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OES

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The Oceans 06 MTS/IEEE-Boston Conference and Exhibition will be held in Boston Massachusetts from September 18-21, 2006. The birthplace of the American Revolution, Massachusetts and the surrounding New England region enjoys a centuries-old relationship with the ocean; from the fishing and whaling ports of Gloucester and New Bedford to the premier technology centers of the Woods Hole Oceanographic Institution and the US Navy's Undersea Warfare Center. Pleasant autumn weather and many tourist sites and activities, combined with a stimulating technical program, will make this Conference a memorable event.

The OCEANS 06-Boston technical program continues to emphasize the traditional core areas of marine science and technology development. Researchers from academia, industry, and government have been encouraged to submit their recent work on topics such as:

- Underwater Acoustics and Acoustical Oceanography
- Sonar Signal / Image Processing and Communications
- Ocean Observing Platforms, Systems, and Instrumentation
- Air and Space Ocean Remote Sensing
- Ocean Data Visualization, Modeling, and Information Management
- Marine Environment, Physical Oceanography, and Meteorology
- Optics, Imaging, and E-M Systems
- Offshore Structures and Technology
- Marine Law, Policy, Management, and Education

In addition, the Boston conference plans to highlight several "hot topic" areas of high current interest to the members of the MTS/IEEE research community:

- Homeland Security Applications
- Tsunami Early-warning Systems
- AUV/UUV/Glider Technology
- Distributed Sensors and Networks
- Tracking and Data Fusion
- Non-acoustic Sensing and Imaging
- Integrated Ocean Observatories
- Marine Mammal Classification
- Arctic Ocean Science
- Optical Properties of Water • Aquaculture Engineering
- Marine Archaeology

For additional Technical Program information contact Technical Program Chair: Dr. Vincent Premus, MIT Lincoln Laboratory at techchair@oceans2006mtsieeeboston.org or at (+1) 781-981-5341

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# President's Corner

At the latest TAB meeting a few items of interest to the society were discussed. For instance, our constitution needs to be reviewed to insure that it is in agreement with a list of "must haves" generated by the IEEE board of directors. These include definition of a quorum, description of the procedure for AdCom action without a face to face meeting e.g., email vote, N&A requirements and petition signature requirements, 2% of membership to get on a ballot by the petition route. Another area that was discussed was the IEEE eXpert Now program. This is a continuing education program run by EAB that uses subject matter experts (SME) in various disciplines to develop tutorials for online access. There are approximately 50 modules at the present time in the system. Our society has not supplied any modules at this time. However, if you feel you may want to contribute to this effort as an SME please contact Liz Creed of our AdCom.

The month of May was a busy one for the society. As usual we were involved in the Offshore Technology Conference (OTC) in Houston the first week of May then came the OCEANS conference the middle of the month in Singapore and at the end of the month we held a symposium in Klaipeda, Lithuania.

The OTC held in the first part of May was very successful this year. The attendance was over 60, 000 and there were two additional tents set up in the parking lot to handle added exhibitors. The event is held the first week of May every year and the planning for the 2007 version is underway. We are also in the process of establishing a chapter in the Houston area. All members in the area should contact Gamal Hassan —gamalhassan@bakerhughes.com— to assist him in formulating programs of interest to the membership.

OCEANS in Singapore was held in a hotel that was across the street from Raffles, a famous place in the literary world in times past. The city is very diverse and there are several areas that are interesting to visit, including a night safari to the zoo. The technical program was diverse and interesting to all attendees. This was our second effort to address our membership around the world and it was moderately successful. Thanks are due to John Potter and his committee.

The US-Baltic symposium, the second in Klaipeda, Lithuania, was as successful as the original. The technical program was very informative and the social arrangements were appreciated by all the attendees. The attendance included participants from all the Baltic countries and the US. Over 140 papers were presented. Vic Klemas and Joe Vadus along with CMR in Klaipeda deserve a hand for their effort in pulling this together.

As stated previously, last year the society rewrote its constitution and bylaws and the membership voted for them. We are now in the process of developing the sister document our policies and procedures manual. This document as one might surmise will spell out the guidelines for the day to day operation of the society. The plan is to have it completed by the end of this year.

Our next event is the OCEANS conference in Boston. The committee has assembled over 450 papers that address a myriad of subjects. The program also includes a track on the GEOSS program, a worldwide effort to monitor environmental conditions. Now is the time to make plans to attend this conference. Registration is easily done thru the conference web site. See the advertisement in this issue of the newsletter. John Irza and his committee have put together a ”don't miss” event.

The next date you should keep open is 18-21 June 2007 for OCEANS 07 Aberdeen. The technical program will include tracks on renewable energy source and the utility of optical systems in the marine environment. See the call in this issue of the newsletter. John Watson and his committee are hard at work to make this a memorable event.

I will again ask that you consider participating in one of the society numerous technical committees that address most areas of interest for ocean engineers. Please contact Sandy Williams so that you may become a part of one of the committees. He will explain what will be required of you and direct you to the committee that best fits your interests. Remember that many hands make the task easier for all

The newsletter welcomes articles of interest to oceanic engineering. Please forward such articles to Fred Maltz. These can include both technical and personal items. As this is a news letter it should include news related to members activities outside the office as well as technical information. Most of the members take personal trips to interesting places and it would be nice to get your view on the site.

I will close by encouraging all to get involved in the society happenings as you will appreciate your membership more fully.

**Jim Barbera, IEEE/OES President**

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# AUV Races and OES Chapters…what do you think?

### *By Jim Collins, VP Professional and Chapters Coordinator*

What is the connection between AUV (autonomous underwater vehicle) races and OES Chapters?,,,nothing at the moment. Surprisingly if on July 12, 2006 you queried on Google the item, “auv race”, you would have come up with only one hit that lead to a discussion of business competition between companies using AUV's for underwater surveying. By comparison and for the sake of completeness, the item, “OES Chapter” +IEEE, gives about twenty-five hits. These google metrics are of debatable significance but are a good place to start in trying to quantify the present impact of the two items and the future impact of a combination of the two that I propose might benefit the ocean community greatly.

AUV's (torpedos not included) had their beginnings in the early 1960's at Seattle's University of Washington's Applied Physics Laboratory with the development of the hard-wired logic Self-Propelled Underwater Research Vehicle (SPURV). With the advent of microcomputers the main impediments to AUV development were the lack of economic high endurance power supplies, a very difficult communications and sensing environment and the ever-present threat of loosing a very expensive vehicle and perhaps the associated research program. In the last decade AUV's in the under 100 Kg weight range are reaching the market in rapidly increasing numbers. It is interesting to note that if one googles the search parameters, AUV +race, the search engine generates about 25.500 hits. This search result reveals many AUV competitions where the AUV's compete against obstacle courses but on a one vehicle at a time basis. I am suggesting we look at the possibility of two or more vehicles on the course at the same time. The interactions between vehicles could promise a very interesting new dimension in such races.

Our OES Chapter system provides a potentially very effective basis for organizing an international AUV race. At present there are a total of sixteen chapters, Five in the USA, five in Canada, three in Europe and three in the Asia-Pacific. Six more are in various stages of formation in the USA, Europe and the Asia-Pacific. One very active Chapter in Japan is based on the Japan Council as opposed to one of the several Sections that exist in Japan. This Chapter has the added benefit of being able to represent OES members on a national versus a local basis.

What do you think? Is it time for the OES to form an AUV Racing League? If so, how do we best do it?

I would like to hear your ideas on this potential new venture for the OES. I can be reached at j.s.collins@ieee.org or by phone at +1 250 595 6928.

# National Ocean Sciences Bowl

1st Place - Lincoln-Sudbury
Regional High School,
Massachusetts
- Blue Lobster Bowl

2nd Place
- Poudre High School,
Colorado - Mountain Mariner Challenge

3rd Place
- Santa Monica High School,
California - LA Surf Bowl

4th Place
- Albany High School,
California - Otter Bowl

The ninth annual National Ocean Sciences Bowl, sponsored by the Consortium for Oceanographic Research and Education (CORE) was held at the Asilomar Conference Center in Pacific Grove, CA May 13-15, 2006. Once again OES was a sponsor of the event and awarded prizes to the 5th through 8th place finishers. Twenty Five schools, each winners of their Regional Competitions, took part in the event. On Saturday, May 13, 2006, the program began with a visit to the Monterey Bay Aquarium. This was followed by various field trips. Following dinner, the group assembled in the chapel for a welcome followed by a very interesting presentation by Cordova High School, Cordova, AK on a research project that the team had done during the year. This was followed by a very interesting presentation by Dr. Dijanna Figueroa, Research scientist for the IMAX film "Aliens of the Deep".

The competitions began at 9:30 AM Sunday morning and continued through Double Elimination Round 4 at 7:00 PM. The Double Elimination Rounds continues Monday morning concluding at 12:15 PM. Following lunch the Awards Ceremony was held in the Chapel. The Awards Ceremony began with an introduction by Dick West, CORE President, in which he stated that "Expanding the knowledge of our young academics in the field of oceanography is a major goal of the NOSB". Vice Admiral Conrad C. Laudenbacher was then introduced and presented the awards to the winning teams:

The OES Awards for the 5th through the 8th Place winners, which include gift certificates for $500.00 for scientific equipment and $500.00 for marine science textbooks for team's school, were awarded to:

5th Place
- MAST Academy, Florida Manatee Bowl

6th Place
- Oconee High School, South Carolina
Southern Stingray Bowl

7th Place
- Langham Creek High School, Texas Dolphin Bowl

8th Place
- Thomas Jefferson High School.
District of Columbia - Chesapeake Bay Bowl

It was interesting to note that of the 25 teams that competed this year 10 of the teams were competing in the finals for the first time and of these teams 3 won awards. The 10th Annual National Ocean Sciences Bowl will be held at Stony Brook, New York in 2007.

**Norman D. Miller**
**Student Activities Coordinator**


# Oceans 2006 Asia Pacific Report for OES Newsletter

The 2006 Oceans conference in Asia Pacific was held as a 100% IEEE OES event for the first time during 16-19 May 2006 in Singapore. The Oceans brand of conference and exhibition is widely known and respected in the Americas, and the recently-adopted 'two-oceans' model now expands this ocean science and technology forum to the exciting and growing arena of Asia Pacific. This was the first true reality check to see if this policy could work, if there was sufficient maturity and interest in the Asia Pacific region to support such an event. The result is a resounding 'yes' with a full and rich programme of tutorials, the student poster competition, the first Underwater Robotics Competition and other features supporting the mainstays of the exhibition and conference. Feedback indicates that the venue, organisation, food and variety of papers scored the highest number of compliments.

While the registration levels fell somewhat short of those desired at 284, the diversity of their origin was encouraging, with participation from 24 countries, primarily from Singapore, Japan, USA, Australia, France, India, Taiwan and Korea. Feedback gathered from attendees confirms that the quality of the material presented in the technical sessions was very good.

Some 31 booths representing the interests of 8 countries were taken in the exhibition area, with exhibitors declaring the venue and booth facilities excellent, particularly the provision of hot snacks to draw visitors.

The exhibition are also hosted the very successful inaugural Underwater Robotics Competition (URC), attracting 11 teams made up of some 50 individuals who generated a flurry of creative solutions and fun. The URC was so popular that it has now been adopted as a permanent feature of the long-standing Singapore Robotic Games.

The tutorial programme was also a strong success, with 6 tutorials attracting some 79 registrants, with topics covering Environmental Ocean Acoustics, Time Reversal Mirrors, Signal and Array Processing, Design of Autonomous Underwater Vehicles, Underwater Acoustic Communications and Multiple Target Tracking. Over 80% of the registrants gave the feedback that they would recommend these courses to others, with instructor knowledge of the subject being graded excellent across the board.

The student Poster Competition, a feature of Oceans since 1989, also brought out some very high-quality research results in 16 accepted submissions from 10 countries. Once again, this was generously sponsored by ONR. As Norman Miller (The Chairman of the judging panel) pointed out, one prizewinner is the student of a previous winner of the same competition some years ago! Another prizewinner drew the attention of the media and those results were reported in the primary local newspaper.

The mounting of an event of the complexity of an Oceans conference and Exhibition by such a small local Chapter and membership base would not have been possible without the considerable advantages obtained from standing on the shoulders of a well-established and influential international Oceans Advisory Board and the developing unified infrastructure pioneered by Rene Garello's team. While there were certainly rough patches to be negotiated, and this Oceans laboured under many tribulations brought on by being caught in the middle between abandoning the old ways and adopting the new, the end result was a very credible achievement for all concerned, the seasoned international players and local committee alike.

I am therefore delighted to be able to report a conference and exhibition of a quality, level and coverage that met and surpassed all initial expectations, with every prospect of growing year by year to become a regional mainstay that OES can be proud of as marine technology breaches the walls of the East and blossoms in SE Asia.

**John R. Potter, General co-Chair Oceans Asia Pacific 06.**

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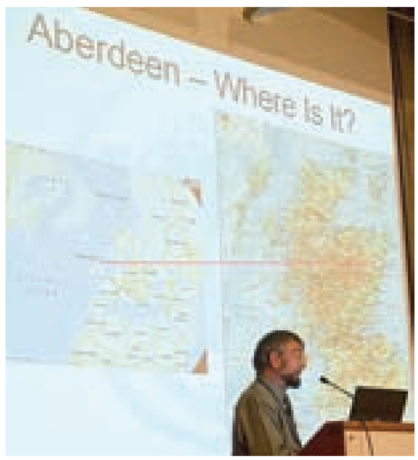
# Photos of Oceans '06 Conference - Singapore

John Potter
- General Chair

Arjuna Balasuriya
- Plenary Chair

Jim Barbera
- OES President

Bill Kuperman
- Plenary Speaker




John Watson
- Oceans '07,
Aberdeen General Chair

Thierry Gaiffe
- Plenary Speaker


Norm Miller
- Student Posters

Milica Stojanovic, Norm Miller,
Rudolph Bannasch and Anthony Liu
- Student Poster Judges


Aanderaa Booth


Jim and Faith Collins
- OES Booth

John Watson and Diane DiMassa
- Oceans ‘07 Aberdeen Booth


FALMAT Booth

Arjuna B., Vanoji B.
and Sardha W. with
Stan Chamberlain

Dancing Singapore
Dragons
- at Banquet

Todd Morrison, Jerry Carroll,
Rene Garello
and Diane DiMassa

Liz Creed,
Joelle Garello
and Bob Wernli

Faith & Jim Collins, John Watson,
Claude Brancart
and Brian Horsburg

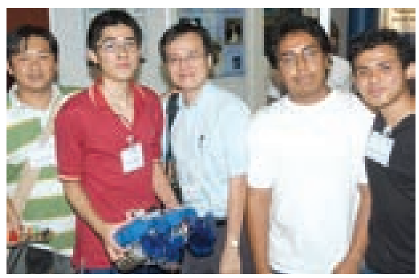
Liz Creed,
Diane DiMassa
and Jim Barbera

Peggy Barbera,
Ferial El Hawary
and Venugopalan Pallayil

Peggy & Jim Barbera,
John Watson
and Brian Horsburg

Tamaki Ura,
Harumi Sugimatsu
and Milica Stojanovic

Ferial El Hawary,
Claude & Leslie Brancart
and Joelle Garello



Robotics Team Winners
- Singapore Polytechnic

Jim Barabera,
Rene & Joelle Garello
and Claude Brancart

AdCom Luncheon

Peggy Barbera, Diane DiMassa,
Bob Wernli, Joelle & Rene Garello
and Sandy Williams


AdCom - Night Safari

# OCEANS '06 ASIA PACIFIC Student Poster Program

The eighteenth Student Poster Program was held at OCEANS '06 ASIA PACIFIC in Singapore . Once again we had a very fine display of student posters. Sixteen poster abstracts were received and fourteen were accepted. Two of the students had scheduling conflicts and were unable to attend and a third student cancelled out just prior to the Conference. Eleven posters were displayed and represented students from China, Japan, New Zealand, Turkey, France, Taiwan, Greece and Singapore. The posters were on display in the Lobby of the Conference Center and were heavily visited by the attendees. The Student Poster Session was organized by Mandar Chitre from the University of Singapore. Support from the Office of Naval Research of the United States Navy underwrote the cost of the program. Prizes for the top six posters were awarded at the Gala Banquet on Thursday evening. The posters were:

Gerard Llort-Pujol, ENST Bretagne, Brest, France
"A New Approach for Fast and High-resolution Interferometric Bathymetry"

Sie-Yu Li, National Cheng Kung University, Tainan, Taiwan
"A Novel Piezo-resistive Type Underwater Acoustic Sensor using SOI Wafer"

Mehdi Farrokhrooz, Shiraz University, Tehran, Iran
"A Performance Comparison Between Conventional PNN and Multi-spread PNN in SHip Noise Classification"

Isil Elmasli, Bilkent University, Ankara, Turkey
"A Wideband and a Wide Beamwidth Acoustic Transducer Design for Underwater Acoustic Communications"

Jose Garcia, University of Hanover, Hanover, Germany
"Adapted Distributed Localization of Sensors in Underwater Acoustic Networks"

Philip Barclay, University of Canterbury, Christchurch, New Zealand
"Bathymetric Results from a Multi-frequency InSAS Sea-Trial"

Daijin Hou, Kobe , Japan
"Evaluation Test Result on Wave Direction Measurement Using GPS Buoy"

Alan Hunter, University of Canterbury, Christchurch, New Zealand
"Fast Fourier-Domain Modelling for an SAS Simulator with Application to Time-Variant Targets, Aspect-Dependent Occlusions, adn Doppler Effects"


Norm Miller, Gerard Llort-Pujol (1st Place Winner), Rene Garello and Imen Karoui (2nd Place Winner)

Norm Miller and Philip Barclay (2nd Place Winner)

Norm Miller and Jose Garcia (3rd Place Winner)

Norm Miller and Oliver Wurl (3rd Place Winner)

Effrosyni-Maria Skordaki, Laboratory of Marine Geology and Physical Oceanography, University of Patras. Patras, Greece
"Heavy Metal Determination in Eastern Mediterranean Marine Sediments by Partial LEaching and High Resolution Inductively Coupled Plasma Mass Spectrometry Techniques"

Liang Zhao, Chinese Academy of Sciences, Beijing, China
"Particle Filtering Detectioin in Turbo Coded OFDM System Over Underwater Acoustic Communication Channels"

Imen Karoui, ENST Bretagne, Brest, France
"Region Based and Incidence Angle Dependent Segmentation of Seabed Sonar Images using a Level Set Approach Combined to Local Texture Statistics"

Lijie Zhang, College of Marine Engineering, Northwestern Polyterchnical University, Xi'an, China
"Spectral Analysis of Noise Characteristics Caused by Ship Propeller Cavitation"

Oliver Wurl, National University of Singapore, Singapore
"Time Trend of Persistent Organic Pollutants in the Atmosphere Over the Indian Ocean Over the Last 30 Years"

He Bing, College of Marine Engineering, Polytechnical University, Xi'an, China
"Underwater Acoustic Spread Spectrum Communication Based on M Family N Group Parallel Transmission"

The Judging Team did and outstanding job of evaluating the posters and reached a concensus on the ranking of the posters. Prizes were awarded as follows:

1st Place
• Gerard Llort-Pujol

2nd Place
• Imen Karoui
• Philip Barclay

3rd Place - Jose Garcia
• Alan Hunter
• Oliver Wurl

All of the Students were asked to stand and were given a round of applause at the conclusion of the Awards.

**Norman D. Miller**
**Student Activities Coordinator**

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# Upcoming Conferences

August 29-31, 2006
**AUVSI's Unmanned Systems North America**
Orlando, Florida
www.auvsi.org

September 4-8, 2006
**Underwater Acoustics 2006**
London, England
www.seiche.com

October 16-19, 2006
**Sea Tech Week**
Brest, France
www.seatechweek-brest.org

October 18-20, 2006
**Techno-Ocean 2006**
Kobe, Japan
www.TO2006-19thOES.com

September 13-15, 2006
**NSSPW '06, Cambridge, UK**
www.oceanicengineering.org

September 18-22, 2006
**Oceans 2006 MTS/IEEE,**
Boston, Massachusetts
www.oceans2006.org

October 9-13, 2006
**TEHOSS 2006,**
Istanbul, Turkey
www.tehoss2006.org

October 18-20, 2006
**AUV '06, Brest, France**
www.auv06.org

December 9-13, 2006
**RAE '06, New Orleans,**
Louisiana
www.estuaries.org

June 18-21, 2007
**Oceans 2007 IEEE,**
Aberdeen, Scotland
www.oceans07ieeeaberdeen.org

Sept 29-Oct 4, 2007
**Oceans 2007 MTS/IEEE,**
Vancouver, Canada
www.oceans07mtsieeevancouver.org

# A New Approach for Fast and High-Resolution Interfometric Bathymetry

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***Email: xavier.lurton@ifremer.fr***

*Abstract - This paper deals with a new bathymetry processing for multibeam echosounders based upon interferometry. Several issues are discussed concerning the number of beams to be formed, the optimal interferometer configuration in terms of minimal angular error, and the multitarget detection. The algorithm is illustrated by data from a 300-kHz multibeam echosounder recorded over a wreck area.*

## I. Introduction

Multibeam echosounders [1] allow, from a single emitted signal, a measure of a great quantity of soundings all along the swath. The principles of acoustic wave propagation and multibeam echosounder techniques are analyzed in [2][3]. In order to retrieve the seafloor relief, bathymetry applications aim at estimating the two-way propagation time of the emitted signal and the arrival angle. Then, the depth and the across track distance are readily determined by trigonometry (neglecting the refraction effects). Two possible approaches are usually carried out: the maximum amplitude instant detection, and the interferometric phase detection.

Interferometry [4] potentially provides a very precisely information by measuring the phase difference between two receiving arrays at the time-sampling rate. The differential phase between two sensors is given by (Fig. 1)

$$\Delta\varphi = \frac{2\pi}{\lambda} d \sin(\theta_a - \theta_s) + 2\pi n \qquad (1)$$

where $\lambda$ is the acoustic wavelength, ?a is the wavefront direction of arrival (DOA), $\theta_S$ the steering angle, and $d$ the spacing between the subarrays centers, commonly called interferometer spacing or baseline. Since the interferometry requires two receiving sensors, the multibeam array is split into two subarrays whose optimal length turns out to be $L/3$, $L$ being the array length (see Appendix A). Thus, wide baselines are more relevant to perform interferometry in terms of minimal angular error. The resulting phase difference is, therefore, $2\pi$ ambiguous; a given echo recorded vs time may be affected by several phase jumps. Algorithms to unbias the differential phase appear as an important issue for interferometry-based methods. Here, the ambiguity is removed by means of the Vernier algorithm [5].

When the backscattered signal reaches the array from an angle normal to the interferometer axis, both sensors are impinged at the same time, so the time delay between them as well as the phase difference is zero (see Eq. (1)). Hence, the zero-phase instant (ZPI) is classically used to estimate the time of arrival (TOA). The phase ramp (as a function of time) is fitted with a polynomial whose intersection at zero-phase gives the instant corresponding to the sounding, the angle being defined by beam-steering. This polynomial approximation acts as a low pass filter decreasing the noise level at the expense of a horizontal resolution degradation. As a result, the polynomial approximation concentrates all the phase samples on one value what implies a mixture of samples that may not have any relationship in terms of topology. In order to improve the reso-

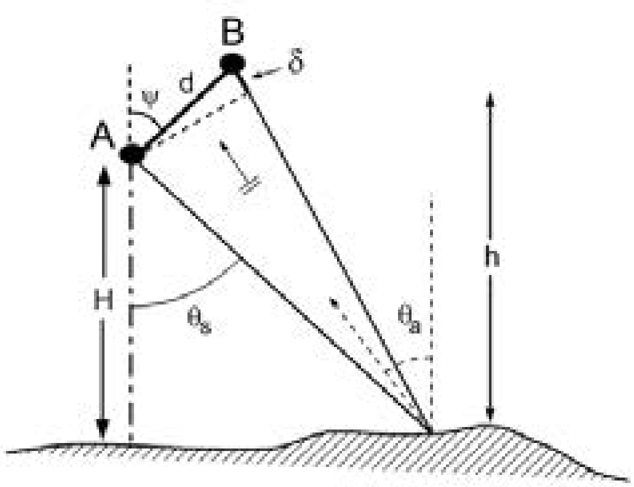


Figure1. Interferometry geometry.

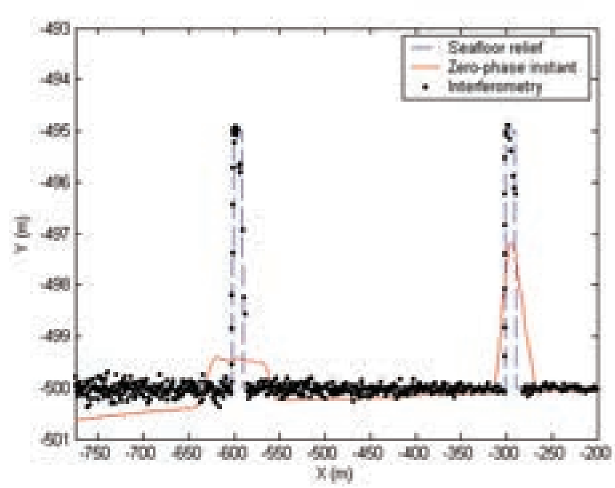


Figure 2. Bathymetric comparison between the zero-phase instant approach and the complete interferometry.

lution, a huge amount of beams are typically formed. Yet, this solution is not right unless the samples concerned for the approximation are different for each beam. Indeed, since the beams are so close, their angular apertures overlap insonifying nearly the same seafloor area. Therefore, the polynomial approximation uses almost the same samples beam after beam to estimate a value that is a topographical mixture of the -3dB beam aperture. In this paper, we propose to form only a few beams, and to analyze each one in order to exploit the maximum quantity of information. It is pointed out, in Section II-B, that the phase is continuous beam after beam so that it is possible to take into consideration all samples belonging to the insonified seafloor section. Thus, each phase sample will correspond to one individual sounding.

Fig. 2 depicts a comparison between these two approaches. For the ZPI approach, 300 beams were formed, and the phase ramp span was fixed by the -3dB beam width. It is interesting to note the bathymetric bias of the ZPI method at the edge of the swath. The observed bias is due to the fact that the phase ramps are not strictly straight lines; their curvature raises a residual variance in the least-square computation. This bias obviously decreases with a smaller fitting interval width, since the curvature effect is lower.

This paper is organized as follows. Section II deals with the interferometry introducing the characteristics of its amplitude and phase, and the correlation coefficient. Section III introduces the proposed algorithm focusing on 2π-ambiguity removal, multitarget detection and multisource fusion. In Section IV, experimental results obtained from data recorded with a 300-kHz multibeam echosounder are presented, showing the performance of the algorithm. Finally, the conclusions are drawn in Section V summarizing the improvements of the proposed algorithm.

## II. Interferometry method

This section deals with the interferometry method, analyzing the contribution of its amplitude and phase to the final algorithm. The interferometry is a method in widespread use to determine the direction of arrival (DOA) of a wave front by comparing the phases of the signals received at separate arrays or at separate points on the same array.

Considering the bathymetric sonar configuration in Fig.1, where $A$ and $B$ are two receiving sensors impinged by signals backscattered from a target point, the cross product of the two interferometric sensors is expressed as

$$Z = S_a S_b^* \tag{2}$$

**Interferometric amplitude**

The interferometric amplitude is given by the absolute value of (2). The amplitude features the power level recorded by the echosounder. When the emitted wave front is backscattered by an object and reaches the antenna, the power level increases. The maximum amplitude instant (MAI) detection was one of the first approaches used, mainly for monobeam echosounders and early multibeam systems, to estimate the TOA of the backscattered signal. For near-normal incident angles, this time detection is quite accurate since the signal envelope is short and sharp. As the grazing angle increases, the time envelope becomes larger and instable affected by a decrease of SNR. As a result of that, the estimation becomes more troublesome and less accurate. An example of wrong detection will be shown in Section IV.

In this paper, the TOA estimation based on the MAI detection is only performed for near-normal incident beams; elsewhere the interferometric phase is performed as introduced in the following section.

**Interferometric phase**

The phase difference between the two interferometric sensors is defined by the argument of (2), and can be written as

$$\Delta\varphi = arg(S_a S_b^*) \tag{3}$$

The interferometric phase features the phase delay between two sensors. When the wave front comes back from an angle normal to the interferometer axis, it reaches both sensors at the same time, so the phase difference will be zero. Instead, if the wave front comes from any other angle, the phase difference

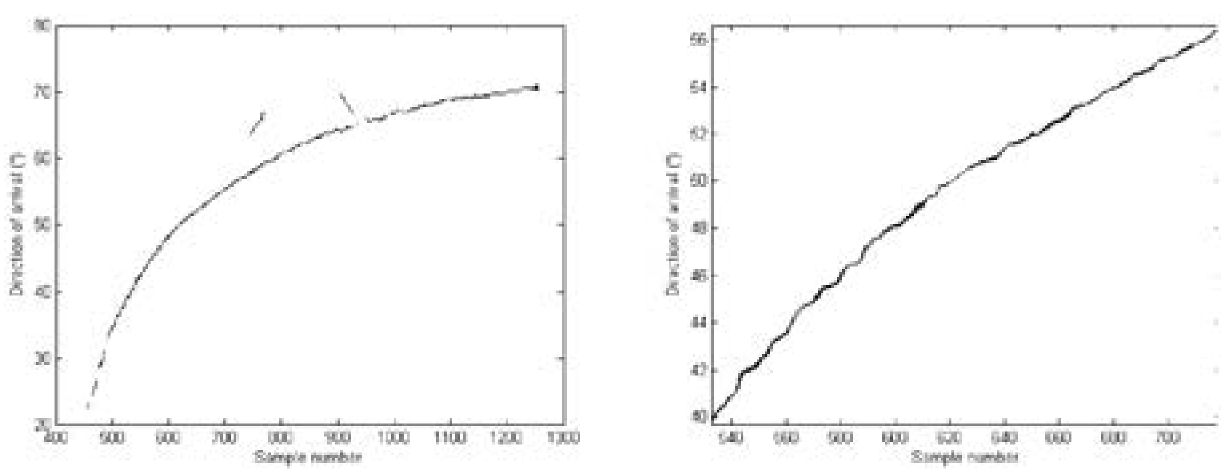


Fig.ure 3. Continuous DOA estimation throughout the range showing that the interferometric phase is continuous beam after beam.

takes values according to (1). This equation allows a continuous estimation of the DOA based upon the multilook.

Multilook techniques are based on the overflight of an area several times. So, the same information is acquired at different instants of time and in different environmental conditions. Then, it is possible to compare and to contrast among them. Concerning the sonar bathymetry, the beam aperture insonifies a seafloor section. For two close beams, there exists a common section illuminated by both that provides a similar information in terms of TOA and DOA. (1) introduces a relation that makes possible the continuous estimation of the DOA at the sampling rate
where k is the wave number, d is the interferometer spacing, and

$$\theta_a = \theta_s + \sin^{-1}\left(\frac{\Delta\varphi + 2\pi n}{kd}\right) \tag{4}$$

n=…,-2,-1,0,1,2,…

Fig. 3 depicts the DOA estimation for 41 beams formed between 25° and 65°. The angular beam aperture varies from 4° at 25° incidence to 10° at 65° incidence. This leads to a very high overlapping between beam footprints revealing a large amount of shared information. Therefore, it proves that the interferometric phase is continuous beam after beam, so it is needless to form hundreds of beams whereas between fifteen and twenty beams can provide the same information. Thereby, the spatial resolution is improved at the expense of an increase of the measurement noise level.

Once the interferometric amplitude and phase are analyzed, we study, in the following section, the reliability of the samples.

**Correlation coefficient**

The complex correlation coefficient statistically measures the degree of the relationship between two given sensors, that is, how closely two sensors are related. It is defined by the expected value of the inter-sensor cross product as follows

$$\gamma = \frac{< S_a S_b^* >}{\sqrt{< S_a S_a^* >}\sqrt{< S_b S_b^* >}} = \mu \ \exp(j\psi) \tag{5}$$

where <·> stands for the expected value of (·), μ is the coherence coefficient, and y is the phase of complex correlation coefficient.

In [5], Sintes introduces an acoustical model that fits the four sources of noise (ambient noise, angular and spatial decorrelation, and multipath impact) causing a loss of phase quality. Thus, the coherence coefficient between two sensors behaves as a good noise performance predictor. Indeed, it is shown, in Appendix B, that this coefficient is directly related to the variance; a high coherence value (normalized to 1) represents a low variance, and vice versa (see Fig. 10). So, for a given phase sample, it is possible to measure its statistical dispersion, i.e. its reliability. Determining the coherence coefficient of each phase sample creates confidence intervals where a minimal variance is ensured. An example will be shown in Section III-C where three confidence intervals appear (see Fig. 4b).

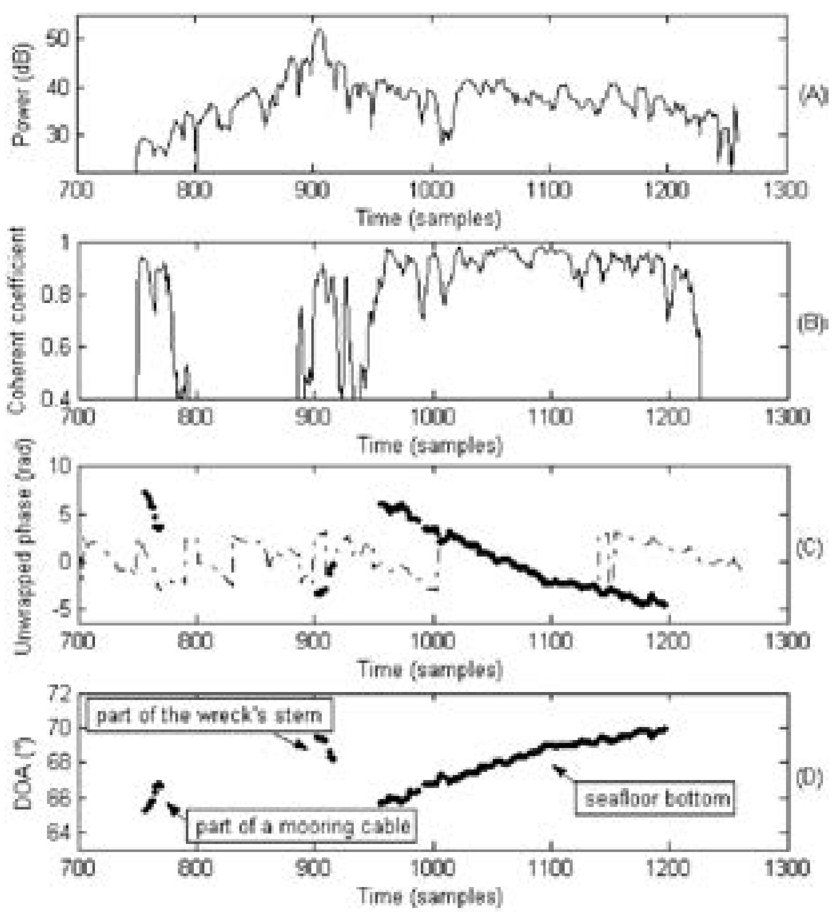


Figure 4. Example of how the algorithm works for a given beam at 68°: (a) backscattered power as a function of time; (b) coherence coefficient creating three confidence intervals; (c) phase difference (in dash-dot line) between receivers 26? apart, and (in solid line) unwrapped phase samples taken into account by the algorithm; (d) DOA estimation as a function of time.

## III. Algorithm basis

In this section, we introduce the proposed algorithm. In Section II-B, it is shown that the phase difference is continuous beam after beam. So, the proposed algorithm forms about fifteen beams providing the same number of soundings than forming hundreds of them. Besides, each phase sample will correspond to an individual sounding by using (4).

Hereinafter, we firstly deal with the 2π-ambiguity removal. Then, we consider the possibility to detect more than one target per beam. Finally, we report on the fusion of the three sources of information: the interferometric amplitude and phase, and the coherence coefficient.

**2π bias remove**

The main drawback of interferometry is its 2π ambiguity. Indeed, (4) arises the problem of estimating the value of n. By applying interferometry to the steered subarrays, the zero-phase instant defines the two-way propagation time of a target being in the interferometer axis. So, if the phase variation is limited to [-π,+π], n is zero during the phase ramp. Yet, as shown in Appendix A, the optimal baseline value in terms of minimal angular error turns out to be 2*L*/3, where L is the receiving array length. Under this configuration, the interferometric phase becomes ambiguous, and n may take other values rather than zero.

A first straightforward way to remove the ambiguity would be to detect those phase jumps around π. Unfortunately, since the coherence coefficient creates separated confidence intervals, no relationship of ambiguity may exist between the ±π phase jumps (see Fig. 4).

Here, we propose to carry out the Vernier method [5]. This method requires two pairs of sensors to remove the ambiguity. Each pair will provide a different phase difference, but the DOA is unique. Thus, (1) can be rewritten with respect to the setting the following relationship

$$\frac{\mathrm{mod}(\Delta\varphi_1, 2\pi)\lambda}{2\pi d_1}+\frac{n_1\lambda}{d_1}=\sin(\theta_a-\theta_s)=\frac{\mathrm{mod}(\Delta\varphi_2, 2\pi)\lambda}{2\pi d_2}+\frac{n_2\lambda}{d_2} \tag{6}$$

where di is the baseline of each pair. Then, n1 and n2 are selected so as to minimize the distance between the normalized phases. The advantage of using a multibeam echosounder rather than a sidescan sonar is that d1 and d2 can be set as required. The basic condition to properly perform the Vernier method is that , and their values depend on the Vernier efficiency [5]. In practice, the multibeam echosounder composed of several sensors is split into three subarrays according to the optimal configuration in terms of minimal angular error (see Section A). Thus, the first pair is composed of M/3 sensors, and the second pair of M/3+1 sensors, where M is the number of sensors composing the antenna.

Next, we report on the multitarget detection; we consider that more than one echo may reach the antenna for a given formed beam.

**Multitarget detection**

Bathymetric methods classically aim at detecting just one echo per beam. Yet, regarding a complex scenario such as a wreck, objects small enough can backscatter a part of the incident power and let the rest go through down to the seafloor. The echosounder will receive two wave fronts, the one from the object and a second from the seafloor. So, within the beam angular aperture, two echoes will reach the receiving array. However, classical methods will just process one, for instance, the most powerful one. Here, the proposed algorithm is intrinsically designed so as to detect more than one echo per beam if necessary.

In order to detect several echoes, we take advantage of the measurement noise properties. Indeed, classical data models consider that the noise has a zero-mean Gaussian distribution whose complex components are not correlated. Therefore, while no echo reaches the echosounder, only noise will be present, and the coherence coefficient μ will be low. Once any echo is detected, this coefficient will increase depending on the measurement quality. In practice, however, the electrical noise is highly correlated. In the following section, we deal with this problem.

**Multisource fusion**

The proposed algorithm reckons with three different sources of information: the interferometric amplitude and phase, and the coherence coefficient.

Firstly, for grazing beams, the maximum amplitude instant detection does not provide a very accurate estimation of TOA. Yet, it is a useful value as a landmark. Indeed, it detects the most reflecting target, but not necessarily the only one. An amplitude threshold is set defining the lower power above which a target will be taken into account.

Secondly, as shown in Section II-C, the coherence coefficient contains the statistical behavior of a phase sample; a high value implies a low variance, and probably a reliable sample. However, the electrical noise has a high coherence value, but its power level is quite weak, below the threshold introduced earlier.

Finally, the phase difference provides an estimation of the DOA. In Section II-B, we showed its continuity beam after beam. However, not all the phase samples contain useful information. To select them, two conditions will be required: a good coherence coefficient and a power level greater than the threshold. See that the electrical noise does not accomplish these requirements.

Fig. 4 depicts a multisource fusion example for a given beam steered at 68°. Firstly, the amplitude and the coherence

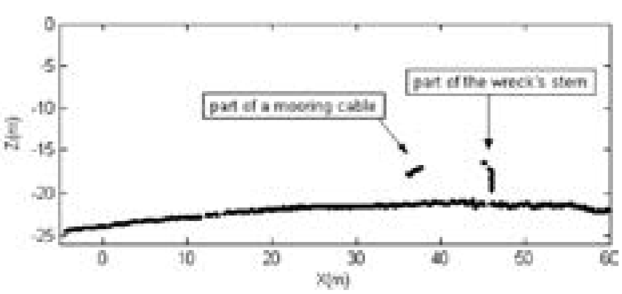


Figure 5. Multitarget detection of a part of a mooring cable and the edge of a wreck.

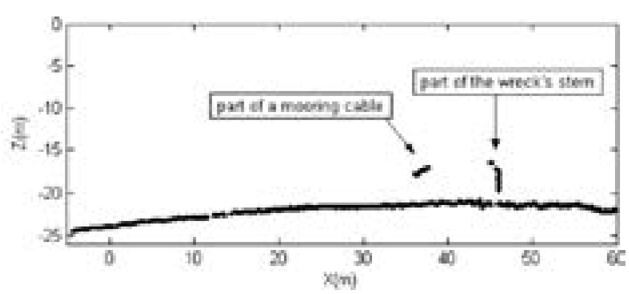


Figure 6. 29 consecutive pings showing the continuity of the mooring cable and the part of the wreck.

coefficient thresholds are empirically set at -25dB under the maximum amplitude, and 0.8, respectively, providing three confidence intervals. Next, the phase difference of each interval is independently unwrapped by means of the Vernier method. The differential phase is prefiltered, in this case, with an 8-sample length window in order to decrease the noise level. Finally, the DOA of each sample is estimated from (4) providing each one a bathymetric sounding.

Several issues from Fig. 4 should be pointed out. Firstly, see that among the three intervals, the most powerful is the one coming from the wreck's stern, and yet, it does not have the higher coherence coefficient. Secondly, note that the power backscattered by the mooring cable is about -25dB below the most powerful echo (the wreck), and about -10dB below the echo coming back from the same direction (the seafloor). Thus, this algorithm works beyond the classical -3dB width. Finally, a classical bathymetry method would just detect the wreck's stern, and would ignore the other echoes.

## IV. Experimentals results

The whole algorithm has been tested using real data recorded from a Kongsberg EM3002 300-kHz multibeam echosounder. Since the interferometry method does not perform properly well around the nadir, the maximum amplitude instant detection featured the estimation of the arrival time for beams between -15° and 25° with respect to the nadir. Beyond that, the interferometric phase was carried out. About 15 beams were formed between 25° and 72° providing about 350 independent soundings. The EM3002 sonar head was pointed about 40° to the side towards a wreck where the seafloor depth was about 25 meters from the sonar head.

Fig. 5 depicts an example of multitarget detection showing a portion of a mooring cable and the edge of the wreck's stern. Classical methods would not have detected the cable because of its weak backscattered power (see Section III-B). Concerning the stern, it would probably have been detected, but it would have left a shadow behind. In order to verify the existence of a cable, Fig. 6 depicts 29 consecutive pings revealing its continuity ping after ping from the top of the stern to the sea bottom.

Bathymetric methods usually select the type of detection (amplitude or phase) depending on a quality factor. The amplitude detection is mostly used for beams near nadir, and the phase detection elsewhere. Yet, one may happen to use the amplitude detection for grazing incidence beams when the two interferometric sensors do not provide a proper phase difference or when the backscattered power is very high. Regarding the second case, objects such as pebbles may backscatter a higher power than sand. Thus, the radiation pattern of a pebble may spread over several beams masking the echo coming from sand. As a result, beams aiming at sand will erroneously detect the more powerful scatter from the pebble. Fig. 7 depicts an example of a magnified pebble detection ('+' marks). Indeed, the TOA estimation of the last beams gets saturated at the same value. Instead, the phase detection provides a more coherent relief since its estimation basically concerns the time delay between two sensors, and the backscattered power just increases or decreases the quality of the estimation, but not its slope.

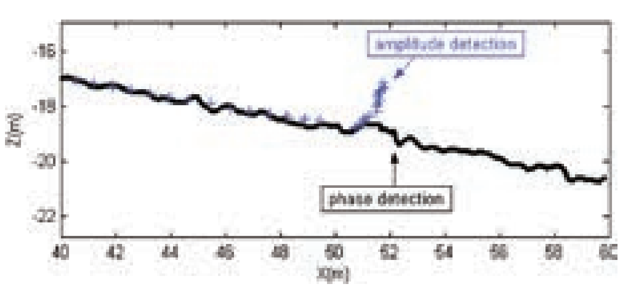


Figure 7. Example of an amplified relief caused by the maximum amplitude instant detection compared to the phase detection.

## V. Conclusion

In this paper, we introduce a new multibeam bathymetry processing. The following issues are discussed:

- We show that it is needless to form hundreds of beams whereas about fifteen or twenty beams are enough to provide a high-resolution DTM. In addition, in this way the computational time is reduced.
- Using wide baselines (2/3*L*) allows a better triangulation and decreases the angular error at the expense of an ambiguous phase difference. The Vernier method is carried out to deal with this.
- It is classically supposed that only one echo per beam is to be detected. Yet, if we ever aim at detecting small objects, a multitarget detection criterion should be reckoned with. An example is shown in Section IV detecting a mooring cable and the edge of the wreck's stern.

Future developments will deal with a phase tracking based upon the Generalized Sidelobe Canceller (GSC) [6][7], and a physical split array designed for an optimal interferometric performance.

**APPENDIX A**

**Derivation of the optimal baseline**

In this appendix, it is shown that the optimal baseline in terms of minimal angular error for classical bathymetric environments is 2/3 of the array length. The baseline defines the distance between the interferometer subarrays centers. We denote the subarray length ($L_s$) and the baseline ($d$) with respect to the array length as follows

$$L_s = (1-\alpha)L \tag{A.1}$$

$$d = \alpha L \tag{A.2}$$

The phase difference between two sensors is given by (1). Thus, the interferometric error can be expressed as

$$\delta\Delta\varphi = \frac{2\pi d}{\lambda}\cos\gamma\,\delta\theta_a \tag{A.3}$$

where $\gamma = \theta_a - \theta_s$. Then, the angular error is

$$\delta\theta_a = \frac{\lambda}{2\pi\alpha L\cos\gamma}\,\delta\Delta\varphi \tag{A.4}$$

The minimal interferometric error can be expressed by the following expression [8]

$$\delta\Delta\varphi = \sqrt{\frac{1}{\mathrm{SNR}}\left(1+\frac{1}{2\,\mathrm{SNR}}\right)} \qquad \text{(A.5)}$$

Concerning the receiving array, the output signal-to-noise ratio (SNR) is defined by the input SNR as follows

$$\mathrm{SNR} = \mathrm{SNR}_{\mathrm{i}} G_D \beta \qquad \text{(A.6)}$$

where $G_D$ is the theoretical nominal directivity gain, and b is a possible degradation coefficient. Then, $G_D$ can be written as a function of the array efficiency as follows [9]

$$G_D = \frac{4\pi S_{\mathrm{eff}}}{\lambda^2} = \frac{4\pi\eta\, l(1-\alpha)L\cos\gamma}{\lambda^2} \qquad \text{(A.7)}$$

where η features the aperture efficiency.
Let us define the following variables

$$\begin{aligned} A &= \frac{\lambda^2}{4\pi L\cos\gamma\sqrt{4\pi\beta l L\cos\gamma\,\mathrm{SNR}_{\mathrm{i}}}} \\ B &= \frac{\lambda^2}{8\pi\beta l L\cos\gamma\,\mathrm{SNR}_{\mathrm{i}}} \end{aligned} \qquad \text{(A.8)}$$

Then, inserting expressions (A.3)-(A.8) into (A.4), the angular error is given by

$$\delta\theta_a(\alpha) = \frac{A}{\alpha}\sqrt{\frac{1}{1-\alpha}\left(1+\frac{B}{1-\alpha}\right)} \qquad \text{(A.9)}$$

By minimizing (A.9), the optimal baseline value depends on $B$ as follows

$$\alpha_{opt} = \frac{5+4B-\sqrt{(1+4B)^2+8B}}{6} \qquad \text{(A.10)}$$

Note that for large SNRi (), the optimal baseline is

$$\alpha_{opt} = \frac{2}{3} \qquad \text{(A.11)}$$

Fig. 8 depicts the optimal baseline for Kongsberg EM300 and EM3002 multibeam echosounders. See that even in complex scenarios, the optimal value is about 2$L$/3, and from (A.1) the optimal subarray length is $L$/3. Note that practically bathymetric scenarios whose SNRi is below -20dB are not exploitable.

## APPENDIX B
### Interferometric phase statistics

This section deals with the statistical behavior of the interferometric phase. The singlelook and multilook cases are analyzed.

### Singlelook analysis

The information received by the two interferometric sensors can be modelled [8] by

Sensor 1: $\qquad S_a = x_a + j\,y_a = R_a \exp(j\varphi_a)$

Sensor 1: $\qquad S_b = x_b + j\,y_b = R_b \exp(j\varphi_b) \qquad$ (B.1)

where xi and yi are zero-mean Gaussian distributed, Ri has a Rayleigh distribution of parameter , and  is a uniform random variable distributed on the interval [-π,+π].

As the sum of independent, identically distributed scatterers are complex Gaussian distributed by the central limit theorem, the probability density function of the 2-component complex Gaussian vector S is [10]

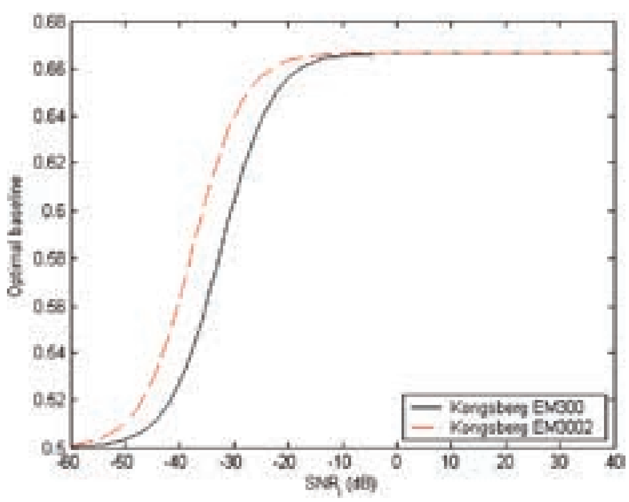


Figure. 8. Optimal baseline as a function of the SNRi for Kongsberg EM300 and EM3002 multibeam echosounders.

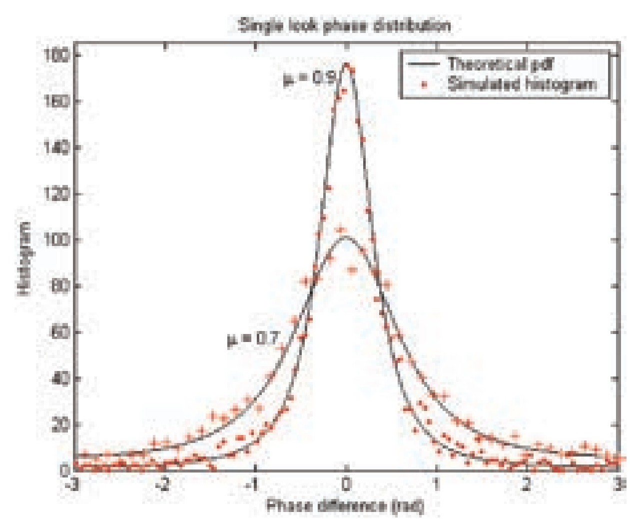


Figure 9. Comparison between the theoretical and simulated pdf of a singlelook distribution for _=0.7 and 0.9, and y=0.

$$P_S(S) = \frac{1}{\pi^2 \, |K|} \, \exp\Big\{ - S^* K^{-1} S \Big\} \qquad \text{(B.2)}$$

where $S = [S_a \; S_b]^T$, $K$ is the covariance matrix of $S$, $|\cdot|$ is the determinant of $(\cdot)$, and $(\cdot)$T and $(\cdot)$* represent the transpose and the conjugate transpose of $(\cdot)$, respectively.

The singlelook phase distribution [8] is expressed as

$$P(\Delta\varphi) = \frac{1-\mu^2}{2\pi}\left[\frac{1}{1-Y^2} + \frac{Y}{(1-Y^2)^{3/2}}\left(\frac{\pi}{2} + \sin^{-1}(Y)\right)\right] \qquad \text{(B.3)}$$

where , $Y = \mu \, \cos(\Delta\varphi - \psi)$, $\mu$ is the coherence, and y is the phase of the correlation coefficient. Fig. 9 depicts the phase difference singlelook distribution for $\mu$=0.7 and 0.9, and $\psi$=0. It is shown that as the coherence coefficient increases, the distribution gets sharper and narrower centered around its mean.

Finally, the singlelook variance is given by [11]

$$var(\Delta\varphi) = \frac{1-\mu^2}{1-\mu^2\cos^2\psi}\left\{\frac{\pi^2}{4} - \pi\sin^{-1}(\mu\cos\psi) + \left[\sin^{-1}(\mu\cos\psi)\right]^2\right\} + \frac{1}{2}\sum_{i=1}^{\infty}\frac{1-\mu^{2i}}{i^2} \qquad \text{(B.4)}$$

where $\mu$ and $\psi$ are defined by (5). Note that both pdf and variance depend on the coherence coefficient.

**Multilook analysis**

Taking

$$Z = \frac{1}{N}\sum_{k=1}^{N} S_a^{(k)} S_b^{*(k)} \qquad \text{(B.5)}$$

the multilook phase difference is defined as

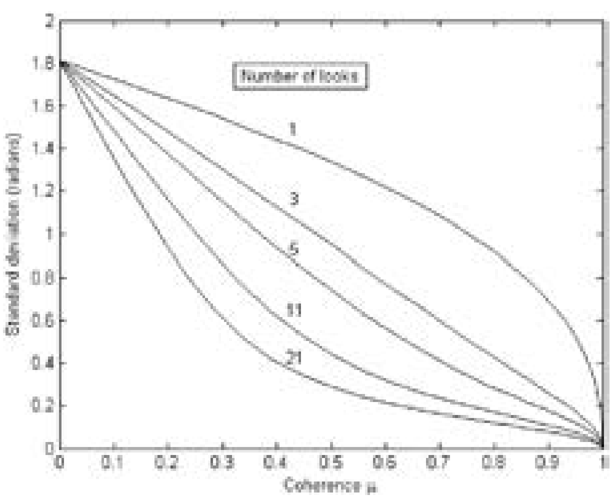


Figure 10. Theoretical standard deviation of the interferometric phase as a function of the coherence coefficient _ for N=1, 3, 5, 11, and 2, and y=0.

$$\Delta\varphi = arg\Big\{Z\Big\} \qquad \text{(B.6)}$$

In [11], Oliver presents an expression involving a finite summation based upon the characteristic function in the Fourier transform domain. The marginal pdf is

$$P(\Delta\varphi) = \frac{(1-\mu^2)^N}{2\pi}\left\{\frac{(2N-2)!}{[(N-1)!]^2\, 2^{2(N-1)}} \cdot \right. \times \left[\frac{(2N-1)Y}{(1-Y^2)^{N+1/2}}\cos^{-1}(-Y) + \frac{1}{(1-Y^2)^N}\right] + \frac{1}{2(N-1)} \times \left.\sum_{r=0}^{N-2}\frac{\Gamma(N-1/2)}{\Gamma(N-1/2-r)}\,\frac{\Gamma(N-1-r)}{\Gamma(N-1)}\,\frac{1+(2r+1)Y^2}{(1-Y^2)^{r+2}}\right\} \qquad \text{(B.7)}$$

where, $Y = \mu\cos(\Delta\varphi - \psi)$, $N$ is the number of independent snapshots, and stands for the gamma function.

An analytical expression of the multilook variance has not been derived in a close form. Yet, Fig. 10 shows the numerical result using (B.7). As expected, the variance decreases as the number of looks or the coherence coefficient increases.

## Acknowledgment

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# US/EU-BALTIC INTERNATIONAL SYMPOSIUM 2006: SUMMARY REPORT

***Joseph R. Vadus, Symposium Co-Chairman***
***Vice President, Oceanic Engineering Society***
***Institute of Electrical and Electronics Engineers***

This second US/EU-Baltic International Symposium was successfully conducted in Klaipeda, Lithuania May 23-25, 2006. The first was successfully held in Klaipeda in 2004. The plan is to continue this series in the Baltic every 2 years. The symposium was sponsored by: Lithuania's Ministry for the Environment and its Center of Marine Research; The National Oceanic and Atmospheric Administration (NOAA); The US Office of Naval Research Global, centered in London; The Institute of Electrical and Electronics Engineer's (IEEE), Oceanic Engineering Society; and supported by Klaipeda University, Kaunas University of Technology and Vilnius University, all in Lithuania; and the University of Delaware in the U.S. Participating sponsors were Dr. Richard Spinrad, Assistant Administrator for Research at NOAA, and CDR. Eric Gottshall, Associate Director for Space, Land and Ocean at ONR Global. Our sponsors greatly insured having a meaningful program.

## INTRODUCTION

The theme of the Symposium was "Integrated Ocean Observation Systems (IOOS) for Managing Global & Regional Ecosystems". IOOS is the ocean component of the Global Earth Observation System of Systems (GEOSS), a high priority topic of over 60 nations. Over 140 papers were presented by authors from over 20 nations, and provided an excellent forum for exchange of research information and promotion of international cooperation. Many papers discussed the problems of natural and man-induced hazards, including oil pollution and the many hazards caused by the thousands of tons of munitions of all kinds that were dumped after World War II. These include chemical weapons that are slowly deteriorating and exposing highly toxic chemicals to Baltic fisheries resources and endangering environmental health. Oil pollution from tankers and drilling platforms is a major concern in accidental spills. There were papers on potential oil spills, and discussions of the controversial offshore drilling platform D-6 producing oil about 20 km from Kaliningrad and Lithuania's southern tip of the Curonian Spit, a World Heritage Site. Neighboring countries, Latvia and Estonia, are especially concerned. Pollution transported by river outflow into the sea is another topic of great concern. Baltic Nations are aware and their Research Centers continue monitoring to detect, control and mitigate risks. Integrated ocean observations provide a major role by providing data and information to assist in cooperative efforts in dealing with such problems.

The Symposium began with three Opening Addresses, followed by eleven invited papers presented in two plenary sessions. On the second day, an excursion was made to the rapidly developing seacoast resort, Palanga, and to the seaport of Klaipeda, A visit by the US Navy Oceanographic Ship USNS HENSON (T-AGS-63) was planned but cancelled a few days before because of unexpected delays due to severe weather near Portugal. The Russian Oceanographic Ship PROFESSOR SHTOKMAN, based in Kaliningrad nearby was able to come to the Port of Klaipeda for the first time by a Russian Ship. Dr. Vadim Paka Director of the P.P. Shirshov Institute of Oceanology arranged the Russian visit, offered a tour of their ship and hosted an informal reception on board. The reception sponsored by the U.S. Embassy and Navy, that was planned to be on board the U.S. ship, was transferred to the hotel.

The Baltic Ocean Observation Systems (BOOS) Group, led by Dr. Erik Buch, Head, Centre for Ocean and Ice, Danish Meteorological Institute held their Annual Meeting in Klaipeda on May 22, the day before the Symposium began. The BOOS Group includes members from the nine nations bordering the Baltic Sea and they are major contributors to the Integrated Ocean Observations System concept. Their strategy 2004-2010 is further integration of operational oceanography activities in the Baltic Sea to enable BOOS to provide an integrated service to marine users and policy makers in support of safe and efficient offshore activities, environmental management, security, and sustainable use of marine resources.

The writer summarizes below, some highlights of the symposium's 140 papers, and edits, paraphrases and abbreviates information provided by and credited to the authors. However, the writer does not necessarily endorse all highlights reported. The writer encourages readers to refer to the proceedings for the full text of the papers.

## OPENING ADDRESSES

In his opening address, Thomas P. Kelly, U.S. Charge d' Affaires at the U.S. Embassy in Vilnius stated that the best way to face complex challenges - controlling oil spills, protecting marine ecosystems, improving navigation and transportation, and enhancing global security on our seas - is through international cooperation The experience and insights gained in one region help provide solutions to problems in another. Consider the following: Scientists at the U.S. Geological Survey note that nutrient deficiencies and mortality in salmon in the Great Lakes and New York are similar to those in the Baltic Sea, a condition brought on by the abundance of invasive species in the salmon's diet. The abundance of nitrates and phosphates in the agricultural runoff of the Nemunas river basin and Curonian Lagoon are caused by the same activities that plague California's San Francisco Bay-Delta region and other areas in the United States. Petroleum spills remain a constant threat to natural and cultural resources around the world. U.S. scientists, government specialists, and policymakers benefit from their extensive and ongoing cooperation with all the countries represented here. Lithuania stands out, thanks to the work of a handful of talented individuals at the U.S. Environmental Protection Agency back in the 1970s. The group at EPA, led by a Regional Administrator named Valdas Adamkus, recognized the U.S. Great Lakes system has much in common with the Baltic Sea. He and his colleagues saw an opportunity to work with Lithuania, even though it was then occupied by the Soviet Union. The program they pioneered brought scientists together to solve common problems. Following the restoration of Lithuania's independence, research continued under the Great Lakes-Baltic Sea Partnership program, with exchanges of technical expertise and personnel. The program officially ended some years ago, but the partnerships continue. And that EPA guy named Adamkus enjoyed the exchanges so much that he engaged in an exchange of his own and became Lithuania's President. The United States aims to develop new partnerships with Lithuania in its role as a NATO ally, an EU member, and great friend of the United States. In the coming weeks, we will sign a new bilateral agreement that will enhance and facilitate science and technology cooperation between the U.S. and Lithuania. The U.S. Government's Fulbright exchange program is active in all of the Baltic countries and offers an exceptional vehicle for exchanging graduate students and accomplished academics between our countries. For example, Dr. Victor Klemas, a Fulbright Scholar from the University of Delaware, has played an important role in planning this conference while teaching at Klaipeda University. The United States views the advancement of science and technology, and international cooperation as a key to our future as a society. (Thomas P. Kelly, U.S.A.)

In his opening address, Lithuanian Deputy Minister of the Environment, Rytis Sadkauskas, stated that it is gratifying to know that an event of such a high level was organized here in Lithuania, and this fact demonstrates Lithuania's contribution to the science of the ocean and the sea. The Baltic Sea is one of the youngest seas in the world, and, its evolution has undergone changes, which have been influenced by human economic activities, and by more rapid exploitation of natural resources. Lithuania governs the smallest part of the sea area of all the Baltic States, just 92 km of the coast. However, this part of Lithuania is well known for its unique nature, it is distinguished by great biological variety and rich biological resources. It is abundant in fish spawning areas and, various routes of fish migration pass through it. The biggest part of the Lithuanian coastal zone belongs to the Curonian Spit, which UNESCO included as a World Heritage Site. Unfortunately, one of the biggest problems in the Baltic Sea is contamination by oil and its products, which causes tremendous damage to the environment, and disorganizes behavior of ecosystems. More intensive cyclonic activity and rising sea level due to the global climate changes, receding sand supplies in the coastal zone and intensive human economic activity have made the processes of shore destruction more active in Lithuania and all over the world. One of our most important aims today is to coordinate the expansion of marine industry, rational exploitation of marine resources and conservation of the environment. In order to implement effective and balanced policy of the environment protection, an important role is allocated to the information about the environment. Therefore, environmental research and complex monitoring is one of the main parts of the environmental protection system, the main aim of which is to present information about the environment and its changes. It should be noted that the monitoring of the Kurshiu Marios (Curonian Lagoon) and the Baltic Sea Ecosystem still maintains a relatively high potential of biological self-purification to overcome the anthropogenic burden. (Rytis Sadkauskas, Lithuania).

A third address was presented by Dr.Zenonas Rokus Rudzikas, President, Lithuanian Academy of Sciences, who gave a broad overview of global perspectives in science and technology and social and environmental concerns. Science and technology is well advanced in the developed nations in Europe compared to the smaller countries recently incorporated in the EU. Most of the large scientific laboratories are in the original EU. Small countries such as the Baltic States, must participate in a cooperative way through small grants. The EU is spending about I billion euros per year for the next seven years and countries like Lithuania must compete with proposals and demonstrate a high degree of excellence. There seems to be a wide gap in funding between basic science research and applied research. This wide gap exists in the U.S. as well. To get more National funding perhaps more attention should be given to applying the basic research to meet some of the taxpayer's applied research needs. The U.S. Massachusetts Institute of Technology is a good example of effective results of applied research. When considering a Lithuanian Institute of Technology there isn't much support given for applying basic research to produce advances in technological needs. Such an institute is not envisioned in the near future. Lithuania must upgrade scientific and technical facilities and make use of emerging technology. There is need for globalization not only in science and technology, but also in education and training. The English language is being universally adopted in international science and technology activities. Considerable demographic and statistical data was presented to support the findings. (Z.R. Rudzikas, Lithuania).

## SYMPOSIUM PROGRAM

### U.S. IOOS Program

The Administration's response to the U.S. Commission on Ocean Policy is the U.S. Ocean Action Plan that provides the priorities for ocean and coastal resources. Among those priorities is building the Global Earth Observation System of Systems (GEOSS), including the ocean and coastal component of the Integrated Ocean Observing System (IOOS), with U.S. leadership by NOAA. The cabinet level Committee on Ocean Policy and the Interagency Committee on Ocean Science and Resource Management Integration have been established, and approved the first U.S. IOOS Development Plan which represents the interagency priorities and plans for the coastal component of the U.S. contribution to IOOS. An Interagency Working Group on Ocean Observations is being established through the Ocean Action Plan governance structure. This working group will be specifically concerned with the interagency management and coordination of IOOS, through a governance structure of Regional Associations designed to meet specific regional requirements and needs coupled with a national backbone of critical observations. Common data management standards and protocols will enable interoperability of regional and national observing systems. Implementation of the global component includes maintaining space-based observations of sea surface temperature), sea surface height, surface vector winds, ocean color, and sea ice; increasing spatial resolution of key in situ observations; and continuing the implementation of in situ observations Priority enhancements for the coastal observing components include increases in spatial and temporal resolution of the existing systems, as well as augmentation of existing platforms with oceanographic sensors. An established network of Regional Coastal Ocean Observation Systems will provide observations, models, and products for regionally-unique user requirements. (R.W.Spinrad, U.S.A.). Other U.S. papers by T.Malone, W.Nowlin and A.Clark reaffirmed the management structure and Action Plan.

**EuroGOOS – a GOOS Regional Alliance**

EuroGOOS is an Association of Agencies, founded in 1994, to further the goals of GOOS, and in particular the development of Operational Oceanography in the European Sea areas and adjacent oceans. EuroGOOS is established with full recognition of the importance of existing systems in operational oceanography and research in Europe at national and regional scales. EuroGOOS now has 33 Members in 17 European countries. Members of EuroGOOS co-operate to establish a concerted European approach to the identification of European priorities for operational oceanography, promoting the development of the science and technology for operational oceanography, and its implementation, assessing the economic and social benefits from operational oceanography. The available resources and the knowledge of user requirements mainly exist at the member agencies and their partners. Due to the user requirements and for practical reasons harmonisation, integration and co-production are best addressed regionally. Through regional task teams EuroGOOS has established and continues to build regional operational oceanographic systems, such as the Baltic Operational Oceanographic system (BOOS), and the European Northwest Shelf System, NOOS. At present relevant parts of the national/regional systems are co-ordinated into a European network that aims to support the pan-European and global requirements. (H.Dahlin, Sweden)

**Industry Role in IOOS**

The National Office for Integrated and Sustained Ocean Observations (referred to as Ocean.US) is a federal interagency planning office sponsored by 10 U.S Federal Agencies: to develop a National capability for integrating ocean observations and predictions to meet research and operational needs and to serve as a National focal point for relating U.S. ocean observing system elements to the Global Ocean Observing System (GOOS);both components of Global Earth Observation System of Systems (GEOSS). The goal is the establishment of the U.S. Integrated Ocean Observing System (IOOS), comprising both a global scale ocean component as well as a regional/local scale coastal component. It includes space-based as well as in situ observations which are fed into a data management system to ensure that they are interoperable and networked. The information produced from IOOS includes long term, large scale climate-related phenomena such as sea level rise and El Niño/Southern Oscillation (ENSO), as well as shorter term, smaller scale events such as storm surge, flooding and its coastal inundation impacts. Private companies will play a critical role. Early attention to configuration management is particularly important since it is essential that IOOS nests seamlessly within the greater GEOSS architecture. Industrial firms have already been retained to begin developing Architecture that is both consistent with GEOSS as well as with all the myriad federal and local governmental bodies. Industrial partners will be both IOOS providers as well as its end users. (A. Clark, U.S.)

**The NW European Shelf: NOOS 2002 -2006**

The NW Shelf Operational Oceanographic System, NOOS was established in September 2002, and membership of NOOS has grown to 14 agencies with responsibilities ranging from ocean monitoring to ocean forecasting, and four associate research institutes. All the coastlines of the European north-west shelf seas are represented. NOOS works through networking to establish collaborative, incremental developments to the day-to-day business of the member agencies. Members of NOOS are active in various GMES Service Element projects, as well as routinely providing national services such as storm surge forecasts, oil spill drift forecasting and harmful algal bloom warning. NOOS Projects include data exchange for sea level observations, storm surge forecast exchange, co-operation on 3D forecast modeling, contributions to the ICES-EuroGOOS North Sea Pilot Project for nowcast ecosystem modeling, exchange of calculated modeled transports, and bi-lateral developments to provide robust and resilient backup for storm surge forecast modeling. (M.Holt, United Kingdom)

**Naval Oceanography**

The U.S. Naval Meteorology and Oceanography Command assesses and predicts the wold’s most challenging operating environment and its impact on global military defense operations. A number of significant recent developments have led to a new vision for Naval Oceanography, incorporating Numerical Ocean Prediction as a key component. Ocean remote sensing and real-time, in-situ data collection capabilities are expanding rapidly. Local and remote data can now be communicated rapidly for central site processing, application, and product distribution. The computational capability to assimilate these data into globally-relocatable high-resolution ocean prediction systems and to produce tactically-relevant ocean prediction products in near term has become an operational reality. (E.Gough, U.S. A.)

**Hazardous Material**

About 1000 battleships and civil vessels sunk in the Baltic Sea during the World War II, more than 300 of them belonged to the Soviet Union. Every sunken vessel might have been carrying military cargo. So, all the unexplored shipwrecks present a potential hazard to the marine ecosystem and its inhabitants. Russia proposes to draw up a Register of potentially hazardous underwater objects, in particular all the vessels, which might have more than 300 kg of ammunition. Searching and exploration of the known sunken vessel is the task proposed by the joint team of Shirshov Institute of Oceanology in Kaliningrad and the Russian Federal Ministry of Extraordinary Situations, and their collaborators. Two surveys were already performed; the first one in the Russian waters in the Finnish Bay (2004), then nearby the Kaliningrad shore (2005). The next survey is planned for 2006 also in Russian waters in the SE Baltic. The tasks include searching, inspection, sampling nearby waters and sediments, analysis of chemical agents, and listing in the Register. Surveys have noted that coordinates of wrecks for some regions were incorrect, and should be continued in much wider areas, and inspection should be repeated more carefully. The same refers to low oil products, phenol, arsine, and chemical agents in water and sediments. Dumpsites in Skagerrak, in 2000, and in the Bornholm Deep, in 2001, found both shipwrecks and chemical indications of the presence of toxic species. (V. Paka et al, Russia)

Recent advances in technology developed by Underwater Ordnance Recovery Inc. have provided a completely new approach to the remediation of unexploded ordnance using a sea floor based platform, of the “Underwater Ordnance Recovery System” which is lowered to the work site. The platform uses a closed circuit hydraulic system to power a boom and grapple, which loads items into a recovery basket for retrieval and disposal. The entire operation is controlled via wireless closed circuit TV from an operator on the surface. It is designed for continuous operations in depths in excess of 60 m and can lift objects in excess of 900 kg close in. This system was successfully tested in Key West Florida. (J. Barton, U.S.A.)

The geo-ecological conditions in the water column and in the bottom sediments are studied in the following areas of the Baltic Sea: in the Curonian and Vistula lagoons, in the mouths of rivers Neman, Pregel, Deima, near seaports, in the area of the oil-platform D-6 in the Gdansk Basin, in the areas of dumped chemical munitions in the Bomholm Basin and in the areas of the proposed laying underwater gas and cable and pipeline routes (1000 stations). The content of more than 15 macro-components and trace metals (including As, Pb, Cu, Cd, Hg, Ba) and C, N, P in the surface layers and in the cores of the bottom sediments were determined. Bottom sediments, which are polluted by arsenic, are found in the following places:

- areas of the dumped chemical munitions in the Bornholm Basin;
- areas where sandy-gravel mixture, enriched by the iron sulfides,was dumped
- near-mouth areas of the South-Eastern Baltic.

The increased contents of As and Ba in the bottom sediments are determined in some places of the Gdansk Basin near the oil-platform D-6. But the contents of these elements in the bottom sediments in all cases were lower than the values, which are limited by Russian standards. (E. M. Emelyanov, V.A. Kravtsov, Russia).

**Environmental Monitoring The D-6 Oilfield**

The necessity for environmental monitoring in the process of oilfield facilities construction and operation was determined by the acting legislation and international commitments of the Russian Federation. In 2003 the Russian program for the Environmental Monitoring the Kravtsovskoe D-6 oilfield agreed with the nature management bodies developed by “LUKOIL-Kaliningradmorneft” Ltd. The Major participants were the Atlantic Branch of the P.P. Shirshov Institute of Oceanology of the Russian Academy of Sciences and LUKOIL, both of Kaliningrad. The major result of their monitoring program in 2003-2005 is the conclusion, that D-6 oilfield development at all stages (construction, drilling, and oil extraction) had not caused marine environment pollution. Oil products in the waters near the offshore ice-resistant fixed platform were at the natural background level. Occasional oil pollution was observed in some locations of the monitoring area. Most often it occurred in the zones of high hydrodynamic activity close to the Sambian -Curonian Plateau (between the platform and the Curonian Spit), and off the Taran Cape. Out of other controlled indices of water pollution in the local and regional monitoring areas neither significant maximum permissible concentration exceeding has been revealed. Variations of all controlled substances concentration were within the seasonal natural limits. The bottom sediment pollution with heavy metals (Cd, Cu, Pb, Cr, Ba, Hg) wasn’t defined. ( O.E.Pichuzhkina,V.V, Sivkov et al., Russia)

This work presents characteristic of zooplankton in the region of the industrial marine environmental monitoring of oilfield “Kravtsovskoe” (D-6) in the south-eastern Baltic Sea in the period from May 2003 to October 2005. The paper based on the data of the 11 expeditions on the R/V PROFESSOR SHTOKMAN, conducted within the approved program of “LUKOIL-Kaliningradmorneft” Ltd. In all seasons of 2003-2005 in Russian waters of the south-eastern Baltic. The taxonomic composition, structure, abundance and biomass of zooplankton in different seasons of the year were investigated. Copepods and rotifers formed the base of the zooplankton community in this region. Abundance and biomass of copepods reached up to 98-99% of total values. In summer, the ratio of rotifer abundance and biomass in some cases reached up to 94% from total abundance and 70% from summary biomass. The quantitative characteristics of zooplankton have shown a high inter-seasonal and inter-annual variability mainly depending on temperature conditions. Any negative tendency in zooplankton related to anthropogenic influence was not revealed. (Shchuka T. A, Russia)

Arsenic occurs as a constituent in many of the chemical weapons dumped into the Baltic Sea; it can be used as an indicator of leakage and dispersal of released munitions to the marine environment. Total arsenic was analyzed in sediment samples taken from the Lithuanian Economic Zone in the Baltic Sea, which included samples from the chemical munitions dumpsite in the Gotland Basin and national monitoring stations in the southeastern Baltic Sea. Arsenic concentrations in sediments ranged from 1.1 to 19.0 mg kg'1 with an average of 3.4 mg kg'1. Although there was evidence of slightly elevated arsenic content in sediments near the weapons dumpsite, arsenic concentrations were nevertheless quite low relative to other investigations in the Baltic and North Seas. (G.Garnaga, A Stankevicius, Lithuania; E.Wyse, S. Azemard, S.de Mora, Monaco).

**Tosmare Canal in Latvia**

Sediment samples were collected from the Tosmare Canal in Liepaja, Latvia over the course of two years. PAHs were extracted from sediments and analyzed by gas chromatography-combustion-isotope mass spectrometry. At least three separate sources of hydrocarbon contamination within the canal were found. Some sources varied only slightly over time. Given the relatively small tidal energy in the system, it was hypothesized that either new sources of PAH settle over time in Tosmare, or that mobilization and re-deposition of existing sources has occurred. (J.Boyd et al., U.S.A.)

**OCEAN OBSERVATION SYSTEMS SUMMARY***

In the US, there is a National Program and Regional Coastal Observing Systems approaches to IOOS include 10 Large Marine Ecosystems in the US EEZ (there are 64 globally) that couple to Regional Associations.

The Great Lakes Observing System addresses a watershed about half the size of the Baltic Sea and has a number of other similarities including populated cities, shallow depths in places, and the societal needs of transportation, emergency response to disasters, education and outreach to its neighbors.

The Gulf of Mexico Coastal Ocean Observing System includes an even larger area that has recently been devastated by hurricanes. If the benefit of a GCOOS plan is calculated at 1% of the value at risk, this is a powerful economic argument for moving forward.

Gulf of Maine Ocean Observing System, GoMOOS raises funds from business members but obtains most funding from agencies, state and federal. It provides data from buoys that are in demand by lobster fishermen and surfers as well as super users.

SeaCOOS in the southeast provides continuous coverage of value to three types of users: super users who mine the data and do research with it; regular users who get some raw data but mostly like tailored products; and general beneficiaries who get the information from TV.

State concerns in New Jersey are focused on hypoxia events. HF radar systems cover the coast at several scales to continuously observe surface currents and feed the model. To extend from the radar surface currents to hypoxia related ocean properties, gliders have been added and these autonomous, self-propelled vehicles, patrol regions when ships are not available.

International Coastal Observatories are illustrated by the Liverpool Bay Coastal Observatory including volunteer ship observations, gliders, radar, and moored sensors data are fed into models and provide horizontal coverage. The web site is critical and heavily used.

Total coastal coverage by HF radar is close to becoming a reality in the east coast of the US from Cape Hatteras to Cape Cod. Data are used by the weather service, by search and rescue, and by power companies who can be warned about power purchase contract buys when the sea breeze is predicted to fail and air conditioner demand will increase. (* summarized by A. Williams, U.S.A.)

**BENTHIC AND OTHER OBSERVATIONS SUMMARY***

Methane hydrates, rich fuels, form on the seafloor in the Gulf of Mexico, and many other places where methane and propane bubble up from thermogenic sources in sediment 10's of meters to 100's of meters thick. Given the appropriate gas composition, hydrocarbon hydrates could occur in the Baltic Sea. Center for Marine Resources and Environmental Technology uses instruments to measure temperature and gas flow, water percolation, and other variables for an extended period. Data are periodically dumped from an in situ data logger. This is an example where an observatory with continuous coverage enables research on processes.

Underwater imaging as an observational tool to monitor coral and fish swimming in the foreground can be enhanced digitally. Then the fish can be discriminated and even identified by specie in some cases by texture. This is a low impact technique applied to a reef in Mauritius

Metals, particularly copper and arsenic, are associated with poor flushing of contaminants in the Baltic, present in the basins and the southern parts of the lagoons, sometimes to 50 times the background concentration. Bioturbation, present in lagoons, is absent in the basins, presumably devoid of macro-biota.

Coastal beach erosion is a concern in Lithuania, particularly in Palanga where it has been great since destruction of a bridge/groin structure to a promenade offshore in a storm in 1999. Wave models have been applied and also scenarios of remediation analyzed and even tried. Reconstruction of the groin helped to the south as did beach nourishment but erosion continues to the north. The sand seems to want to go to Latvia.

The situation in coastal Louisiana is serious as well with loss of sediment and increased vulnerability to hurricanes from loss of the barrier at the coast. Total ecological tests of remediation plans are now applied and tested in 700 stations of 13 ecological types of environment

Acoustic techniques can monitor underwater meadows rapidly, compared to diving. In Puck Bay, Poland, the reduction of such meadow in the last 20 years is observed by echo sounder and side scan sonar survey. Understanding the acoustic scattering characteristics of the grass is needed to obtain species data as well as coverage but much progress has been made in monitoring the meadows. (*summarized by A. Williams, U.S.A.)

IOOS provides a reliable prospect for establishing reliable estimates of important fluxes. The primary mechanism is the calibrated and validated numerical forecast model assimilating data from the watershed, estuary, and continental shelf. The model's ability to assimilate serial shipboard data as well as continuous, autonomous sensor data improves the ability to measure nutrients, chlorophyll, oxygen, and other important biochemical constituents gives promise that flux measurements will become routine. The Chesapeake Bay represents the case of an urban estuary with a developing observing system. The recent expansion of the Chesapeake Bay Observing System (CBOS) beyond the confines of single institution and beyond the research community has provided a significant boost to the cooperative effort necessary to provide the required flux estimates. (W.C. Boicourt, U.S.A,)

**REMOTE SENSING SUIMMARY****

Oil detection is effectively done by radar. However, by using different polarizations of the radar waves, one can further improve the detectability of the oil slicks. Furthermore, oil slicks and water have different noise signals, and even that should be investigated for distinguishing oil slicks from other types of slicks.

Ocean color provides a good indication of productivity for the open ocean. However, in turbid Case 2 coastal waters, dissolved organics and suspended sediments make it difficult to detect the suspended and dissolved products in the water column. Therefore hyperspectral techniques, neural networks and better atmospheric correction approaches need to be further investigated.

Remote sensing is an important tool for coastal management and disaster response. Satellite and aircraft imagery was actively used in planning the rescue of flood victims during hurricane Katrina. Of particular interest are remote sensing techniques for detecting coastal changes in wetlands and land cover. One approach holding much promise uses biomass change as an indicator for coastal land cover change.

Studies of the Port of Klaipeda indicate that by making small improvements the physical security of the port could be improved significantly. Port security and management must concern itself not only with physical security, but also with environmental security. Planning is underway to develop industries in the port of Klaipeda which will be environmentally sound, minimizing the amount of waste created. (** summarized by V. Klemas, U.S.A.).

**Environmental Monitoring**

Seatrack Web is a fully operational oil drift forecasting system and it covers the Baltic Sea and part of the North Sea. The drift model calculates the three-dimensional movements of substances or objects at sea, including sinking, stranding and turbulent dispersion. For oils, the evaporation, emulsification and wave-induced vertical dispersion are also calculated. Drift trajectories can also be run in the backtracking mode, indicating the source of an object or spill. Primary users are oil combating authorities in the countries surrounding the Baltic Sea. Seatrack Web 2.0 provides many new GIS layers, and is more user friendly. Automatic Identification System is introduced into the system in order to more easily find illegal polluters. (C. Ambjorn, Sweden) In January, 2005, a severe storm hit the Baltic Sea region. Estonian towns Parnu and Haapsalu were flooded with storm surge waters with considerable damage and economic loss. Due to the BOOS cooperation, numerical forecasts became available and they were convincingly much more accurate than the forecasts made by traditional methods. Advantages of modern operational oceanography were clearly demonstrated and Estonian Centre of Environmental Investments launched a project to establish BOOS/ HIROMB-based marine forecasts in Estonia. Special attention is given to the validation of forecasts and the need to apply local VHR forecast models that are linked to the Baltic-wide operational system.(J. Elkcn et al., Estonia)

The coastal sea of the southern Gulf of Finland is under heavy anthropogenic stress due to the development of harbors and the increase of ship traffic. During dredging operations, the increase of suspended particulate matter (SPM) concentration in the seawater is inevitable and water transparency diminishes worsening underwater light conditions This is a negative effect on the growth of benthic macroalgae, which is an indicator of water quality in the coastal zone. Monitoring of SPM transport and distribution along with the estimation of dredging impact on marine environment is crucial especially when sensitive and critical marine areas are close to a dredging site. The monitoring system combines satellite remote sensing, measurements, and numerical modeling. (T. Kouts et al, Estonia)

The Curonian Lagoon is a large shallow coastal water body between the Curonian Spit and the Lithuanian Coast. The average water level in the lagoon is mostly higher compared to sea level, and it flows into the Baltic Sea. Its ecosystem is influenced by fresh and saline water masses. A characteristic feature of the lagoon is high bioactivity and the mixing of salty marine water and fresh river water. The water salinity data of the Curonian Lagoon were retrieved from the national monitoring data for the period of 1961-2004 to determine salinity distribution and its variation in the course of time and forecasting the chemical regime in respect to variation and spreading tendencies. The saline marine water rise into the lagoon is caused mainly by stronger winds of western and northern directions forming a water pile-up near the southeastern coast of the Baltic Sea and marine water flows into the lagoon through the Klaipeda Strait. Salinity increased in the northern part of the Curonian Lagoon in 1961-2004. Global warming can also cause increases in salinity. The growing problem is more intense anthropogenic activity and its influence of the natural environment. (I. Dailidiene, A. Stankevicius, B. Tilickis, L. Davulien, Lithuania)

Fisheries Surveys were performed seasonally at randomly stratified monitoring stations. Factors in terms of sediment type, depth range and season influencing species diversity, abundance and biomass of catches within Lithuanian Exclusive Economic Zone (LEEZ) were investigated. Length-age distribution of commercially important species, namely cod, flounder, herring and sprat, were analyzed. As a result, nursery areas for species were detected and closed as a fishery. The fish species studied were grouped into species living permanently in the coastal zone and species in migrations between the shallow zone and other habitats, only utilizing the coastal zone during some life history stages. The northeastern part of LEEZ was detected as the area where young individuals of herring, sprat, smelt and shad form rather dense schools. (R.Statkus, Lithuania)

## ACKNOWLEDGEMENT

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# US/EU - Baltic International Symposium 2006

R.Spinrad, NOAA;A.Stankevicius,Lith; J.Vadus, USA
J.Barbera, USA;CDR.Gottshall,ONRG

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J.Barbera;J.Vadus: CDR.Gotshall,ONRG

J.Barton,USA; J.Vadus; V.Klemas: V.Paka, Russia

Symposium Chairs with CMR Staff

CMR Symposium Staff

R/V PROFESSOR SHTOKMAN

On Deck: R.Spinrad, NOAA, E.Gough,US Navy

Vadim Paka hosting reception on board R/V SHTOKMAN
Jen Werner,NOAA

E.Gough, US Navy; R.Spinrad, NOAA disembarking

Jen Werner, NOAA; A.Spinrad, USGS

J & P.Barbera at the Amber Museum


Klaipeda Hotel


US Navy Reception Buffet


J.& P. Barbera; A.& R. Spinrad, NOAA; J.Vadus


H.Dahlin, Sweden; A. Stankevicius;
J.Vadus


R.Jasinevicius, Symp.Co-Chair,Lith.


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## *For Immediate Release*
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## *Oceans ’06 Publicity Co-Chair*

Revolutionizing Marine Science and Technology:
MTS/IEEE Oceans 2006 Boston is Ready to Welcome over 2500

*A Message from MTS/IEEE Oceans 2006 Chairman, John Irza*
The week of Oceans’06 Boston kicks-off on Monday, September 18-September 21 with a lineup of tutorials and workshops during the day and concludes with advance registration and a welcome reception in the evening.

Tuesday September 19 will mark the official commencement of the Technical Program and opening of the Exhibition Hall. The Tuesday morning plenary session will focus on Ocean Observing Systems and will feature Dr. Margaret Leinen, the Assistant Director for Geosciences at the National Science Foundation, Dr. Richard Spinrad, the Assistant Administrator of the National Oceanic and Atmospheric Administration, and Dr. Jose Achache, the Group on Earth Observations GEO Secretariat Director.

Wednesday’s plenary will focus on the theme of Oceans’06, “Revolutionizing Marine Technology.” A great deal of technical innovation has sprung forth from the mission-driven challenges of developing and deploying advanced technologies in the world’s oceans.

Wednesday evening will feature the Oceans gala which will be held at the Boston Museum of Science. The entire Blue Wing of the museum is reserved for our use as well as the “Theatre of Electricity”. Our Canadian partners will be providing the pre-gala reception at the Museum.

The final official day of technical sessions and exhibition will be on Thursday. A brown bag lunch and tour of the exhibit hall will be provided for secondary school students and educators, offering them an opportunity to be introduced to marine technology in a hands-on manner.

According to Technical Chair, Vince Premus of Oasis, Inc., 500 abstracts were received by the technical program committee for OCEANS’06 MTS/IEEE – Boston. The committee is in the final stages of the review process and they expect to accommodate 390 papers in the final program; 100 of which are coming from countries such as Norway, Canada, Italy and Australia.

The technical program will have a very strong representation in a number of hot topic areas, foremost among those being Coastal and Ocean Observatories. Sonar signal processing will also be prominently featured, particularly in the areas of Synthetic Aperture Sonar, Vector Sensor Array Processing, and Acoustic Communications. All three of these technical areas are experiencing resurgence in funded research in the defense and commercial sectors. Additional areas expected to be well represented will include Oceanographic Instrumentation, Gliders and AUV applications, Aquaculture Engineering, and Current Measurement and HF Radar.

Exhibits Chairman, Mike Stewart, of MJ Stewart Associates, reports, “the exhibit area is filling up and currently we have 72 companies and organizations that have reserved 114 booths. We expecting to end up with 175 to 200 booths by showtime. There are several larger pavilions that will be representing NOAA, Hawaii Ocean Science & Technology, Government of Canada and Newfoundland and Labrador”.

To shine a light on all the students in the greater Boston area, we will have an enlarged student poster area. Thirty reviewed college student posters will be on display from entries all over the country. Hundreds of students are expected to visit Oceans 2006 in search of career opportunities. Adjacent to the poster sessions will be displays of unmanned AUVs and ROVs developed by students. There is also a concerted effort underway to have education and research institutions represented in the exhibit hall. There will be two sponsored coffee breaks each day in the exhibit area, which will bring welcome “traffic” to the exhibit hall. On Tuesday evening, there will be a wonderful reception held in the exhibit hall toward the end of the day.

*Exhibitors Showcase:*
This year the highly successful Exhibitor Product Showcase that attracted standing room only audiences at Oceans 2000 in Providence has returned. All exhibitors are invited to submit abstracts and then full papers to the Exhibitors Showcase track. This tract will provide exhibitors with a scheduled time to give talks or demonstrations on their new technology, applications, or programs. Space is limited and abstracts will be reviewed by a technical panel. Abstracts are due no later than July 15, 2006.

Submit to: http://www.ocean06mtsieeeboston.org Contact: M. L. Merrill 781 740 1456; martrep@aol.com, or Bob Lobecker at 401-847-9297; Robert.lobecker@verizon.net.

*Canadian Connection:*
OCEANS’06 is shaping up this year to have a large connection with the Canadian Marine Technology industry, in advance of next year’s OCEANS’07 in Vancouver, and ’08 in Quebec City. The Canadian Consulate in Boston has signed on as a major sponsor of the conference. They will have a 10 booth pavilion and are heavily marketing Canadian companies to show their products and services at the Exhibition, taking advantage of booth discounts negotiated as part of their sponsorship agreement. They are confident of attracting 25 Canadian companies to the show. In addition, the Government of Newfoundland will have a 9 booth pavilion and is expecting 5 to 10 companies from their Province to come. Finally, the Government of Quebec is developing a marine technology cluster located around Remouski on the Saint Lawrence River, and has made inquiries about booth space and discounts.

To register, to obtain exhibit information, to submit an Exhibitors Product Showcase abstract, to make reservations for accommodations and to inquire about sponsorship opportunities go to www.oceans2006.org.

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**Put these dates in your diary:**

**DATES TO REMEMBER:**

First Call for Papers: March 2006
First Call for Tutorial Sessions: June 2006
First Call for Student Posters: June 2006
Abstract Submission Deadline: December 2006
Earlybird Registration closes: 01March 2007

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