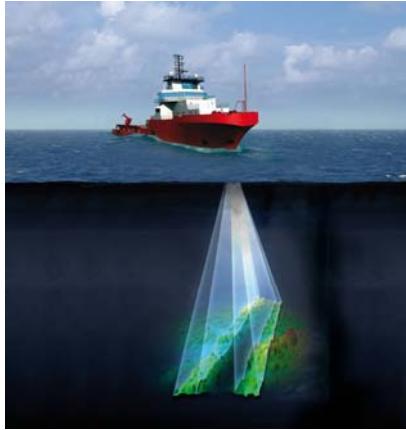
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Multi-Ping Operation Advantages



Via multi-ping operation (two simultaneous pings), the ping rate can be doubled compared to conventional multi-beam echo sounders with single-ping operation. Multi-ping operation has the following advantages:

- ✓ **Higher survey speed (i.e. lower survey costs)** for fixed data density or
- ✓ **Higher data density (i.e. better data quality)** for fixed survey speed.

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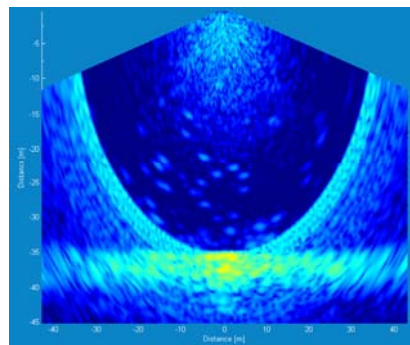
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High-Resolution WCI Data Storage Data Formats

- ✓ For the online storage of high-resolution WCI data, appropriate data formats have been specified, implemented and tested.
- ✓ Alternatively to WCI data, stove-oriented raw data can be stored.
- ✓ The data formats are open to the public.
- ✓ The stored data include all necessary information in order to apply online or offline algorithms for the automatic localization and quantification of gas bubbles in the water column.



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High-Resolution WCI Data Storage Hardware Components / Firmware



SeaBeam 3030/3050
Transceiver Unit

- ✓ To enable an online storage of highly resolved WCI data (or alternatively stove-oriented raw data), special firmware for high sophisticated hardware boards has been developed.
- ✓ These boards provide the necessary signal band widths and include FPGAs and DSPs of the newest technology.
- ✓ All hardware boards including all FPGA and DSP firmware are finally developed and tested.

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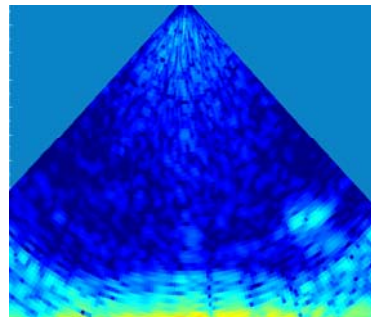
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High-Resolution WCI Data Visualization HydroStar WCI Viewer

- ✓ For the online and offline visualization of high-resolution WCI data and stove raw data, specific software components have been developed.
- ✓ These software components are based upon the MATLAB development environment and allow an easy integration of algorithms for the automatic detection of gas bubbles in the water column.
- ✓ The components have been integrated into the **HydroStar WCI Viewer** software package, which is adapted to scientific and operational requirements concerning water column imaging.
- ✓ The components have been successively extended by additional functions and optimized concerning performance (data rates).



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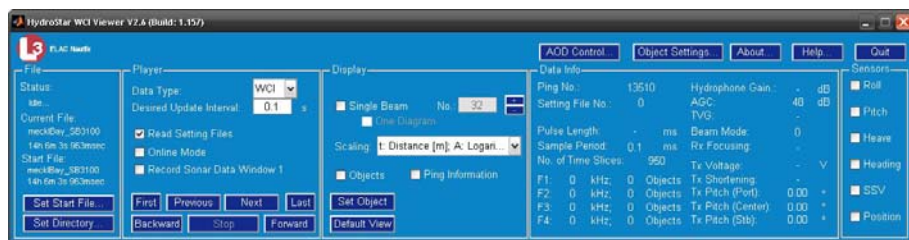
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High-Resolution WCI Data Visualization Characteristics of the HydroStar WCI Viewer (1)

- ✓ Online and offline visualization
- ✓ Visualization of water column image (WCI) data or stave raw data
- ✓ Data playback as a film or as single pictures
- ✓ Forward and backward running
- ✓ Linear or logarithmic amplitude scaling
- ✓ Marking, storage and visualization of objects in the water column
- ✓ Storage of WCI data or stave raw data as AVI video files



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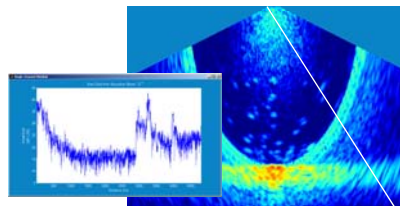
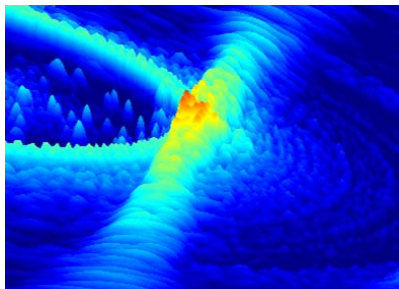
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High-Resolution WCI Data Visualization Characteristics of the HydroStar WCI Viewer (2)

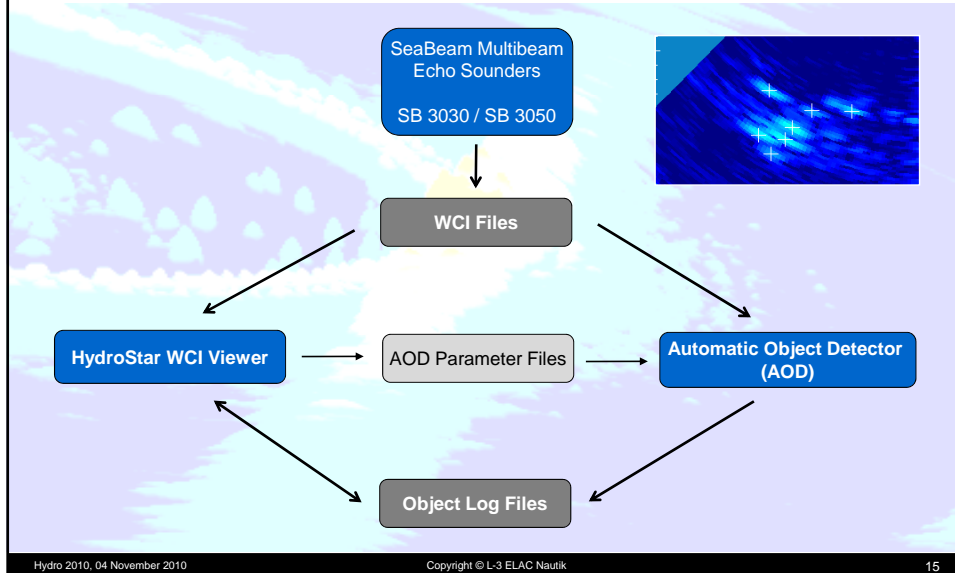
- ✓ Selectable amplitude colour scaling
- ✓ Time scaling and distance or sample scaling
- ✓ Zoom function
- ✓ 2D and 3D Visualization
- ✓ Single beam / single channel function
- ✓ Additional sensor windows (roll, pitch, heave, heading, SSV, position)
- ✓ Running under MS Windows and Linux
- ✓ Open development platform (MATLAB)



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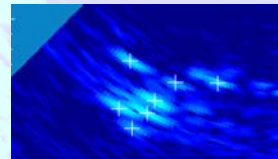
Development Approach

✓ Step 1:

- Identification and localization of gas flares, based upon WCI data which have been reduced in data volume.

✓ Step 2:

- Quantification of gas flares, which have been identified in step 1.
- The quantification is based upon non-reduced high-resolution WCI data.

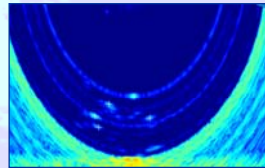




Object Detection Automatic Object Detection (AOD): Step 1

Main Processing Stages of Step 1: (Identification and Localization of Gas Flares, Based Upon Reduced WCI Data)

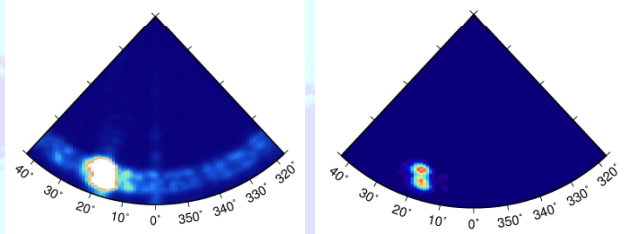
- ✓ WCI data conversion and processing
- ✓ Advanced data processing
- ✓ Object detection



Object Detection AOD: Automatic Object Detection (1)

WCI Data Conversion and Processing

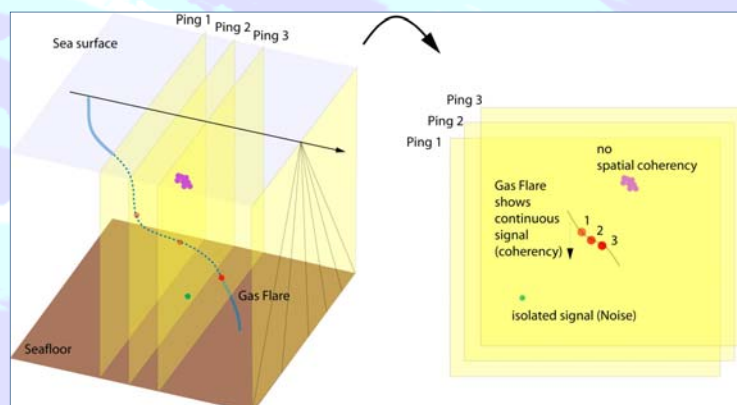
- ✓ Conversion of (complex-valued) WCI data to modulus (magnitude) data
- ✓ Data reduction by data windowing, based upon a-priori information; selection of:
 - Depth range
 - Beam angle range
- ✓ Data cleaning (2D processing)



Advanced Data Processing: Overview

- ✓ Selective resampling / binning to decrease computation time:
 - Depth binning: Travel time / depth
 - Beam angle binning: Across-ship beam angle
 - Ping binning: Consecutive pings in the along-ship direction
- ✓ Transformation of the 3D volume data into sequences of 2D data subsets (e.g. beam oriented subsets and time slice oriented subsets) which represent the 3D volume in different manners
- ✓ Volume coherency check, based upon volume processing of the sequences of 2D subsets

Volume Coherency Check



- ✓ Volume coherency is **one main criterion** for the detection of **gas flares**.



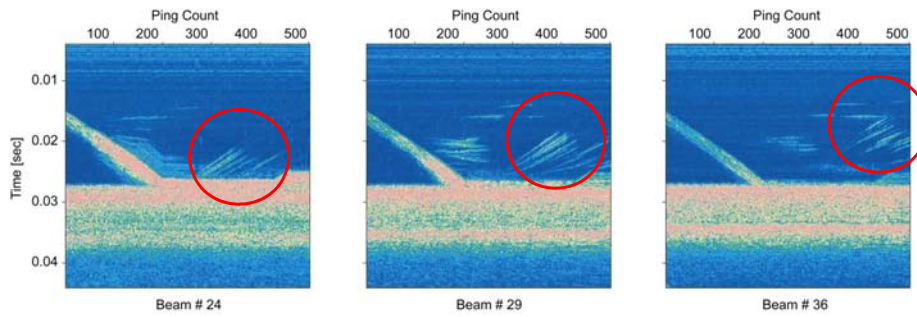
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Object Detection AOD: Automatic Object Detection (4)

Volume Coherency: Beam Oriented 2D Subsets



WCI data provided by courtesy of Dr. Jens Schneider von Deimling,
Leibniz-Institute for Baltic Sea Research (IOW), Warnemünde

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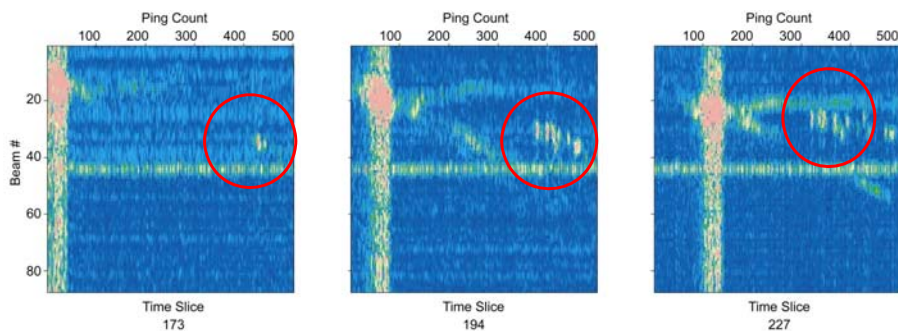
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Object Detection AOD: Automatic Object Detection (5)

Volume Coherency: Time Slice Oriented 2D Subsets



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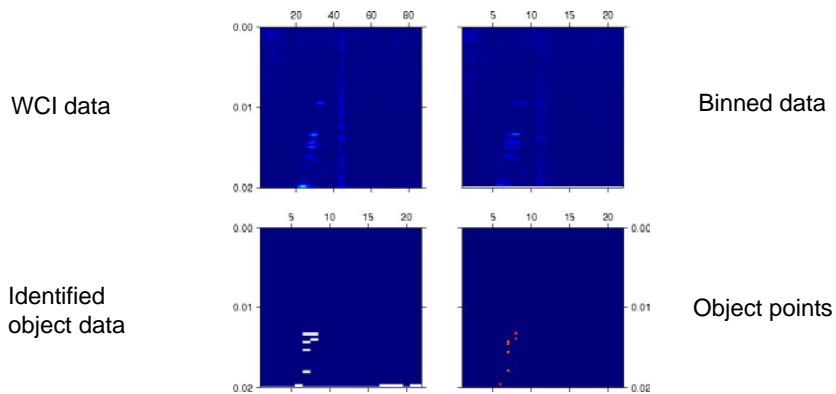
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IFM-GEOMAR

Object Detection AOD: Automatic Object Detection (6)

Object Detection



Storage of object points within object log file

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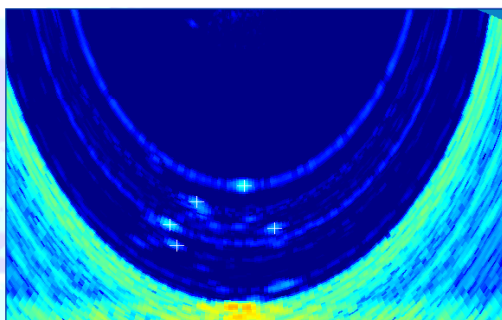
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Object Detection Object Visualization



SeaBeam Multibeam
Echo Sounders
SB 3030 / SB 3050

WCI Files

HydroStar WCI Viewer

Automatic Object Detector
(AOD)

Object Log Files

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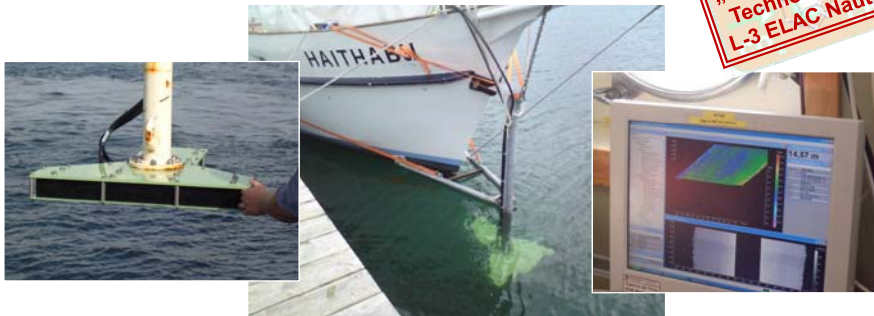


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Results Sea Trials (1)

- ✓ During 2009 and 2010, several sea trials with a SeaBeam 3050 MBES were carried out during which, among other things, the WCI capabilities were tested.
- ✓ The results achieved during the sea trials are very good.

**„SUGAR Inside“
Technology by
L-3 ELAC Nautik**



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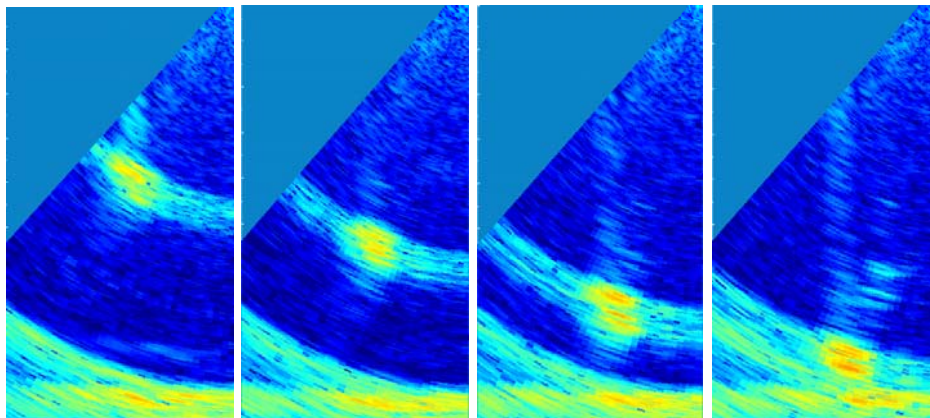
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Results Sea Trials (2)

Results achieved within the EU Project BONUS/BALTIC GAS by a SeaBeam 3050 MBES on R/V POSEIDON in 11/2009 and 12/2009.



*WCI data provided by courtesy of Dr. Jens Schneider von Deimling,
Leibniz-Institute for Baltic Sea Research (IOW), Warnemünde*

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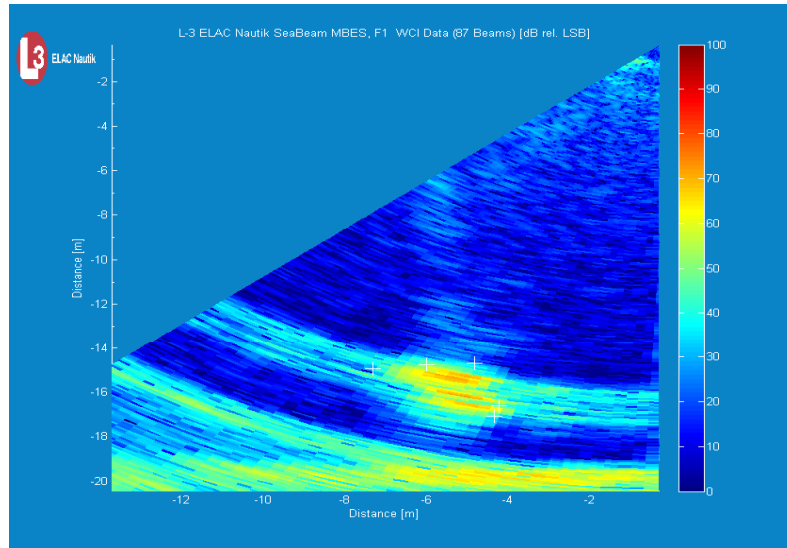
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Results WCI Video with Marked Objects



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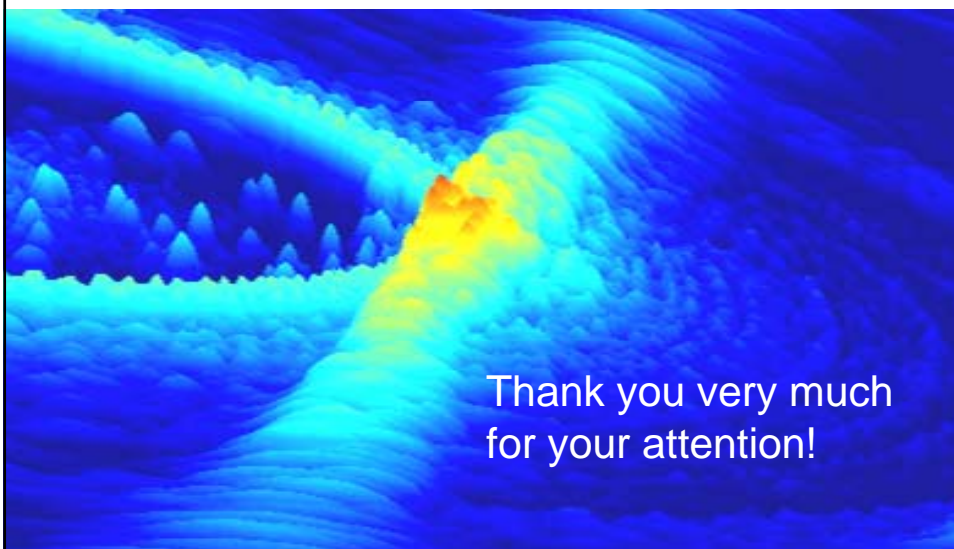
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Hydro-Acoustic Gas Bubble Detection and Prospection Techniques



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