Hydralab 2008

Proposals for access to facilities at NTNU

User selection panel October 30\textsuperscript{th} 2008

Hull, UK
Proposals:

HYIII-NTNU-22
Title: INVESTIGATION OF NON-OPTIMISED AND OPTIMISED SHIP MOTION RESPONSES IN INTACT AND DAMAGED CONDITIONS
User group leader: GE. Hearn, University of Southampton, School of Engineering Sciences, UK

HYIII-NTNU-23
Title: Hydrodynamic Drag Measurements of Riparian Woodland Trees – Part 2
User group leader: Catherine AME Wilson, Cardiff School of Engineering, Cardiff University, UK

HYIII-NTNU-24
Title: Water column stratification, phytoplankton diversity and consequences for resource use and productivity
User group leader: Maren Striebel, Ludwig-Maximilians-University Munich, Germany

HYIII-NTNU-25
Title: EXTREME WAVES IN DIRECTIONAL WAVE FIELDS TRAVERSING UNIFORM CURRENTS
User group leader: Jaak Monbaliu, K.U.Leuven, Department of Civil Engineering, Belgium

HYIII-NTNU-26
Title: WAVE AND CURRENT FORCES AND RESULTING RESPONSES OF MOORED MULTI-BODY FLOATING OFFSHORE SYSTEMS
User group leader: Nuno Miguel Magalhães Duque da Fonseca, Tenhical University of Lisbon, Centre of Marine Technology and Engineering, Portugal

HYIII-NTNU-27
Title: Drag and roughness characteristics of a Surface Treated Coating (STC)
User group leader: Maxim Candries, Hydrex NV / Subsea Industries NV, Department of Research and Special Projects, Belgium
Please send the completed form by e-mail to the facility provider:

- Norwegian University of Science and Technology (NTNU): Alexandra Neyts, alexandra.neyts@bio.ntnu.no

1. Title of the proposal

   INVESTIGATION OF NON-OPTIMISED AND OPTIMISED SHIP MOTION RESPONSES IN INTACT AND DAMAGED CONDITIONS

2. Requested facility/facilities:

   NTNU Ocean Basin, Trondheim, Norway with waves only (no wind or current)

3. Applicant's full name and title (User Group Leader)

   Professor Grant E. Hearn, Professor of Ocean Engineering Science

4. Affiliation

   School of Engineering Sciences, University of Southampton, Highfield, Southampton, SO17 1BJ, UK

   Male
   Tel.: +44 (0) 23 8059 3769 (direct)
   Fax: +44 (0) 23 8059 7322
   E-mail: g.e.hearn@soton.ac.uk
   Web-site: www.soton.ac.uk/ses/research/fsi/

5. Full name, titles, positions in institution, nationalities and gender of all other persons participating in the project (NB: only users who intend to access the facilities!)

<table>
<thead>
<tr>
<th>Name, titles and affiliation</th>
<th>Position</th>
<th>Nationality</th>
<th>M/F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prof. John Chaplin, School of Civil Engineering and the Environment, University of Southampton</td>
<td>Professor of Applied Fluid Mechanics</td>
<td>British</td>
<td>M</td>
</tr>
<tr>
<td>Prof. Carlos Guedes Soares, School of Marine Technology and Engineering, Technical University of Lisbon</td>
<td>Head of Department</td>
<td>Portuguese</td>
<td>M</td>
</tr>
<tr>
<td>Dr. Rumen Kishev, Ship and Offshore Dynamics Division, Bulgarian Ship Hydrodynamics Centre</td>
<td>Head of Division</td>
<td>Bulgarian</td>
<td>M</td>
</tr>
</tbody>
</table>
6. Names and access period of those that made use of the access programme to this facility in previous EC framework programmes:


7. Estimated number of access days requested

12 days in total. The first two days will be occupied in setting up the model. This could be carried out in a dock.

8. Estimated total number of the visiting person-days

(sum of the days of presence at the installation of all the members of the visiting team);

Hearn & Chaplin would be present for all 12 days of test plus a pre-test visit.
Soares would be present 6 days.
Kishev would be present for 6 days
Funding is also requested for travel and subsistence for two PhD students (one each from Southampton and Lisbon) to be present throughout the tests. Uncertainty over the timing makes it impossible to identify individuals at this stage.

9. Most appropriate period for the experiments?

Are there any constraints for the period when you may or may not perform the experiments?

Not earlier than 9 months after the announcement.

10. Tentative list of instrumentation requested (contact us for information; if you also use your own instruments, please give the characteristics)

Wave and six degree-of-freedom motion monitoring transducers, associated conditioning units and data acquisition system. Access to additional ports in the NTNU in-house data acquisition system to permit monitoring of the motions of the internal free surface using transducers provided by the team.
11. Description of the proposed work (maximum of four A4 pages).

INVESTIGATION OF NON-OPTIMISED AND OPTIMISED SHIP MOTION RESPONSES IN INTACT AND DAMAGED CONDITIONS

Scientific context

Research on the motion of damaged ships reported by Soding (2002) in Germany, Dongkon et al. (2007) and Hong et al. (2007) in Korea, Korkut et al. (2004) in Turkey and the UK, Santos et al. (2002) in Portugal and known ship capsize investigations by Kishev in Bulgaria is partially a response to marine incidents as the Herald of Free Enterprise, the European Gateway, the Estonia and others.

The catalyst for the proposed investigation is quite distinct. It arises from the optimal design of intact ships.

Hearn and a number of his co-researchers, former colleagues at the University of Newcastle upon Tyne, have investigated the hydrodynamic optimisation of ship hull forms to simultaneously improve peak seakeeping responses, wave making resistance and added resistance (Hearn & Wright, 1999). Parallel research was carried out by Day & Doctors (1997).

Within these studies it was observed that theoretical estimates of additional viscous resistance did not exceed 4%. This was outweighed by the larger improvements in the wave making and added resistance components. Furthermore, the intact stability of the ships (monohull or catamaran) was not adversely affected.

Whilst win-win scenarios may be attractive there is often a negative impact somewhere. Standard naval architectural calculations revealed no negative factors. This was equally disturbing. The idea that the ‘damaged optimised ship’ might have worse motions than the ‘damaged non-optimised ship’ seemed a perverse if undesirable possibility. Hence at Southampton University, Hearn and his research students started to investigate this possibility.

The Southampton theoretical studies

Analysing a damaged ship is not simply a case of undertaking the diffraction and radiation fluid structure interaction analysis to reflect the changes in added mass and fluid damping coefficients caused by its damage (though this approach is often found in the literature). Similarly, to model the equations of motion consistently one must invent a method of assigning the non-zero cross products of inertia that come into play as a consequence of the trim and heeling caused by the presence of water within the damaged ship. To have some confidence that the damaged ship study has some relevance (rather that represent an unlikely event) there is a need to identify the most likely location of that damage and its extent.

To respond to the last point a number of different accident related databases have been provided, some from the public domain and others of a private nature, covering the period 1935 to 2002. This permitted most-likely damage location and extent to be identified for a number of different ship types (reported in a Southampton PhD thesis by Saydan (2006), and
by Hearn et al. (2008)). The computation of the damaged ship cross products of inertia was devised using the conditions of zero value for the intact ship (a very common practice) and then from an equivalent point mass representation the cross terms of the damage ship were estimated. Without including the internal free surfaces in the fluid structure interaction analysis, but including a full inertia matrix Saydan showed that the motions of the damaged optimised ship were different (often larger at certain frequencies) than those of the damaged non-optimised ship.

For the most significant two damage cases (hold 2 and holds 1 & 2 of the Derbyshire flooded) the Saydan’s work was extended to include the hydrodynamic coupling of the internal free surfaces with the usual external six degree of freedom radiation problems together with the provision of the wave excitation loads on ship and internal free surfaces. The resulting motions were different, and exceeded the clearance within the holds. Consequently the influence of the air between internal free surface and deck (adiabatic or isothermal assumptions are not very significant) was reflected in the stiffness matrix for the 9 or 12 degree of freedom system (for one or two flooded holds). This confirmed that there were more significant motions of the damaged optimised hull than for the non-optimised hull. Also, the motions of the free surface were now more realistic and believable.

Within the theoretical study the internal free surfaces were modelled as mass-less plates with the 3 degrees of freedom of heave, roll and pitch. The air gap and the stiffness of the air within were a function of the relative motion of the ship and so the motion equations had to be analysed iteratively. The resulting stiffness matrix is significantly more complex than the standard motion response equations.

The full analysis has been reported and is under discussion following publication by RINA (Hearn et al., 2008).

The need for the proposed experimental investigation

Whereas the studies driven by Hearn have used the frequency domain in the manner described, and Soares and his co-workers have undertaken time domain studies with assumptions concerning water ingress flows, there is now a need to validate these approaches. The local experimental facilities available at Southampton are towing tanks of insufficient length and depth. Soares et al. and Korkut et al. have undertaken experimental investigations using very small models. Often small models are necessary so that wave headings of limited magnitude can be investigated within the towing tank width. The team of Hearn, Chaplin, Soares and Kishew propose to carry out motion studies of damaged ships at a larger scale, in order to obtain high quality data on the internal free surface motions and on the flow of water into the holds. These experiments demand a correspondingly large facility so that, as in the analyses, the results are free of wall and finite water depth effects.

The flooding behaviour and the motion of the internal free surfaces crucially needs to be documented accurately in order to provide definitive checks on the theory, validating the mass-less flat plate model, and to identify any requirement to improve methods of analysis.

Additional to validation of different theoretical analyses is the question of the extent to which optimisation of ship hull forms ought to be pursued, and whether there is a perverse possibility of damaged optimised ships having motion responses that significantly exceed those of their intact form and the damaged non-optimised ship form.
One can also argue that ships that carry sensitive and environmentally threatening cargoes ought to have their behaviour appreciated in some depth so that appropriate responses for different conditions can be worked out in advance. Confidence in such a remit would depend upon our ability to model damaged ships *per se* and predict their likely responses.

The existing theoretical studies and the proposed experiments will improve our understanding and assist in the enhancement of our engineering analysis capability for damaged floating ships and may be extended to other marine structures. For example, the results will also be beneficial to our modelling of floating and fixed oscillating water columns (OWC), whether they are treated as isolated OWC units or included (as planned) as part a proposed modified clam based wave energy extraction device.

**The need for access to NTNU facilities**

The detailed theoretical studies assume open water and infinite fluid depth. The size of the NTNU tank will permit a reasonable model scale (without significant tank wall and tank bottom effects) and permit a larger scale of model than could be used in a towing tank. Korkut *et al* (2004) used a 1/125 scaled Ro-Ro model to fit Newcastle tank conditions. While a 1/40 scaled Ro-Ro model was used by Dongkon *et al.* (2007) in their basin, the current thinking is that a 1/60 scaled (5m long) model of the bulk carrier of *Derbyshire* is excessive by towing tank standards because of the large associated displacement. Nevertheless, it is this scale (i.e. a 5m long model) that is called for in the present proposed research programme, so that reliable measurements can be obtained to suit the requirements of the analysis. This especially true here given the implications of some of the theoretical frequency domain analysis of excessive motions for a damaged optimised ship form – and the implications if verified.

**Analysis of Results**

The collected data will be stored in raw collected state to allow any later subsequent re-analysis. Otherwise data will be analysed by investigators to provide transfer functions of each degree of freedom of floating structures and internal free surfaces for comparison with predicted results for different wave frequencies and headings. The data will be made available for wider access within blind benchmarking exercises, similar to those conducted on vortex-induced vibrations of risers by Chaplin.

**Publication Plan**

Joint authorship publication in: (i) appropriate conferences and (ii) journals of the Institute of Mechanical Engineering or RINA, or Ocean Engineering or other journals of standing.

**Role of each Team member**

Grant Hearn will organise model production so that the form is consistent with the 3D representation used in the theoretical fluid structure interaction analysis. With colleagues at the Wolfson Unit on the campus (WUMTIA) the mass distribution will be determined to provide consistency with the dynamic motions modelling. He will also organise pre-visit testing in Solent and contribute to the associated data analysis.
John Chaplin has long experience of a wide range of experimental techniques in fluid/structure interaction. He will contribute to the design and implementation of the various measuring systems on the model vessel, the execution of the tests, and the data analysis. A multi-channel system (Retzler, et al., 2004) will be employed for measuring run-up within the ship.

Carlos Guedes Soares will bring his theoretical and experimental expertise within the context of a partially flooded ship and his knowledge and insight regarding the mechanisms of flooding and their modelling. Collectively the team can use the stored time histories to seek validation of the Carlos Soares time domain approaches as well as the frequency domain approach.

Rumen Kishev has extensive experience in seakeeping investigations. Additionally his practical knowledge of ship stability loss and risk of capsizing will be useful in ascertaining the model preparation and balancing (with recognition of free surface corrections) to achieve stated required static equilibrium conditions.

The width and depth of the team is sufficient to provide high quality models and model testing of the intact and damaged ship hull forms.

References (Additional relevant publications by the proposers are listed in their CVs.)


12. **Technical details and specifications of the planned experiments (maximum of one A4 page)**

The experiments will be carried out using a highly instrumented 5m long model constructed in Southampton, with the assistance of WUMTIA.

*Prior to arrival* it will be necessary for us to identify ballast distribution in the model so that:

(a) The centre of gravity and moments of inertia match those of the intact ship.

(b) For each damage condition cross products of inertia (as determined using the novel calculation method of Hearn and Saydan) are also correct.

Only if these are consistent will the ship conform to the assumed static equilibrium conditions assumed in the reported theoretical studies of Hearn *et al.* (2008).

The model ship will be equipped with multiple water surface elevation gauges to record internal free surface motions when in the damaged condition.

The entire system will be checked out in the Southampton Solent towing tank, where we will be able to carry out tests in head sea wave conditions with small yaw angles, though in the presence of wall and bottom effects.

*The first two days* of the tests at NTNU will be occupied by ballasting the model (according to the design distributions) and statically testing that the freeboard and orientation of the model is as required for (i) the intact case (ii) the two flooded conditions of Table 3 of Hearn *et al.* (2008). Intact and damaged water lines are to be marked on the models in each case to ease the checking procedure.

Holes in the hull will be opened and closed by radio control, so as to minimize disturbances and delays during the tests.

Tubes installed in the hull will facilitate pumping out of flooded holds, also by radio control. All systems will be checked out in still water conditions.

*Days 3 to 11* will be occupied by free-running tests in a variety of wave conditions. Tests on each of the three vessel configurations will be carried out over three days.

*Day 12* is for contingencies and de-mounting.

**Appendix (please provide in a separate file)**

One page CVs for the team are provided in a separate pdf file.
CURRICULUM VITAE
Grant Ernest HEARN

Present position (since 2000): Professor of Ocean Engineering Science, School of Engineering Sciences, University of Southampton, Southampton SO17 1BJ.

Academic qualifications: BSc (Mathematics) Bath University of Technology (1970), MSc (Applied Mathematics) Sheffield University (1971), Research Student (Applied Mathematics) Sheffield University (1971-73)

Professional qualifications: Chartered Engineer, Fellow of the Royal Institution of Naval Architects, Chartered Mathematician, Fellow of the Institute of Mathematics & Applications.

Previous employment:

1976 – 1978 Higher Research Officer (1976), Principal Research Officer (1977), Chief Mathematician and Head of Mathematics Support Group (1977-78), British Ship Research Association (BSRA), Wallsend, Newcastle upon Tyne

1974 – 1976 DTI Research Fellow in Naval Architecture, Department of Naval Architecture and Offshore Engineering, University of Strathclyde, Glasgow

1973 – 1974 Research Fellow, Department of Applied Mathematics, University of Sheffield


Research interests
Grant Hearn works on both mathematical and physical modelling of different fluid structure interactions. He is essentially an applied mathematician working on the theoretical hydrodynamics of ships, offshore structures and wave energy devices, motion dynamics, Green functions, ship collision avoidance & control and autonomous underwater vehicles (hydrodynamics and control). At SRDE I worked on waveguides, at BSRA on ship vibration, wave energy and turbulent boundary layer theory and at Pilkington developed novel solution techniques for solving Navier Stokes equations in multi-connected domains applied to multi–stirrer interaction with molten glass flows in the ‘float process’. At Newcastle I specialised in 3D diffraction and radiation analysis together with second-order drift forces and low frequency wave damping to facilitate improving time-domain simulations of moored structures. Optimisation of monohulls & catamarans was investigated using Genetic Algorithms. Ship Manoeuvring and control increased breadth of research. Current interests include: Hydrodynamics and control of AUV (application of thrusters control), AUV design, Damaged ships and the hydrodynamics of the Anaconda wavepower device - developing a novel fluid structure interaction analysis for the flexible & distensible tube.

Membership of other bodies
• Editorial Boards: Ocean Engineering Referee for RINA, Fluids & Structures Journal, Ocean Engineering and others on ad hoc basis.
• Vice-President and Executive Member of Institute of Mathematics & Applications until 2005.

Selected recent publications


CURRICULUM VITAE
John Reginald CHAPLIN

Present position (since 1999): Professor of Applied Fluid Mechanics, School of Civil Engineering and the Environment, University of Southampton, Southampton SO17 1BJ.

Academic qualifications: BSc (1st class honours, 1967) and PhD (1970) in Civil Engineering, University of Bristol.

Professional qualifications: Chartered Engineer, Fellow of the Institution of Civil Engineers.

Previous employment:

1986 – 1999  Professor of Hydraulics, Department of Civil Engineering, City University, London


1974 – 1985  Lecturer (appointed Senior Lecturer 1983) in Civil Engineering, University of Liverpool.

1972 – 1974  Assistant Engineer, Rendel, Palmer & Tritton (Consulting Engineers), London

1970 – 1972  Research Associate, Institute of Hydromechanics, Karlsruhe University, Germany

Research interests
John Chaplin works on both mathematical and physical modelling of fluids flows that are of fundamental relevance to applications in offshore and coastal engineering, but is primarily an innovative experimentalist. Since the mid-1970s he has conducted experiments on interactions between waves and structures, specifically on environmental forces on surface piercing bodies in regular, irregular, extreme and breaking waves at large scale; the ringing response and hydrodynamic damping of compliant offshore structures; vortex-induced vibrations of deep water tension risers. Current interests include the hydrodynamics of the novel Anaconda wavepower device.

Membership of other bodies
- Scientific Organising Committees: International Society of Offshore and Polar Engineers; OMAE, ICOE etc

Selected recent publications
CURRICULUM VITAE
Rumen Zdravkov KISHEV

Present position (since 2004): Head Ship and Offshore Dynamics Department, Bulgarian Academy of Sciences – Bulgarian Ship Hydrodynamics Centre, Varna

Academic qualifications: MSc (Naval Architecture) Technical University Varna (1972), PhD (1980) St Petersburg State Maritime University, Russia.

Professional qualifications: Union of Scientist in Bulgaria,

Previous employment:
2003 – 2004 Offshore Design, Senior Engineer, Keppel FELS Singapore,
1986 – 2002 Head of Ship Dynamics Department, Bulgarian Ship Hydrodynamics Centre (BSHC), Varna, Bulgaria
1972 – 1986 Research Scientist, Ship Seakeeping Department, Bulgarian Ship Hydrodynamics Centre (BSHC), Varna, Bulgaria

Research interests
Rumen Kishev works primarily in the physical modelling and testing of marine structures for seakeeping, mooring response and design testing related to research ships and offshore structures (jackets, jack-ups & offshore platforms), stability of ships and stabilisation methods, dynamic behaviour of offshore mariculture farm cages, ship deck-wetness assessments and virtual prototyping of naval ships.

His contribution to the ITTC progress has involved co-authorship of the Committee Reports on Seakeeping and Environmental Modelling cited earlier.

He has carried out experimental research at various tank facilities around the world including: DMI Denmark, El Pardo Model basin Spain,

Membership of other bodies
• Editorial Boards: Secretary SMSSH’83, Chairman STAB’97, Secretary CABSs’95 & secretary MARIND’98 International Conferences held at BSHC Varna.
• Member of Seakeeping Committees of 20th, 21st & 25th ITTC, Modelling Committee of 25th ITTC, Member of ECOR- University of Newfoundland, Canada, Member of NATO NIAG SBDVP Group & NATO NG6 SG60/6 Groups on Virtual Ships

Selected recent publications
Kishev, R., Model testing of deepwater mooring systems, Blacksea’08, Varna, Bulgaria, 2008
Kishev, R & Rakitin, V, Model tests on stabilizing moment created by passive anti-rolling tanks, STAB’06, Rio de Janeiro, 2006
Kishev, R., Maron, A., Rakitin, V. & Chalakov, V., Experimental verification of an advanced deck wetness prediction method, 10th IMAM Congress, Lisbon, Portugal, 2005

Mendes, A., Kishev, R., Chaplin, J.R. & Tomchev, S., Experimental determination of the hydrodynamic loading on a model of offshore platforms in waves and currents, ISOPE, Seattle, USA, 2000
CARLOS GUEDES SOARES

1. Academic Qualifications

- MSc in Civil Engineering, Massachusetts Institute of Technology, 1976.
- MSc in Naval Architecture and Marine Engineering, (curricular), Massachusetts Institute of Technology, 1976.
- "Ocean Engineer” Massachusetts Institute of Technology, 1976.
- Doctor Engineer, Norwegian Institute of Technology, University of Trondheim, Norway, 1984.

2. Honorary Degrees and Awards

- **Honorary Professor**, Technical University of Varna, October 2003.
- **Scientific Prize UTL/Santander**, for the Professor of the Technical University of Lisbon with largest number of published papers and citations in ISI Journals for all areas of Engineering in the period 2000-2006.

3. Present Responsibilities

2000 – Present: Professor and Head of the Naval Architecture and Marine Engineering Department, Instituto Superior Técnico, Technical University of Lisbon.

2000 – Present: Coordinator of the Post-Graduation Programme (MSc. and PhD) in Naval Architecture and Marine Engineering


4. Coordination of National and International Research Projects

- Marine Environment (14 projects)
  - Ship Dynamics and Hydrodynamics (6 projects)
- Marine Structures (10 projects)
  - Ship Design and Maritime Transportation (4 projects)
- Safety, Reliability and Maintenance (4 projects)

5. Participation in National and International Research Projects

- Marine Environment (8 projects)
  - Ship Dynamics and Hydrodynamics (16 projects)
- Marine Structures (8 projects)
  - Ship Design and Maritime Transportation (16 projects)
- Safety, Reliability and Maintenance (14 projects)

6. Publications

Co-editor of Reliability Engineering and Systems Safety (since 1992); Guest Editor of 4 ‘Special Issues’ of ‘Marine Structures’; 7 ‘Special Issues’ of ‘Reliability Engineering and System Safety’, 1 ‘Special Issue’ of ‘Coastal Engineering’. Editor or Co-editor 5 International Books and 12 National Books. Editor or Co-editor 19 International Conference Proceedings.

**Papers**
- **Marine Environment** (51 papers in International Journals; 3 papers in National Journals; 31 papers in Book Chapters; 59 papers in Conference Proceedings)
- **Ship Dynamics and Hydrodynamics** (54 papers in International Journals; 4 papers in National Journals; 38 papers in Book Chapters; 53 papers in Conference Proceedings)
- **Ship Structures** (41 papers in International Journals; 4 papers in National Journals; 25 papers in Book Chapters; 42 papers in Conference Proceedings)
- **Ship Design and Maritime Transportation** (4 papers in International Journals; 2 papers in National Journals; 21 papers in Book Chapters; 11 papers in Conference Proceedings)
- **Safety, Reliability and Maintenance** (48 papers in International Journals; 4 papers in National Journals; 63 papers in Book Chapters; 49 papers in Conference Proceedings)
Please send the completed form by e-mail to the facility provider:

- CNRS Coriolis/LEGI Grenoble: Joel Sommeria, sommeria@coriolis-legi.org
- DHI Water & Environment: Jens Kirkegaard, jkj@dhigroup.com
- Hamburg Ship Model Basin (HSVA): Karl-Ulrich Evers, evers@hsva.de
- Norwegian University of Science and Technology (NTNU): Alexandra Neyts, alexandra.neyts@bio.ntnu.no

1. Title of the proposal
Hydrodynamic Drag Measurements of Riparian Woodland Trees – Part 2

2. Requested facility/facilities: Towing tank at SINTEF (Norway)

3. Applicant's full name and title (User Group Leader)
Dr Catherine Anna Margaret Elizabeth Wilson

4. Affiliation
Eco-hydraulics Research Group
Cardiff School of Engineering,
Cardiff University, Newport Road, Cardiff CF24 3AA
Male/Female: Female
Tel.: +44 (0)29 20874282
Fax.: +44 (0)29 20874597
E-mail: wilsonca@cardiff.ac.uk
Web-site: http://www.engin.cf.ac.uk/whoswho/profile.asp?RecordNo=249

5. Full name, titles, positions in institution, nationalities and gender of all other persons participating in the project (NB: only users who intend to access the facilities!) (enlarge the table if necessary):

<table>
<thead>
<tr>
<th>Name, titles and affiliation</th>
<th>Position</th>
<th>Nationality</th>
<th>M/F</th>
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<tbody>
<tr>
<td>Aberle, Jochen Egon, Dr.-Ing. Leichtweiß-Institute for Hydraulic Engineering Technische Universität Braunschweig</td>
<td>Head of Hydraulic Laboratory &amp; Research Fellow</td>
<td>German</td>
<td>M</td>
</tr>
<tr>
<td>Lameranner, Walter, Dipl.-Ing. Institute of Soil Bioengineering and Landscape Construction, University of Natural Resources and Applied Life Sciences, Vienna</td>
<td>Research Assistant</td>
<td>Austrian</td>
<td>M</td>
</tr>
<tr>
<td>Rauch, Hans Peter, Dr. rer. nat. tech. Institute of Soil Bioengineering and Landscape Construction, University of Natural Resources and Applied Life Sciences, Vienna</td>
<td>University Assistant</td>
<td>Austrian</td>
<td>M</td>
</tr>
<tr>
<td>Schoneboom, Thomas, Dipl.-Ing. Leichtweiß-Institute for Hydraulic Engineering Technische Universität Braunschweig</td>
<td>Research Associate</td>
<td>German</td>
<td>M</td>
</tr>
</tbody>
</table>
Sharil, Suraya, BSc, MSc  
Eco-Hydraulics Research Group  
Cardiff School of Engineering  
Cardiff University  

PhD-student  
Malaysian  
F

Thomas, Dafydd Huw, MSc, BSc  
Talybont Research Station  

Forest Hydrologist  
British  
M

6. **Names and access period of those that made use of the access programme to this facility in previous EC framework programmes:**
   So far no access to this facility but to CEHIPAR, Madrid, Spain from 25th March 2008 to 21st April 2008: C. Wilson; J. Aberle; H P. Rauch; T. Schoneboom; W. Lammeranner

7. **Estimated number of access days requested:** *this includes the time needed for building the test setup, testing and calibration when necessary, experiments, and removal of the test setup:*
   20 days

8. **Estimated total number of the visiting person-days**
   80 days

9. **Most appropriate period for the experiments?**
   The experiments need to be conducted in the months of June or July when the trees have their maximum leaf coverage.

10. **Tentative list of instrumentation requested**
    2/3 underwater video cameras; load cells capable of measuring up to 500 N; load cell frame capable of supporting individual and groups of trees; balances; perspex cylinders for measurements of volumetric plant parameters; hot air cabinets for biomass estimation; vehicle for plant transport.

11. **Description of the proposed work (maximum of four A4 pages).**
    Please see separate File.

12. **Technical details and specifications of the planned experiments (maximum of one A4 page)**
    Important details are included in the description of the proposed work.

**Appendix**
CV of each group member in File Appendix.doc.
1. Scientific context

Vegetation-flow interactions are central to many problems of practical interest to hydrologists and hydraulic engineers including flood risk assessment, sediment transport studies, and eco-hydraulic studies. Furthermore, flooding and climate change have both become major issues for society and this, together with recent EU directives (Habitat Directive 92/43/EEC; Water Framework Directive 2000/60/EC) give these types of studies added significance.

The main objective of this proposal is to improve current approaches for the accurate prediction of flows in riparian floodplains, with a focus on common European woodland trees. Currently, flow resistance is assigned to vegetated channels and floodplains on an ad hoc basis (e.g., Chow, 1959) and the aim of this work is to develop and formulate physically-based formulae which quantify hydraulic resistance of single and groups of trees as a function of their characteristics. This will lead to improvements in numerical modelling tools for integrated environmental and hydraulic management (e.g., Wilson et al., 2006).

Probably one of the most in-depth studies in terms of the range of velocities examined, determination of plant streamlining area, and scale of experiments, was conducted by Oplatka (1998). Oplatka measured the drag on mainly multi-stemmed willow trees (Salix purpurea and Salix viminalis) whose heights ranged from 1.8 - 4.5 m for velocities which were increased in increments of 1 ms^{-1} up to 4 ms^{-1}. A drag force - velocity relationship which tended towards a linear rather than a squared function was presented. This is thought to be due to the decrease in plant frontal area with increasing velocity resulting in a relatively smaller increase in the rate of change in drag with increasing velocity. While the study conducted by Oplatka is perhaps one of the most extensive to date, improvements are needed in terms of the resolution of the velocities examined, measurement of frontal plant area under flow action, quantification of the contribution of the tree foliage to the drag and determination of plant parameters. Additionally, the former study focused on multi-stemmed trees and it would be advantageous to examine the drag-velocity relationship for European species and plant morphologies which are exemplary of both multi-stemmed and single-stemmed trees.

To the best of our knowledge, the resultant drag on an individual tree element which is part of a larger group of trees has not been measured directly until today. Hence, it is not possible to evaluate 'sheltering effects' encountered by a tree immediately downstream and adjacent to other tree elements (see Figure 1) adequately. The results of such a study should have far reaching implications and lead to improvements for the prediction of flood levels through forestation.

In this project we propose to characterise the hydraulic resistance of riparian woodland through direct measurement of hydrodynamic drag on single trees following from previous studies (Oplatka, 1998; Wilson et al., 2008) and extending the previous study that was commenced through the HYDRALAB programme at CEHPAR (Madrid) to focus on both single trees and a group of trees.

2. Previous experience

Some of the team members have previous laboratory experience in the smaller-scale measurement of drag (Wilson et al, 2008; Schoneboom et al 2008). Moreover a recent study at prototype scale was conducted using a towing tank at the CEHIPAR facility (Madrid) in April 2008.
Due to time constraints the access time was used to investigate the drag force-velocity relationship of **single** trees of varying height, species, and tree structure rather than **groups** or assemblages of trees. Furthermore the experiments focused on the contribution of the trees leaves to the overall drag (see Figure 1). However unfortunately Spring was late in its arrival and the trees did not possess the full quantity of leaves that would be expected. Currently we are processing the data and the results are highly promising; preliminary hydraulic results are shown in Figure 1 for some tree specimens with and without leaves.

![Figure 1: Drag force-velocity relationships for tree specimens (Alnus and Salix) with and without leaves for experiments conducted at CEHIPAR (Madrid)](image)

3. **Scientific aims**

This is a multi-disciplinary project where we propose to link the hydrodynamic drag force characteristics of single trees and a group of trees to the biomechanical and physical properties of the tree structures. Therefore the scientific and experimental objectives comprise the following hydraulic and tree measurements:

**Hydraulic objectives:**
- Investigate a high resolution drag force-velocity relationship (velocity increments of 0.25 ms\(^{-1}\)) for **single** trees
- Investigate a high resolution drag force-velocity relationship (velocity increments of 0.25 ms\(^{-1}\)) for **groups** of trees
- Investigate the degree of tree bending and streamlining through examining the lateral and longitudinal compression of the plants
- Investigate the contribution of leaves to the overall drag of trees
Tree properties to be characterised:
- Quantify the frontal projected area of the plant under flow action (varying velocity conditions) and under no flow action
- Quantify the vertical distribution of leaves, biomass and volume
- Quantify the leaf area index
- Quantify the bending behaviour of the trunk/branches

4. Methodology and Test Matrix

Single trees and groups of trees (Figure 2) will be attached to the load cell(s) on the towing tank carriage. The specimen will be pulled through the water until it reaches a constant velocity. Test runs will be conducted within the range of velocities 0.25 to 5 ms⁻¹ and the velocity will be increased in increments of 0.25 ms⁻¹ between tests. It is anticipated that the maximum drag force of a single tree is up to 300 N depending on the tree size. The projected frontal and plan area of the specimen will be recorded by digital video and cameras which are mounted in front, above and at the side of the support frame. For the tests conducted with groups of trees, the drag force of each tree within the group is to be determined. Physical and biological plant characteristics will be quantified for each single plant. An outline of the test matrix is given in Table 1.

Table 1 Outline of experimental series and parameters

<table>
<thead>
<tr>
<th>Series</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preliminary I</td>
<td>Verification of drag force-velocity relationship for a uniform rigid cylinder</td>
</tr>
<tr>
<td>Preliminary II</td>
<td>Repetition of selected experiments that were conducted at CEHIPAR (Madrid)</td>
</tr>
<tr>
<td>A</td>
<td>Single natural tree with leaves, different tree heights will be tested</td>
</tr>
<tr>
<td>B</td>
<td>Single natural tree without leaves, different tree heights will be tested</td>
</tr>
<tr>
<td>C</td>
<td>Groups of rigid cylinders, arranged in regular formation</td>
</tr>
<tr>
<td>D</td>
<td>Groups of trees, tree of smaller heights</td>
</tr>
<tr>
<td>E</td>
<td>Groups of trees, trees of larger heights</td>
</tr>
</tbody>
</table>

Figure 2: Experimental set-up of a group of trees with load cell arrangement. Flow direction is from right to left.
5. **Publication plan**

The team members involved have a strong track record of dissemination including publishing in international peer-reviewed journals. Since there are very few studies to date which have been carried out experiments at this scale and using both single and groups of trees we plan to maximize the dissemination of this project to the research community. From the experiments conducted at CEHIPAR in April 2008, two publications are already in preparation.

6. **Justification for access**

The facilities offered through the HYDRA LAB program are unique and the team members do not have access to such facilities in their own countries. The interdisciplinary nature of the multinational research team gives this work added significance. Moreover the experiments proposed herein will be used to improve numerical models and thus have huge scientific potential in terms of flood prediction and protection.

7. **The role of each team member (see Table 3)**

<table>
<thead>
<tr>
<th>Team member</th>
<th>Institution</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr Catherine Wilson</td>
<td>Cardiff University (UK)</td>
<td>Project Leader</td>
</tr>
<tr>
<td>Dr Hans Peter Rauch</td>
<td>BOKU (Austria)</td>
<td>Co-Investigator</td>
</tr>
<tr>
<td>Dr Jochen Aberle</td>
<td>Technische Universität Braunschweig (Germany)</td>
<td>Co-Investigator</td>
</tr>
<tr>
<td>Mr Thomas Schoneboom</td>
<td>Technische Universität Braunschweig (Germany)</td>
<td>Responsible for drag force measurements/towing tank</td>
</tr>
<tr>
<td>Mrs Suraya Sharil</td>
<td>Cardiff University (UK)</td>
<td>To provide support to drag force and tree measurements</td>
</tr>
<tr>
<td>Mr Walter Lammeranner</td>
<td>BOKU (Austria)</td>
<td>Responsible for tree measurements</td>
</tr>
<tr>
<td>Mr Huw Thomas</td>
<td>Forest Research (Forestry Commission, UK)</td>
<td>To integrate experimental design with end-users needs</td>
</tr>
</tbody>
</table>

The work will also be discussed with Prof. Alf Tørum while being on site.

**Acknowledgements**

The work discussed in section 2 was undertaken at the CEHIPAR facility (Madrid) and funded through FP6: ‘Structuring the European Research Area’ Hydralab III programme.

**References**


Hydrodynamic Drag Measurements of Riparian Woodland Trees – Part 2

Technical Details and Specifications

Single trees and groups of trees will be attached to the load cell(s) mounted on a support frame to the towing tank carriage. For this purpose it is most likely necessary to construct a support frame. The trees will be mounted on the load cells by our team members. According to our experiences from the part 1 experiments, mounting the trees is relatively straightforward (see Figure 1).

Several load cells are required for the measurements as it is planned, if possible, to measure drag forces on each specimen mounted to the towing tank. The specimen will be pulled through the water until it reaches a constant velocity. Test runs will be conducted within the range of velocities 0.25 to 5 m/s\(^1\) and the velocity will be increased in increments of 0.25 m/s\(^1\) between tests. It is anticipated that the maximum drag force of a single tree is up to 300 N depending on the tree size.

![Figure 1: Mounting of a specimen to a load cell during part 1 experiments in Madrid at CEHIPAR (left) and side view of tree being pulled through the water at a velocity of 1 m/s (right).](image)

The projected frontal and plan area of the specimen will be recorded by digital video and cameras which are mounted in front, above and at the side of the support frame (for an example of such pictures see Figure 1). For this purpose, two to three (submersible) digital cameras are required. If these cameras are not available at the Towing Tank facility, we may be able to supply such cameras for the duration of the experiments.

Support is also needed for the sourcing of the trees and transport of the trees to the facility. For the tests the team prefers natural trees. For this purpose, it should be clarified with the local river administration if natural trees from the field will be available (may be from different places). If it is not possible, trees have to be organized and purchased from nurseries. We will be happy to contact local river administration to clarify this issue and also to discuss the selection of potential tree species. It would be helpful if a truck can be organized for the transport of the trees. A team member will be responsible for the trees (cutting, transport and vegetation measurements).

Several instruments are required for vegetation measurements such as a foam background (required for photographing of specimen) as well as perspex cylinders for measurements of volumetric plant parameters, balances, and hot air cabinets for biomass estimation.

Further detailed technical issues may be clarified before starting the experiments by email contact or a short visit of a team member.
Dr. Catherine A. M. E. Wilson CEng, MICE, PhD, BEng

Name: Catherine A. M. E. Wilson
Current Post: Senior Lecturer in Environmental Hydrodynamics and Director of the Eco-hydraulics Research Centre
Department: School of Engineering, Cardiff University
Date of Birth: 30 December 1971

Academic Qualifications
BEng in Civil and Structural Engineering, University of Sheffield, 1994
PhD in ‘Meandering Compound Channel Flow’, University of Bristol, 1998

Brief Career Summary
1998 - 2001 Post-doctoral Research Associate, University of Bristol
2001 - 2007 EPSRC Advanced Research Fellow and Lecturer, Cardiff School of Engineering
2007 - current Senior Lecturer and Director of the Eco-hydraulics Research Centre, Cardiff School of Engineering

Executive Summary
- Holder of an EPSRC Advanced Research Fellowship (2001-2007)
- Developed novel and innovative approach to physical characterisation and simulation of vegetation-flow interaction in Computational Fluid Dynamic codes
- Published the first ever book chapter on Vegetation-flow interaction. In Computational Fluid Dynamics: Applications in Environmental Hydraulics (Wiley and Sons)
- Conducted one of the most extensive flood studies for the Environment Agency UK
- Published 42 academic articles in high quality academic journals, books and peer-reviewed international conference proceedings
- Continually received funding (£548K over 5 years) from highly competitive sources, including both EPSRC and NERC
- Prizes for academic papers: ICE UK Prize 2004 and IAHR JFK Prize 1995
- Member of Local organising committee for the IWA/IAHR 5th International Conference of Hydroinformatics
- UK EPSRC college member: member of interviewing panels for sessions 2003 and 2004 Advanced and Senior Research Fellowships, 2006 panel member for INTERACT Call 4

Professional Qualifications and Membership
2001 Member of the International Association of Hydraulic Research and Engineering
2002 Elected Committee member IAHR UK Section Committee
2003 Graduate Member of Institution of Civil EngineersMember of the British Hydrological Society (BHS)
2004 Founding and Elected Committee member of BHS Wales
2005 Full Member of the Institution of Civil Engineers
2005 Chartered Engineer

Selected Publications
Dr.-Ing. Jochen Aberle

Name: Jochen Egon Aberle
Current Post: Head of Hydraulic Laboratory & Research Fellow
Work address: Leichtweiß Institute for Hydraulic Engineering
Technische Universität Braunschweig
Beethovenstr. 51a, 38106 Braunschweig, Germany
Telephone: +49-(0)531-3913922, Email: j.aberle@tu-bs.de
Date of Birth: 13th October 1969
Nationality: German

Academic Qualifications
Dipl.-Ing., Civil Engineering, Universität Karlsruhe (TH), Germany, 1996.
Dr.-Ing., Civil Engineering, Universität Karlsruhe (TH), Germany, 2000.

Brief Career Summary
1997 - 2000 PhD Student and Research Engineer, Institut für Wasserwirtschaft und Kulturtechnik, Universität Karlsruhe (TH), Germany.
2008 - present: Head of Hydraulic Laboratory & Research Fellow, Leichtweiß Institute for Hydraulic Engineering, Technische Universität Braunschweig.

Executive Summary
- Award of the Ehrensenator Huber-Preis 2001 Universität Karlsruhe (TH), Germany
- Secretary of Hydraulic Instrumentation Section of IAHR
- Secretary for River Flow 2010 Conference
- Invited Speaker for XXVIII School of Hydraulics, Krag, Poland
- Published 40 academic articles in high quality academic journals, books and peer-reviewed international conference proceedings

Memberships
- International Association of Hydraulic Research and Engineering (IAHR)
- IAHR-Hydraulic Instrumentation section
- New Zealand Hydrological Society
- German Association for Water, Wastewater and Waste working parties "Basic Morphodynamic Phenomena in Rivers" and "Approaches for the hydraulic-morphological assessment of natural rivers"

Selected Publications
Dr. rer. nat. tech. Hans Peter Rauch

Name: Hans Peter Rauch
Current Post: University Assistant
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Department of Civil Engineering and Natural Hazards
University of Natural Resources and Applied Life Sciences
Peter-Jordan-str. 82, A-1180 Wien
Telephone: +43-1-47654-7304, Email: hp.rauch@boku.ac.at
Date of Birth: 16th June 1966
Nationality: Austrian

Academic Qualifications
Graduate Engineer, Forestry, Torrent and Avalanche Control,
University of Natural Resources and Applied Life Sciences, Vienna, 1996.
Doctor rer. nat. tech., Landscape Planning, University of Natural
Resources and Applied Life Sciences, Vienna, 2005.

Brief Career Summary
1996 – 1998 Research Assistant, Institute of Hydraulics, Hydrology and Water
Resources Management, Vienna University of Technology
1997 - 1998 Lecturer of Practice in Soil Bioengineering, Department of Soil
Bioengineering and Landscape Planning, University of Natural
Resources and Applied Life Sciences, Vienna
1998 - 2000 Research Assistant, Department of Soil Bioengineering and Landscape
Planning, University of Natural Resources and Applied Life Sciences, Vienna
2000 - present University Assistant, Institute of Soil Bioengineering and Landscape
Construction, Department of Civil Engineering and Natural Hazards,
University of Natural Resources and Applied Life Sciences, Vienna

Selected Publications
Rauch H.P., Lammeranner W., Niederschick M., Stangl R., Florineth F., Rachoy C. (2008): A
decision guidance for the implementation of soil bioengineering techniques. In:
Interpraevent (Hrsg.), 11th Congress Interpraevent 2008, Mikos M., Hübl J. (Eds.),
In: Institute of Engineering, Tribhuvan University, Kathmandu, Nepal, Workshop on
Soil Bioengineering Experiences and Practices - Challenges to Implementation ,
Workshop proceedings, Workshop on Soil Bioengineering Experiences and Practices
- Challenges to Implementation, 8.10.2007, Kathmandu.
Europe. In: Institute of Engineering, Tribhuvan University, Kathmandu, Workshop on
Soil Bioengineering Experiences and Practices - Challenges to Implementation ,
Workshop proceedings, Workshop on Soil Bioengineering Experiences and Practices
- Challenges to Implementation, 8.10.2007, Kathmandu.
Suraya Sharil, BSc, MSc

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Age: 30
Nationality: Malaysian

Academic Qualifications
BSc. Civil & Structural Engineering, Civil & Structural Engineering Department, Faculty of Engineering, Universiti Kebangsaan Malaysia, 2000.
MSc. Civil & Structural Engineering, Civil & Structural Engineering Department, Faculty of Engineering, Universiti Kebangsaan Malaysia

Brief Career Summary
2001 – 2004 Tutor, Civil & Structural Engineering Department, Faculty of Engineering, Universiti Kebangsaan Malaysia
2004 - 2007 Assistant Lecturer, Civil & Structural Engineering Department, Faculty of Engineering, Universiti Kebangsaan Malaysia
2007 - present On study leave whilst registered for PhD Programme at Cardiff University

Selected Publications
Dipl.-Ing. Thomas Schoneboom

Name: Thomas Schoneboom
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             Technische Universität Braunschweig
             Beethovenstr. 51a, 38106 Braunschweig, Germany.
             Telephone: +49-(0)531-3913986, Email: t.schoneboom@tu-bs.de
Date of Birth: 31st March 1979
Nationality: German

Academic Qualifications
Dipl.-Ing., Civil Engineering, Technische Universität Braunschweig,
Germany, 2005

Brief Career Summary
2005 – present Research Associate, Leichtweiß-Institut für Wasserbau, Technische
             Universität Braunschweig

Selected Publications
             Strömungsfeld. BAW-Workshop: Boden- und Sohlstabilität - Betrachtungen an der
             Schnittstelle zwischen Geotechnik und Wasserbau, 17.09.2004, Bundesanstalt für
             Wasserbau, Karlsruhe.
             of vegetation elements. ICHE 2008, Nagoya, Japan (accepted)
Dipl.-Ing. Walter Lammeranner

Name: Walter Lammeranner
Current Post: Research Assistant
Work address: Institut für Ingenieurbioleogie & Landschaftsbau
Department für Bautechnik & Naturgefahren
Universität für Bodenkultur Wien
Peter Jordan-Straße 82, A-1190 Wien.
Telephone: +43-1-47654-7315, Email: walter.lammeranner@boku.ac.at
Date of Birth: 5th December 1974
Nationality: Austrian

Academic Qualifications

Brief Career Summary
2003 – present Research Assistant, Institute of Soil Bioengineering and Landscape Planning, University of Natural Resources and Applied Life Sciences, Vienna

Selected Publications
Dafydd Huw Thomas, MSc, BSc

Name: Dafydd Huw Thomas
Current Post: Forest Hydrologist
Department: Talybont Research Station
Cefn Gethiniog
Talybont-on-Usk
Brecon
Powys
LD3 7YN
Date of Birth: 4th April 1978
Nationality: British

Academic Qualifications
MSc Environmental Water Management, University of Cranfield, Silsoe
BSc (Hons) Environmental Earth Science, University of Wales, Aberystwyth

Brief Career Summary
2000 – 2001 Neath Port Talbot County, GIS Technician, Borough Council
2002 Environment Agency, Flood Defence Officer
2002 – 2003 Parsons Brinckerhoff Ltd., Project Manager (Hydrology)

Current Key Work Areas
• Hydraulic and hydrological impact of woodland restoration on floodplains
• Educating and promoting the use of floodplain woodland as a “soft engineering” and sustainable approach to flood defence/alleviation
• Forestry Commission representative at meetings involved in flood defence, river basin planning and land use management.

Memberships
• Member (graduate) of the Chartered Institute of Water and Environmental Management (CIWEM)

Selected Publications
Please send the completed form by e-mail to the facility provider:
- CNRS Coriolis/LEGI Grenoble: Joel Sommeria, sommeria@coriolis-legi.org
- DHI Water & Environment: Jens Kirkegaard, jkj@dhigroup.com
- Hamburg Ship Model Basin (HSVA): Karl-Ulrich Evers, evers@hsva.de
- Norwegian University of Science and Technology (NTNU): Alexandra Neyts, alexandra.neyts@bio.ntnu.no

1. Title of the proposal:
   Water column stratification, phytoplankton diversity and consequences for resource use and productivity

2. Requested facility/facilities: NTNU - Sletvik Field station

3. Applicant's full name and title (User Group Leader): Maren Striebel

4. Affiliation
   (name and full postal address of the applicant's institution, including department or school):
   Aquatic Ecology Group; Department Biology II; Ludwig-Maximilians-University Munich
   Großhaderner Str. 2 ; 82152 Planegg-Martinsried; Germany
   Female
   Tel.: 0049 89 218074213
   Fax.: 0049 89 218074211
   E-mail: Striebel@zi.biologie.uni-muenchen.de
   Web-site: http://www.biologie.uni-muenchen.de/ou/ ecology/aquat_e/index.html

5. Full name, titles, positions in institution, nationalities and gender of all other persons participating in the project (NB: only users who intend to access the facilities!):

<table>
<thead>
<tr>
<th>Name, titles and affiliation</th>
<th>Position</th>
<th>Nationality</th>
<th>M/F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr. Robert Ptacnik</td>
<td>Research Scientist</td>
<td>German</td>
<td>M</td>
</tr>
<tr>
<td>Norwegian Institute for Water Research</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stephan Behl</td>
<td>Research assistant and PhD student</td>
<td>German</td>
<td>M</td>
</tr>
<tr>
<td>Department Biology II, LMU Munich</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maria Stockenreiter</td>
<td>Research assistant and PhD student</td>
<td>German</td>
<td>F</td>
</tr>
<tr>
<td>Department Biology II, LMU Munich</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Florian Haupt</td>
<td>Research assistant and PhD student</td>
<td>German</td>
<td>M</td>
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<tr>
<td>Department Biology II, LMU Munich</td>
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<td></td>
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<tr>
<td>Dr. habil. Stephen Wickham,</td>
<td>Assistant Professor</td>
<td>Canadian</td>
<td>M</td>
</tr>
<tr>
<td>Dept. of Organismic Biology, University of Salzburg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prof. Dr. Ulrike-G. Berninger</td>
<td>University Professor</td>
<td>German</td>
<td>F</td>
</tr>
<tr>
<td>Dept. of Organismic Biology, University of Salzburg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PD Dr. Herwig Stibor</td>
<td>Assistant Professor</td>
<td>Austrian</td>
<td>M</td>
</tr>
<tr>
<td>Department Biology II, LMU Munich</td>
<td></td>
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</tr>
</tbody>
</table>

HYDRALAB-III is an I3 within the Research Infrastructures Programme of FP6

Contract No:RII3-CT-2006-022441

10 June 2008

page 1
6. Names and access period of those that made use of the access program to this facility in previous EC framework programs:

Dr. Herwig Stibor: August-October 1999, August-October 2001, August-October 2003; Maren Striebel: August-October 2003

7. Estimated number of access days requested; this includes the time needed for building the test setup, testing and calibration when necessary, experiments, and removal of the test setup:

30 days

8. Estimated total number of the visiting person-days

(sum of the days of presence at the installation of all the members of the visiting team);

210 person-days

9. Most appropriate period for the experiments?

Are there any constraints for the period when you may or may not perform the experiments?

Preferred period: June - September

10. Tentative list of instrumentation requested (contact us for information; if you also use your own instruments, please give the characteristics)

Requested instruments: Raft and mesocosm infrastructure, boat, equipment for nutrient analyses, fluorometer,

Own instruments: Filtration bench (24-units), inverse microscopes (Leitz DMP1) and stereoscopic microscopes (Leitz MZ5), light probe (LiCor 205), FlowCam flowcytometer, pumps for compressed air to manipulate enclosure water column stratification, sampling equipment, epifluorescence microscope (Nikon eclipse 50i)
11. Description of the proposed work (maximum of four A4 pages).

Scientific context, theoretical framework and methodology

Stratification and diversity
The seasonal stratification of water columns determines the general availability of the resources light and nutrients for phytoplankton growth (Diehl 2002; Diehl et al. 2002). Experiments manipulating the depth of mixing layers and/or the mixing intensity showed that these physical parameters strongly affect phytoplankton primary production by influencing phytoplankton light exposure and affecting phytoplankton mortality by sedimentation (Diehl 2007; Jäger et al. 2008). However, seasonal stratification can be affected and disturbed by -seasonal effects such as strong rain and wind events. Hence, disturbances of water column stratification imply disturbances for phytoplankton dynamics since it causes alterations in the relative supply of light and nutrients (Flöder & Sommer 1999). According to ecological theory, the frequency of disturbance strongly affects the diversity of biological communities (Huston 1994). Whether disturbances increase or decrease the diversity of a community also depends on the productivity and the resource supply rate (Huston 1994). In environments with low nutrient supply, the same disturbance may have opposing effects on phytoplankton communities as compared to environments with high nutrient supply. This important interaction between disturbances and nutrient supply rate is, however, seldom considered in investigations of disturbance effects on plankton communities.

Diversity and resource use efficiency
Environmental effects on phytoplankton diversity will have extensive consequences extending beyond changes in species composition. A recent metaanalysis including about 3000 freshwater and brackish phytoplankton samples shows that diversity is the best predictor for the resource use efficiency (and thereby carbon production) and the stability of the resource use efficiency in phytoplankton communities (Ptacnik et al. 2008). Consequences of these findings are that in less diverse communities resources may be more easily monopolized by bloom forming species and that phytoplankton – zooplankton interactions are less stable, possibly hampering trophic transfer (Ptacnik et al. 2008). Based on data from experiments with natural algal communities from 46 lakes and 30 laboratory cultures we demonstrated experimentally that the efficiency of using the resource light, the carbon production and the biomass composition (carbon to nutrient ratio) of freshwater phytoplankton communities is indeed related to diversity (Striebel et al. 2008).

The carbon to nutrient ratio of phytoplankton in turn is an important parameter determining nutrient recycling, transfer efficiency between phytoplankton and zooplankton, stability of phytoplankton - zooplankton interactions and diversity of zooplankton communities (Urabe & Sterner 1996; Sterner et al. 1997; Urabe et al. 2002).

Therefore, disturbance mediated effects of diversity on resource use and biomass stoichiometry of phytoplankton communities can have major impacts on the functioning of the entire pelagic ecosystem. We propose to analyze these un-investigated links between disturbances of water column stratification and diversity and its consequences for marine plankton dynamics in a gradient of disturbances at different nutrient supply rates in a large scale mesocosm experiment.

Scientific aims:

We hypotheses that experimental disturbances of water column stratification will have consequences for phytoplankton diversity and thereby affect the resource use efficiency and carbon production of phytoplankton and phytoplankton – zooplankton interactions.
The objectives of our study are as follows:

1) To analyse the relationship between disturbance of water column stratification and phytoplankton diversity
The relationship between water column stratification, rate of disturbance and phytoplankton diversity has been studied to some detail in freshwater environments. However, there is a considerable lack of evidence for marine environments. Closing this gap of knowledge would allow generalizing possible relationships between stratification disturbances and phytoplankton diversity in pelagic environments.

2) To analyse the relationship between phytoplankton diversity and diversity dependent resource use efficiency, the stability of resource use efficiency and carbon production
Data from meta-analyses and experiments clearly demonstrate that species diversity is one of the best predictors of the resource use efficiency and the carbon dynamics of phytoplankton communities in freshwater and brackish environments. It is surprising that, despite the global importance of marine phytoplankton (responsible for about 50% of global carbon production!), the relationship between phytoplankton diversity and carbon dynamics has not been investigated in marine environments. Our experiments will result in a first data set showing how species diversity, resource use efficiency and carbon production are linked within a marine phytoplankton community.

3) To analyse the relationship between diversity dependent carbon dynamics of phytoplankton and zooplankton growth
The carbon content and the carbon to nutrient ratio of phytoplankton biomass are most important for zooplankton growth. In freshwater experiments it has been shown that phytoplankton diversity influences carbon assimilation and nutrient uptake unequally. This results in phytoplankton diversity dependent shifts in the carbon to nutrient ratio within phytoplankton biomass, influencing phytoplankton food quality for zooplankton. We will investigate the link between disturbances of the water column, phytoplankton diversity and its consequences for zooplankton growth in a marine pelagic community.

4) To analyse the relationship between disturbance and the growth and diversity of ciliates
Ciliates have population growth rates equalling or exceeding those of phytoplankton. As a result, the response to disturbance of phytoplankton in ciliate-edible size classes may be masked by changes in abundance and diversity of their ciliate grazers. Our experiments will show how rapid changes in the grazer community can influence the impact of disturbance on primary producers.

5) To analyse the relationship between disturbance of water column stratification and the abundance and diversity of mixotrophic protists
The exact mechanisms controlling the abundance and diversity of mixotrophic protists and their contribution as producers and consumers to the carbon flow are still poorly understood. Changes in water column stratification and the resulting (hypothesized) abiotic and biotic changes are likely to also affect the mixotrophs in the mesocosms. These direct and indirect effects will be investigated in our experiments.

Proposed analysis of the results:

We will analyse five links within our dataset of experimentally manipulated marine phytoplankton communities:
1- The link between stratification disturbance and diversity.
2- The link between phytoplankton diversity, resource use efficiency, stability and carbon dynamics.
3- The link between phytoplankton diversity, carbon dynamics and zooplankton growth.
4- The link between phytoplankton diversity and ciliate diversity and biomass.
5- The link between stratification disturbance and the taxonomic and functional diversity and mixotrophic protists

We will use the results from microscopic enumeration and classification of heterotrophic, mixotrophic and photoautotrophic protists, carbon incorporation measurements, bacterivory experiments, dissolved and particular nutrient analyses and zooplankton egg production and somatic growth experiments to analyse the above mentioned links.

Analyses will be performed using classical methods of regression- and variance analyses.

**Publication plan:**

Counting of plankton samples and the exact analyses of the results will need about 6 month. We plan to publish a first paper originating from the experiment within one year after its completion in an international peer reviewed journal such as Limnology and Oceanography or Marine Ecology Progress Series

**Justification for access:**

The Trondheim Research Infrastructure (Sletvik field station) provides excellent conditions to perform marine field enclosure experiments in an easy, cost saving and well controlled way in a sheltered coastal lagoon but still with the full inventory of North Atlantic phyto- and zooplankton. Additionally, the group has already experience in performing large mesocosms experiments in Sletvik field station and in the cooperation with NTNU working groups. Several members of our group have large expertise in working with North Atlantic plankton communities, which is an important prerequisite to perform and analyse the proposed experiments.

**Role of team members:**

**Maren Striebel:** team leader, will plan and coordinate the experiments; has experience with North Atlantic plankton communities (Stibor et al. 2006a, Striebel et al. 2008).

**Robert Ptacnik:** high experience with analyses of effects of diversity on phytoplankton communities (Ptacnik et al. 2003; Ptacnik et al. 2004; Ptacnik et al. 2008), will perform and analyze field experiments.

**Stefan Behl:** well experienced in experimental plankton ecology and analyses of plankton experiments (Striebel et al. 2008), will perform laboratory growth experiments (egg production).

**Florian Haupt:** well experienced in experimental plankton ecology and in performing and analyzing zooplankton experiments, will perform laboratory growth experiments (somatic growth).

**Maria Stockenreiter:** well experienced in experimental plankton ecology, experience in performing and analyzing phytoplankton experiments, will analyze field phytoplankton samples.

**Herwig Stibor:** experience with marine mesocosms experiments (Vadstein et al. 2004, Stibor et al. 2004a; Stibor et al. 2004b; Sommer et al. 2005; Stibor et al. 2006b) will perform special measurements such as primary production and respiration of plankton communities.

**Stephen Wickham:** well experienced in experimental plankton ecology in both freshwater and marine systems (Wickham et al. 2004; Wickham and Berninger 2007), will identify and enumerate ciliates from the experiments.

**Ulrike-G. Berninger:** well experienced in experimental investigation of mixotrophic protists and protistan bacterivory (Sanders et al. 2000, Moorthi and Berninger 2006) will perform experiments to identify mixotrophs.
References


12. Technical details and specifications of the planned experiments (maximum of one A4 page)

Mesocosm experiments with natural algal communities

We will study the responses of a natural coastal phytoplankton community to manipulations of the stratified water column. We will install 24 enclosures (12m depth) and disturb the stratification of the water column by artificially mixing the water column with compressed air with different time intervals (1-8 days). Undisturbed mesocosms will act as the least disturbed mesocosms in the gradient. We will perform the experiments at two nutrient levels, a low (0.5 µg P l⁻¹ d⁻¹) and a moderate to high supply level (2.5 µg P l⁻¹ d⁻¹) compared to the natural loading of the system (Vadstein et al. 2004). We will follow the response of the phytoplankton, protist (ciliate and flagellate) and zooplankton communities to stratification disturbances for 4 weeks. We are especially interested in the consequences of stratification disturbances for phytoplankton diversity and thereby phytoplankton resource use efficiency and carbon dynamics. Measurements will include phytoplankton and zooplankton composition and dynamics, nutrient dynamics, phytoplankton stoichiometry and resource use efficiency. Additionally, phytoplankton from the different treatments will be fed to zooplankton in controlled laboratory growth experiments to calculate trophic transfer efficiencies. Experiments, quantifying bacterial uptake by heterotrophic and mixotrophic protists will be performed.

Laboratory growth experiments

We will perform zooplankton growth experiments during the last two weeks of the mesocosms experiments. Copepod species (Temora, Acartia) will be collected in Hopavågen and incubated in 200 ml bottles containing water from the different mesocosms treatments which will be changed daily. We will follow egg production of the copepods over 14 days. Additionally, eggs from laboratory copepod cultures (Acartia tonsa, supplied by the Institute for Marine Sciences, Kiel, Germany) will be hatched and somatic growth of juvenile copepods cultured with water from the different mesocosms treatments (200 ml bottles, daily exchange) will be quantified according to standard methodology.

Analyses

Phytoplankton species composition, phytoplankton stoichiometry (particulate organic carbon (POC) particulate organic nitrogen (PN) and particulate organic phosphorus (PP); filtration with GF-F filters) and nutrients will be analysed at the start of the experiment and afterwards, twice a week. Phytoplankton will be enumerated from samples fixed with Lugol’s iodine and with an inverted microscope using Utermöhl chambers. Phytoplankton biovolume will be determined using a cell counter (Casy® Counter). Primary productivity of the different phytoplankton communities will be determined with the 14C method. Detailed pigment analyses will be performed with HPLC to see whether taxonomic diversity is coupled with pigment diversity (functional diversity). Zooplankton and ciliate abundance and species composition and zooplankton biomass composition (POC, PP, PN) will be analysed twice a week. Mixotrophic protists will be identified microscopically (ciliates, dinoflagellates) or experimentally (nanoflagellates, via bacterivory).
NAME: MAREN STRIEBEL

DATE OF BIRTH: 30.04.1979; ULM, GERMANY

ACADEMIC EDUCATION

September 1998- August 2000  Basic study period in biology at University Ulm

August 2000- July 2004 Main study period in biology at Ludwig-Maximilians-Universität (LMU) Munich.
Diploma thesis: “The Influence of mixing depth on phytoplankton-Daphnia interactions with focus on the phytoplankton” (in german)

July 2004 Diploma in Biology

July 2004 – October 2005 Research assistant at LMU Munich during AQUASHIFT (DFG founded project);
Teaching assistant in various courses in ecology: Plankton ecology, Experimental plankton ecology, Basal course Ecology and Evolutionary Biology

November 2005 - present PhD studies at Ludwig-Maximilians-Universität Munich, Department Biology II, Aquatic Ecology; advisor: PD Dr. Herwig Stibor (DFG founded project)

PUBLICATIONS


PRESENTATIONS

ASLO summer meeting 2005, Santiago de Compostela.
Poster: Light-nutrient ratios and phytoplankton-zooplankton dynamics in lakes of different trophic status; ASLO poster award.

DGL Jahrestagung 2006, Dresden.
Talk: Licht-Nährstoff Verhältnisse und Phytoplankton-Zooplankton Dynamiken in verschiedenen nährstoffreichen Seen.

SIL Congress 2007, Montreal.
Talk: The effect of diversity on light mediated changes in phytoplankton production and stoichiometry: A laboratory experiment.

CLIMAX Master Class 2007, Amsterdam.
Talk: Light induced changes of plankton growth and stoichiometry: Experiments with natural phytoplankton communities.

Poster: The effect of diversity on light mediated changes in phytoplankton production and stoichiometry: A laboratory experiment.
CURRICULUM VITAE

NAME: STEPHAN BEHL
DATE OF BIRTH: 30.07.1980 IN ASCHAFFENBURG, GERMANY

ACADEMIC EDUCATION

October 2001- December 2006
Studies in biology at Ludwigs-Maximilians-Universität München (LMU Munich)
Main subject: Ecology; minor subjects: Anthropology, Human Genetics, Zoology and Systematic Botany
Diploma thesis: „Effects of species diversity on light and nutrient utilisation by phytoplankton“ (in german)

December 2006
Diploma in Biology

January 2007 – Mai 2007
Research assistant at the Aquatic Ecology Group, LMU Munich

June – August 2007
Research assistant for a field investigation project of the German Primate Center in the Amazonian rain forest, Peru

Since September 2007
Research assistant and PhD studies at Ludwigs-Maximilians-Universität München, Department Biology II, Aquatic Ecology,
Advisor: PD Dr. Herwig Stibor

PRESENTATIONS, POSTERS AND PUBLICATIONS


Behl, S. The effect of diversity on light mediated changes in phytoplankton production and stoichiometry: Laboratory and field experiments. Oral presentation. 1st EES conference 2007, Munich.


CURRICULUM VITAE

NAME: Maria Stockenreiter
DATE OF BIRTH: 10.02.1980 in Rosenheim

ACADEMIC EDUCATION

October 2000- September 2002 Studies in chemistry at Ludwig-Maximilians-Universität München (LMU Munich)
October 2002- June 2007 Studies in biology at Ludwig- Maximilians- Universität München (LMU Munich)
Main subject: Ecology; minor subjects: Zoology and Neurobiology
Diploma thesis: “Influence of diel vertical migration (DVM) of Daphnia hyalina on phytoplankton” (in german)
June 2007 Diploma in Biology
June 2007- January 2008 Research assistant at Ludwig- Maximilians- Universität München, Department Biology II, Aquatic Ecology
Since April 2008 PhD studies at Ludwig- Maximilians- Universität München, Department Biology II, Aquatic Ecology.
Advisor: Dr. Herwig Stibor.
PhD thesis: Optimizing lipid production by planktonic algae

PRESENTATIONS AND POSTERS


PUBLICATIONS

CURRICULUM VITAE

NAME: FLORIAN HAUPT
DATE OF BIRTH: 09.04.1978

ACADEMIC EDUCATION
November 1998 - December 2004
Studies in biology at Ludwigs-Maximilians-Universität München (LMU Munich)
Main subject: Ecology
Minor subjects: Zoology; Informatics; Landscaping and nature conservation (TU Munich)
Diploma thesis: “The influence of mixing depth on phytoplankton-daphnia-interactions with focus on the zooplankton” (in german)

December 2004
Diploma in Biology

Since June 2006
PhD studies at Ludwigs-Maximilians-Universität München, Department Biology II, Aquatic Ecology, Advisor: Dr. Herwig Stibor
PhD thesis: “Effects of daphnia vertical migration on phytoplankton communities”

ORAL PRESENTATIONS


Haupt F., M. Stockenreiter, M. Baumgartner, M. Boersma, H. Stibor. Does diel vertical migration of daphnia influence the phytoplankton community structure? SIL international meeting, August 2007, Montreal, Canada.


PUBLICATIONS

CURRICULUM VITAE  STEPHEN A. WICKHAM

Organismal Biology, University of Salzburg
Tel.: +43-662 8044 5603    Fax: + 43-662 8044 5698
e-mail: steve.wickham@sbg.ac.at

CITIZENSHIP: Canadian   BIRTHDATE: 9 October 1959

EDUCATION:
•  B.Sc.  University of Toronto, 1983

PROFESSIONAL EXPERIENCE:
•  Universität Assistant (Assistant Professor), Dept. of Organismal Biology, University of Salzburg, Jun. 2003 – present.
•  Oberassistent (senior Assistant Professor), Zoological Institute, University of Cologne, Oct. 1999 – May 2003
•  Wissenschaftlicher Assistent (junior Assistant Professor), Zoological Institute, University of Cologne, Oct. 1997 - Oct. 1999
•  Guest Scientist, Max-Planck Institute for Limnology, 1992-94
•  Research Associate, Department of Biological Sciences, Dartmouth College, 1989-92
•  Research Assistant, University of Oklahoma Biological Station, 1986-87, 1988 -1989

PROFESSIONAL SERVICES
•  Suporvisor of 8 Diploma (MSc) and 4 PhD-theses, regular referee work for scientific journals and grant agencies.

GRANTS
•  9 national and international peer reviewed research grants

RECENT PUBLICATIONS
ULRIKE-G. BERNINGER

Organismal Biology, University of Salzburg
Tel.: +43-662 8044 5647 Fax: + 43-662 8044 5698
e-mail: ulrike.berninger@sbg.ac.at

CITIZENSHIP: German
BIRTHDATE: 28 January 1961

EDUCATION:
• 1980-1986: University of Hannover (D), "First Staatsexamen" in Biology and English
• 1986: University of Hannover and Institute of Freshwater Ecology (UK), "Examens"- Thesis: DNA Investigations on the microfauna in a productive pond with special consideration of the ciliates
• 1987-1990: Free University of Berlin (D) and Institute of Freshwater Ecology, Ph.D. Dissertation: The Functioning and Significance of Microbial Food Webs in Freshwater Environments
• 1998: Veterinary Highschool of Hanover (D), Habilitation: Occurrence and ecological significance of free-living protists in pelagic and benthic habitats

PROFESSIONAL EXPERIENCE:
• Mar 2003 - present: University Professor, Dept. of Organismal Biology, University of Salzburg (A)
• 2000 – 2003: Senior scientist, Alfred-Wegerner Institution for Polar- and Marine Research (D)
• 1997 – 2000: "Hochschuldozentin", Institut für Meereskunde, Universität Kiel (D)
• 1992 – 1997: Scientist, Max-Planck Institute for Marine Microbiology, Bremen (D)
• 1990-1992: PosDoc at Woods Hole Oceanographic Institution (USA)

PROFESSIONAL SERVICES
• Supervisor of 16 Diploma (MSc) and 4 PhD-theses, Associate Editor (Marine Biology), regular referee work for scientific journals and grant agencies, Vice Dean of the Faculty of Natural Sciences, University of Salzburg.

GRANTS
• 6 national and international peer reviewed research grants

RELEVANT PUBLICATIONS
Curriculum Vitae

Herwig Stibor, male
Birth: 08.04.1967, Salzburg
Citizenship: Austria
Marital status: married, two children
Home Address: Baumhau 1, D-85665 Moosach, Germany.
Tel.: 0049 (0) 8091 567262

information in freshwater predator-prey systems”. Advisor: Prof. Dr. Winfried Lampert
2003: University of Munich, Germany: Venia legendi (Habilitation) in Ecology and Zoology

Sciences, Kiel, Germany (Department of Experimental Ecology, Prof. Dr. Ulrich Sommer).
Participation in the European Union funded project COMWEB (COMPARATIVE ANALYSIS
OF FOOD WEBS BASED ON FLOW NETWORKS) which included extended research stays
in Norway, Spain and Finland.
Since 12/1998: Assistant professor C1, Department Biologie II, University of Munich,
Germany.
Since 12/2004: Assistant professor C2, Department Biologie II, University of Munich,
Germany

Professional Services: Supervisor of 20 diploma- and 5 Ph.d theses; referee work for 12
scientific journals and 4 grant agencies; chief officer for radiation security at LMU München;

Grants: 13 national and international peer reviewed research grants

Publications: 39 publications in peer reviewed scientific journals; numerous talks at national
and international conferences. Relevant recent publications:

- Stibor, H., Vadstein, O., Diehl, S., Gelzleichter, A., Hansen, T., Katechakis, A., Lippert, B., Løseth,
  K., Peters, C., Roederer, W., Sandow, M., Sundt-Hansen, L., & Olsen, Y. 2004. Copepods act as a

- Sommer, U., Hansen, T, Blum, O., Holzner, N., Vadstein, O., & Stibor, H 2005.Copepod and
  microzooplankton grazing in mesocosms fertilised with different Si:N ratios: no overlap between food
  spectra and Si:N influence on zooplankton trophic level. Oecologia 142: 274-281

- Olsen, Y., Agusti, S., Andersen, T., Duarte, C.M., Gasol, P., Gismervik, I., Heiskanen, A-S., Hoell,
  E., Kuuppo, P., Lignell, R., Reinertsen, H., Sommer, U., Stibor, H., Tamminen, T., Vadstein, O.,
  Vaqué, D., & Vidal, M. 2006. A comparative study of responses in plankton food web structure and
  function in contrasting European coastal waters exposed to experimental nutrient addition. Limnology
  and Oceanography, 51:488-503.

  Combining dialysis and dilution techniques to estimate gross growth rate of phytoplankton and grazing

- Striebel, M., Spörl, G., & Stibor, H. 2008. Effects of light on plankton stoichiometry and zooplankton
  growth: experiments with phytoplankton communities from different nutrient rich lakes. Limnology and

  pelagic producer – grazer systems in a gradient of nutrients and mixing depths. Ecology 89: 1272-
  1286.
Curriculum Vitae Robert Ptacnik

* 1972 in München, Germany; married, two children.

Phytoplankton-ecologist at the Norwegian institute for Water Research (NIVA), Oslo

**PhD**

May 2000 -June 2003 at the Institute for Marine Research, Kiel, Germany (magna cum laude).

Title of thesis: 'Omnivory in planktonic food webs: A study on the impact of mixotrophic flagellates and microzooplankton on food web dynamics and productivity'.

**Projects (involved; NIVA only)**

- THRESHOLDS (2005-2008): Thresholds for sustainability in coastal ecosystems. (modeling and development of indicators for phytoplankton nutrient limitation)

**Selected publications**


**Professional Organizations**

- American Society of Limnology and Oceanography (ASLO).
- Nordic phytoplankton and periphyton group (NPPG)
Please send the completed form by e-mail to the facility provider:

- CNRS Coriolis/LEGI Grenoble: Joel Sommeria, sommeria@coriolis-legi.org
- DHI Water & Environment: Jens Kirkegaard, jki@dhigroup.com
- Hamburg Ship Model Basin (HSVA): Karl-Ulrich Evers, evers@hsva.de
- Norwegian University of Science and Technology (NTNU): Alexandra Neyts, alexandra.neyts@bio.ntnu.no

1. Title of the proposal
   EXTREME WAVES IN DIRECTIONAL WAVE FIELDS TRAVERSING UNIFORM CURRENTS

2. Requested facility/facilities:
   MARINTEK OCEAN BASIN

3. Applicant's full name and title (User Group Leader)
   Jaak Monbaliu, Ph.D., Professor

4. Affiliation
   (name and full postal address of the applicant's institution, including department or school):
   Hydraulics Laboratory
   Department of Civil Engineering
   Kasteelpark Arenberg 40
   K.U.Leuven
   postbus 2448
   3001 Heverlee
   BELGIUM
   Male/Female: Male
   Tel.: + 32-16-321661
   Fax.: + 32-16-321989
   E-mail: jaak.monbaliu@bwk.kuleuven.be

5. Full name, titles, positions in institution, nationalities and gender of all other persons participating in the project (NB: only users who intend to access the facilities!) (enlarge the table if necessary):

<table>
<thead>
<tr>
<th>Name, titles and affiliation</th>
<th>Position</th>
<th>Nationality</th>
<th>M/F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfred R. Osborne, PhD, Universita’ Torino, Italy</td>
<td>Professor</td>
<td>USA</td>
<td>M</td>
</tr>
<tr>
<td>Miguel Onorato, PhD, Universita' Torino, Italy</td>
<td>Researcher</td>
<td>ITALIAN</td>
<td>M</td>
</tr>
</tbody>
</table>
Luigi Cavaleri, Dr., Istituto di Scienze Matine – CNR, Italy

Alessandro Toffoli, PhD, Det Norske Veritas, Norway

Elzbieta M. Bitner-Gregersen, PhD, Det Norske Veritas, Norway

Michel Benoit, PhD, EDF R&D Laboratoire National d’Hydraulique et Environnement (LNHE), France

Fabrice Ardhuin, Ph.D., Hab., Service Hydrographique et Océanographique de la Marine, France

Alexander Babanin**, PhD, Swinburne University of Technology, Melbourne, Australia

**We include Alexander Babanin to the proposing team as scientific advisor. His specific role is explained in section (vii) below. However, it is not the intention that he will be present for the physical experiments and therefore none of the funding asked for to do this experiment will be used for him.

6. Names and access period of those that made use of the access programme to this facility in previous EC framework programmes:
   Jaak Monbaliu, Alessandro Toffoli - October 2007
   Miguel Onorato, Alfred Osborne, Luigi Cavaleri - February 2003, October 2007

7. Estimated number of access days requested; this includes the time needed for building the test setup, testing and calibration when necessary, experiments, and removal of the test setup:
   Depending on the time needed for testing and calibration and the preliminary tests, a reasonable number of access days would be from 12 to 15 working days.

8. Estimated total number of the visiting person-days
   (sum of the days of presence at the installation of all the members of the visiting team);
   We expect to have 4 persons per day for each day of test, therefore a total number of 60 person-days would probably be alright.

9. Most appropriate period for the experiments?
   Are there any constraints for the period when you may or may not perform the experiments?
   Our preferred test period would be starting from the last week of August 2009. In any case, the proposing team is quite flexible and mostly any time of the year would be alright if scheduled with some advance.

10. Tentative list of instrumentation requested (contact us for information; if you also use your own instruments, please give the characteristics)
    20 wave gauges, electronic current sensors, 6 probes to monitor the current in the presence of waves

11. Description of the proposed work (maximum of four A4 pages).
    This must specify the installation needed and should contain a brief description of:
The scientific objectives

Extreme waves represent a serious threat for marine structures. An accurate description of the statistical properties of the surface elevation can contribute to improvement of warning criteria for extreme waves in wave forecasting and to enhancing safety at sea in general [1]. There are many mechanisms that can lead to the formation of large amplitude waves and hence to a different shape of the probability density function of the surface elevation: for example, nonlinear processes such as the modulational instability [2-6], and wave-current interaction [7,8]. The present research intends to investigate the combined role of the modulational instability and wave-current interaction on the formation of extreme waves in two horizontal dimensions, when waves cross a steady current.

In absence of ocean currents, numerical and theoretical works [2-6] have demonstrated that nonlinear processes as the modulational instability have a relevant role in the formation of extreme waves, provided waves are sufficiently steep and narrow banded. Under these circumstances, large amplitude waves may occur within a fairly short scale of tens of wavelengths [4-6]. However, strong deviations from Gaussian statistics are only observed if waves are rather long crested i.e. the spectral energy is concentrated on a narrow range of directions. For short crested seas (broad directional distributions), the effect of modulational instability becomes less prominent and, as a result, the occurrence of extreme waves does not exceed predictions from linear or second-order theory [9,10]. Recently, a comprehensive analysis on the effect of directionality on the modulational instability has been carried out in the Marintek's directional wave basin (the same facility that we intend to use for the present research) by some of the participants of this proposing team under contract 022441 (RII3). Experimental results confirmed the existence of a transition region between strongly to weakly non-Gaussian wave fields as short crestedness increases [11]. This transition is determined by a balance between nonlinearity (which promotes non-Gaussian behaviour) and directionality (which suppresses non-Gaussian behaviour). Thus, if there are circumstances when the nonlinearity is locally enhanced, we can expect that non-Gaussian behaviour will persist at broader directional spreads.

In region of strong currents (for example, the Gulf Stream, the Agulhas Current and the Kuroshio Current), large amplitude waves can also be expected as a result of wave-current interaction; interesting, in this respect, are a number of ship accidents reported near the Agulhas Current, off the South African coast [7,8]. One possible mechanism that may lead to the formation of extreme wave events can be triggered when a current flows with opposite or oblique direction to incident wave trains. In these circumstances, if the current is strong enough, the wave energy is forced to coalesce in certain areas [8] with a consequent formation of large waves (caustic theory). In a random wave field, this may result in a substantial modification of the statistical distribution of the surface elevation [12]. Depending on the strength of the current, however, deviations from Gaussian statistics might require scales of thousands of wavelengths before appearing [12]. It is important to mention that previous studies have only considered the interaction between a linear wave field and a current, excluding therefore contributions from nonlinear mechanisms. According to the linear dispersion relation, however, the wavenumber increases in the process of the wave-current interaction for current opposing waves (see, e.g., [8]), even in the presence of relatively mild current conditions. Under adverse currents, waves become shorter with a consequent increase in wave steepness, making nonlinear processes, e.g. the modulational instability mechanism, more likely. Nonetheless, the role of nonlinear mechanisms on the statistical properties of the wave field, and hence the possible increase in the probability for the formation of extreme waves, is not yet clear under these circumstances. In the light of results of [11], however, it is reasonable to assume that, in such environment, non-Gaussian behaviour may persist at broader directional spreads.

A number of laboratory experiments have been undertaken to verify the behavior of regular and irregular waves when opposing a strong current (see, for example, [13]). Experimental results, though, have been obtained in wave flumes, where only long crested waves can be considered (i.e., one dimensional problem). Fewer experiments have dealt with waves crossing oblique currents [14]
but these have been confined to a study of the kinematics and linear properties. With the proposed research, we intend to access the directional wave basin facility at Marintek in order to address the more general two dimensional problem, where a multi directional wave field propagates obliquely over a uniform current in partial opposition. Our goal is to verify experimentally the role of increasing wave steepness due to wave-current interaction on the modulational instability mechanism, and hence the formation of extreme waves, within a wide range of wave directional spreading. In particular, we intend to verify whether the presence of a current could lead to the modulational instability of broad directional wave trains, which are expected to be stable in absence of a current. With such an experiment, it is our purpose to achieve a more complete understanding of the mechanisms forming extreme waves in more realistic ocean wave conditions, where waves and currents are present.

References

(ii) Test setup and test programme
In order for the experiment to be successful, the experimental facility must fulfill the following requirements:
a) the water must be deep enough in order to consider waves in infinite water depth;
b) the wave basin must be long enough in order for the modulational instability to develop (usually from random waves, the required length is around 30 wavelengths);

c) a directional wave maker is necessary in order to generate directional wave fields;

d) the wave basin must allow the generation of a steady current oblique to the wave field;

e) a large number (20-25) of wave gauges should be available to measure the surface elevation;

f) a number of electronic current sensors should also be available to monitor the current.

In this respect, the ocean basin at Marintek offers a unique opportunity to achieve the goal described above. The dimensions of the wave basin are large enough to assure that waves can undergo the modulational instability process. A multi-flap wave maker is able to generate directional wave fields for a wide range of directional spectra, ranging from long to short crested waves. Furthermore, a steady current can be generated by water circulation above and beneath a false floor within the basin. The current is parallel to the multi-flap wave maker. Therefore, only conditions of a directional wave field perpendicular and oblique to the current are feasible. However, we still believe that these experiments can contribute to a better understanding and statistical description of directional waves in the presence of a current.

There is no need to introduce any test model in the wave tank; we only require the largest number of wave probes available at Marintek. We intend to distribute the wave gauges at different distances (fetches) from the wave maker; we also intend to concentrate 6 wave gauges at a few metres from the wave maker and at a distance equivalent to about 15 and 25 wavelengths. This will allow to estimate the directional spectrum close to the wave generator and at locations where statistical properties are expected to be far from being Gaussian, measuring the combined effect of nonlinear mechanisms, directionality and wave-current interaction on the spectral shape. A number of instruments will also be deployed in order to monitor the current along the basin.

(iii) The methodology and programme of the work

The methodology of the experiment will be fairly simple. The idea will be to run different tests characterized by different Jonswap-type spectra with different angular spreading distributions (ranging from long to short crested) over a steady current. In the directional basin, the current can flow in the longitudinal basin direction, so that it crosses waves generated by the multi-flap wave maker. Moreover, specified mean wave direction can be superimposed; this would in principle allow the wave field to cross the current obliquely. The angle between waves and current should be properly chosen in order to limit reflection, since there is no beach on the left side of the basin, and in order to reduce shadow zones.

Our idea is to perform a first set of experiments characterized by the absence of the current to make sure that the experimental results previously obtained in the wave basin at Marintek will be recovered. Successive tests will then be characterized by the presence of a current. We plan to perform these experiments such that the angle between the mean wave direction and the current is equal to 110 degrees so that the wave field will be partially in opposition to the current; previous experiments with the aforementioned mean wave direction were already performed at Marintek without detecting significant reflection from the side wall. Under this wave-current configuration, we intend to tests at least 5 different wave fields characterized by different directional spreading ranging from long to short crested conditions, in order to understand the role of the wave directionality. At least two different wave steepness conditions will also be considered. As the knowledge of the statistical properties is the main target of the present study, we intend to repeat each experiment by changing random amplitudes and phases. In this respect, the idea is to perform five 20-minute runs with the same spectral conditions but different random amplitudes and phases in order to have enough samples to achieve statistically significant results.

Although a perpendicular configuration between waves and current should not lead to significant interaction, we also plan to run a few tests under this condition. Furthermore, it would
also be of interest to perform a few runs with an angle greater than 110 degrees (for example, 130 degrees), even though it is outside the optimal basin conditions; to this end, some preliminary tests will be essential to verify the influence of reflection at the measurement locations. At least two or three different wave directional spreading conditions should be tested.

We have estimated that considering waves with period of 1 second (i.e. wavelength of 1.5 metres in deep water) modulational instability should appear at around 30 meters from the wave maker (in the absence of current). Therefore, our experiments will be performed with a dominant period of 1 second. We also intend to use the wave current at its maximum speed, which is about 0.2 m/s for deep water conditions. Using linear dispersion relation, we estimated that the wave-current interaction can produce an increase in wave steepness of about 10-15%.

We plan to perform our experiments in a maximum of 15 working days. First 3-4 days will be used to test the available software to generate directional spread waves and for properly placing the probes in the wave tank and perform preliminary tests (including a few runs with monochromatic waves); particular attention will be given to evaluate the reflection from side walls, which could be done by reconstructing directional wave spectra from the 6-gauge arrays. The random experiments will probably last no longer than 8-10 days.

(iv) Proposed analysis of the results

The present project has the role of studying the probability of occurrence for extreme waves in realistic sea state conditions. Therefore, the analysis will be concentrated on the statistical properties of the recorded data. In particular, we intend to compute the probability density function of the surface elevation and its third and fourth order moments (skewness and kurtosis respectively), as well as the probability distribution of wave heights and wave crests. The directional spectrum and its evolution along the basin will also be estimated from the experimental data.

(v) Publication schedule

The results of the proposed experiments will be presented in a number of international journal and conference publications.

(vi) The expected benefits from the use of the large installation

Everyday, operational forecasting centres (such as the European Centre for Medium Range Weather Forecast) provide the forecast of the significant wave height, the direction of propagation and the dominant wave period of the waves (all these quantities are computed from the directional spectrum). We expect that our work will give a contribution to improve the forecast of extreme waves. Furthermore, these results will also represent an important contribution to the design and operation of marine structures, when located or operating in regions of strong current.

(vii) The proposing team

The present proposing team gathers highly qualified ocean wave scientists and researchers from different countries and institutions. The team includes specialized researchers in nonlinear waves, wave-current interaction, wave statistics, operational wave forecasting, experimental oceanography and numerical simulations. Alexander Bababin is added to the team because of his extensive work and specific expertise on the estimation of directional wave properties, and concurrent analysis and interpretation, from arrays of wave gauges. The estimation of the directional properties in the wave basin, in fact, represents a rather crucial task in the experiment as it will be used to estimate the amount of reflection from the side wall and hence to support the deployment of wave gauges in reflection-free areas. Each of the senior members of the proposing group has been working in the field of extreme waves, each with different perspectives. The coalescence of all these highly specialized researchers makes the present team unique and suitable for performing the proposed experiment and successively analyzing the data.
12. Technical details and specifications of the planned experiments (maximum of one A4 page)

The planned experiments only requires the generation of specified wave fields. No additional tests models are therefore required. The initial spectral conditions at the wave maker should the respect the following conditions:

a) the spectral conditions in the frequency domain must be represented by a JONSWAP spectrum with peak period of 1 s. The peak enhancement factor will be equal to 3 and 6 and Phillips parameter will be set equal to 0.014 and 0.016 respectively; this configuration will allow the initial wave steepness to be equal to 0.13 and 0.16 (without current).

b) the directional distribution should be described using a $\cos^N(\theta)$ (frequency-independent) function, where the coefficient N assumes the following values: 840; 200; 90; 50; 24. A broader spreading condition with N equal to 4 should also be tested if it does not generate too much reflection from the side walls (especially at places where the instrumentations are deployed);

c) the mean wave direction must be chosen so that it forms an angle of 110 degrees with the direction of the current; tests with angle of 90 and 130 degrees are also planned.

d) The current should be run at its maximum speed, i.e. 0.2 m/s.

We also require that the water depth is set to 3 m, which is deep enough to consider the waves in infinite depth, but shallow enough to deploy the wave gauges. We intend to perform a few tests in order to decide the more appropriate locations where deploying the instruments, especially to avoid effects related to reflection.

Appendix (please provide in a separate file)
CV of each group member (max 1 page per person)
Fabrice ARDHUIN

Born April 23, 1975, Carcassonne, France. Married, one child.

Address: 13 rue du Chatellier, 29609 BREST Cedex, France
Tel: 02 98 14 99 36, Fax: 02 98 22 18 64. Email: arduin@shom.fr

Education 1997: M.Sc., Ecole Polytechnique, Palaiseau, France

Position 2001- : Researcher / project manager at the French Navy Hydrographic and Oceanographic Service.

1999: “outstanding student paper award”, Fall AGU general assembly, San Francisco for work on wave dissipation due to bottom friction.
2000: “outstanding student paper award”, Fall AGU general assembly, San Francisco for work on the scattering of waves by random bottom topography.
2008: Nicholas P. Fofonoff Award from the American Meteorological Society “For theoretical and observational research on the interaction of ocean surface waves with the sea floor and ocean currents, and developing accurate coastal wave prediction models.”
2008: Journal of Physical Oceanography Editor’s Award “For many wellconsidered, constructive, and timely reviews.”

Research interests: ocean wave dynamics and wave interactions with the bottom and water column (wave-current-turbulence interactions), numerical wave modelling and forecasting (http://www.previmer.org/previsions/vagues), remote sensing, exotic but useful applications of wave models.

Selected publications (out of 27 peer-reviewed journal papers, H-index: 7):

Chapron, B., F. Collard et F. Ardhuin, 2005, Direct measurements of ocean surface velocity from space: interpretation and validation, JGR, 110, C07008.


CURRICULUM VITAE
Alexander V. Babanin
September 2008

POSITION:
Associate Professor
Faculty of Engineering and Industrial Sciences
Swinburne University of Technology

ADDRESS:
H38, PO Box 218, Hawthorn, VIC 3122, Australia
E-mail: ababanin@swin.edu.au
Tel.: +61-3-9214-8033; Fax: +61-3-9214-8264

EDUCATION:
● BSc Physics (1983) Lomonosov Moscow State University, Russia
● MSc Physical Oceanography (1983) Lomonosov Moscow State University, Russia
● PhD Physics and Mathematics (1990) Marine Hydrophysical Institute, Sebastopol, Russia

PROFESSIONAL EXPERIENCE:
● March 1983 to September 1986: Engineer, Marine Hydrophysical Institute, Sebastopol, Russia
● September 1986 to November 1990: Junior Scientist, Marine Hydrophysical Institute, Sebastopol, Russia
● November 1990 to July 1994: Research Associate, Marine Hydrophysical Institute, Sebastopol, Russia
● July 1994 to November 1996: Senior Scientist, Marine Hydrophysical Institute, Sebastopol, Russia
● November 1996 to April 1997: Honorary Visiting Fellow, School of Mathematics, The University of New South Wales, Sydney, Australia
● April 1997 to September 2000: Research Associate, School of Civil Engineering, University College, The University of New South Wales, Canberra, Australia
● April 2000 to February 2001: Study Leave, University of Miami, Florida, USA
● October 2001 to March 2004: Research Fellow, School of Civil and Environmental Engineering, The University of Adelaide, Adelaide, Australia
● April 2004 to December 2006: Senior Lecturer, School of Engineering and Science, Faculty of Engineering and Industrial Sciences, Swinburne University of Technology, Melbourne, Australia
● January 2007 – present: Associate Professor, Faculty of Engineering and Industrial Sciences, Swinburne University of Technology, Melbourne, Australia
● February 2008 to July 2008: Sabbatical Leave, Potsdam Institute for Climate Impact Research, Potsdam, Germany

SELECTED PUBLICATIONS:
● Toffoli, A., M. Onorato, E. Bitner-Gregersen, A.V. Babanin, 2008: Wave crest and trough distributions in a broad-banded directional wave field, Ocean Engineering, accepted on the 14th of August
Curriculum vitae of Michel Benoit

Surname BENOIT
Given name Michel
Date of birth August 5th, 1966
Nationality French
Present position Senior scientist of EDF R&D (since December 2007)
Director of Saint-Venant Laboratory for Hydraulics (Université Paris Est, common research unit between EDF R&D, Ecole des Ponts ParisTech, CETMEF).

Education and degrees:
- Civil Engineer of “Ecole Centrale Paris” (Specialty “Ocean”) – Paris, France (1989)
- University grade of assistant professor from the l’Université du Sud Toulon Var (2006) with specialty “Meteorology, physical oceanography and physics for geophysical topics”.

Professional qualifications:
Activity Maritime, Coastal and Harbour Engineering
Proficiency Fluid Mechanics, Maritime and Coastal Hydraulics
Specialities - Coastal engineering (harbour and power plants design,...)
- Wind waves, storm-surges and currents : analysis, generation, physics
- Numerical modelling of wind waves, by using either phase-averaged approach (developer of TOMAWAC module) of phase-resolving approach (Boussnisp-type models, HOS method, etc.)
- Physical modelling in maritime hydraulics. Former responsible of the multidirectional wave basin of EDF R&D. Generation and analysis of multidirectional waves (PADINES software).
- Marine and coastal structures (breakwaters, platforms,...)
- Sediment transport and morphodynamical evolutions

Other affiliations and activities:
Teaching Lecturer and responsible of the “Fluid mechanics” and “Coastal engineering” courses at Ecole des Ponts ; Lecturer of the “Coastal and harbour engineering” course at Ecole Centrale Paris.

Member of the WISE (Waves In Shallow-water Environments) international working group, of the IAHR association (Int. Association for Hydraulic Research) and of the CLAROM French association (marine hydrodynamics).

Selected publications (related to the topic of the present proposal):
Luigi Cavaleri

ISMAR
S.Polo 1364
30125 Venice, Italy

born: 15 March 1940 in Venice, Italy
nationality: Italian
degree: Mechanical Engineer, University of Padua, Italy, February 1965
: Master of Aeronautics, California Institute of Technology, Pasadena, California, USA, June 1969

Since September 1969, researcher at ISMAR, formerly Istituto Studio Dinamica Grandi Masse (ISDGM) of Italian National Research Council (CNR) in Venice, Italy.

Since September 1991 Director of Research at ISMAR.

From January 2006 till March 2007 Director of ISMAR (Institute of Marine Sciences), appointment released because of age limits

Presently Associated Researcher at ISMAR.

Main activities -

- Design and supervisor to the construction of the oceanographic buoy of ISDGM -
- Design and supervisor to the continuous modifications made on the oceanographic tower of ISDGM –
- Wind and wave measurements
- Numerical wave modeling
- Wind modeling
- Coastal processes

Recent publications

“Extreme waves, modulational instability and second order theory: wave flume experiments on irregular waves”

“Comparison of wind and wave measurements and models in the Western Mediterranean Sea”
Ocean Engineering, Vol.34, Issues 3-4, pp.526-541

“Wave modelling – the state of the art”

J95 2008 Bertotti, L., and L. Cavaleri
“Analysis of the Voyager storm”

J96 2008 Bertotti, L., and L. Cavaleri
“The predictability of the Voyager accident”
Curriculum Vitae

Name: Monbaliu
First Name: Jaak
Nationality: Belgian
Date of birth: May 27, 1959

current position:
  • Professor at the Katholieke Universiteit Leuven - Hydraulics Laboratory – Department of Civil Engineering.

research field:
  • coastal engineering with emphasis on spectral modelling of ocean waves

education:
  • Civil Engineer - K.U.Leuven - 1982
  • Master of Engineering Science - University of Western Ontario (Canada) - 1985
  • Ph. D. - Department of Civil Engineering - K.U.Leuven - 1992

Work experience:
  • Associate Professor K.U.Leuven Hydraulics Laboratory 2001-2006
  • Assistant Professor K.U.Leuven Hydraulics Laboratory 1998-2001
  • Senior engineer in the morphology and coastal engineering division of the company IMDC (International Marine and Dredging Consultants) 1994-1998 (part-time)
  • Assistant professor K.U.Leuven Hydraulics Laboratory 1995-1998 (part-time)
  • Doctor-Assistant K.U.Leuven Hydraulics Laboratory 1994-1995 (part-time)
  • Assistant K.U.Leuven Hydraulics Laboratory 1985-1992
  • Research and Teaching Assistant, Boundary Layer Wind Tunnel Laboratory, University of Western Ontario, 1982-1985

Recent Publications:
CURRICULUM VITAE
24-10-2006

Nome: Miguel Onorato
Date and place of birth: 01 June 1970, Torino, Italy
Work address: Dipartimento di Fisica Generale, Università di Torino
Via P. Giuria, 1 – 10125 Torino – Italy
Home address: Via Solairano 3/A, Pino Torinese (TO) 10025, Italy
Telephone: +390116707454 (work)
Electronic-mail: onorato@ph.unito.it or miguel.onorato@gmail.com

Employment
Since December 2004: Researcher (permanent position) at the Università di Torino, Dipartimento di Fisica Generale, Torino, Italy
From 2002-2004: Research contract, Università di Torino, Dipartimento di Fisica Generale, Torino, Italy
From 2000-2002: Post-Doctoral researcher, Università di Torino, Dipartimento di Fisica Generale, Torino, Italy

Education
From 1996-2000: Phd student in Fluid Mechanics, Politecnico di Torino, Torino, Italy
1994 Laurea in Fisica, Università di Torino

Project manager
Group leader of the project: “Evolution of double-peaked spectra and of unstable wave packets” Wave Flume Canal de Investigación y Experimentación Maritima, Contract Nº: HPRI-CT-2002- 00195

Scientific interests
Nonlinear waves, ocean waves, extreme waves, turbulence

Selected Publications
Resume: A. R. Osborne

Born in Houston, Texas 30 November 1942.

1967  B. S. in Physics at the University of Houston, Texas.
1974 Ph.D. in Physics at the University of Houston.
1988- Professor of Physics in the Faculty of Sciences, Avogadro Department of Physics, University of Torino.
1983-1998 Member of the Graduate School Committee, Physics Department, University of Torino.
1993- Editor in Chief of the journal Nonlinear Processes in Geophysics of the European Geophysical Society and the American Geophysical Union.
1995- Member of the Graduate School Committee for the Doctorate in Fluid Dynamics Research, Polytechnic Institute-University of Torino.
1999- Avogadro Professor of Physics in the Faculty of Sciences, Avogadro Department of General Physics, University of Torino.

Brief Summary of Career

Worked in Two Groups at the Manned Spacecraft Center -

NASA Awards for Scientific Excellence
Apollo 11 (For distinguished service to put man on the Moon, 1969)). Apollo 13 (For the safe return of the Apollo astronauts after the explosion, 1970)). Skylab (Instrument design and simulation for the x-ray telescope, 1973, 74)).

Exxon Production Research (1974-1982)

Office of Naval Research:
Ongoing research program for the last 15 years on nonlinear Fourier methods. Served as Program Officer as IPA 2001-2003.

Selected papers
CURRICULUM VITAE
10-09-2008

Name: Toffoli
First Name: Alessandro
Nationality: Italian
Date and place of birth: 11 November 1975, Torino, Italy
Work address: Det Norske Veritas
Veritasveien 1, 1322 Høvik, Norway
Home address: Totengata 4, 0658, Oslo, Norway
E-mail: toffoli.alessandro@gmail.com

Current Position:
• Post Doc – DNV Research and Innovation, Det Norske Veritas, Norway.

Education:
• Ph. D. in Civil Engineering - Katholieke Universiteit Leuven (Belgium) - 2006
• Master in Civil Engineer - Politecnico di Torino (Italy) - 2001

Work Experience:
• Research Assistant / Member of Accademic Personnel, Hydraulic Laboratory, Dept. Civil Engineering, Katholieke Universiteit Leuven (Belgium), 2001-2006

Research Fields:
• Physical oceanography, ocean and coastal engineering with emphasis on wave statistics and extreme waves

Recent Publications:
Elzbieta Maria Bitner-Gregersen, Nationality Norwegian. Employed as a Principal Research in Det Norske Veritas AS, DNV Research and Innovation.

She has a Master of Science degree in Hydroengineering from the Technical University of Gdansk, Poland, and PhD in non-linear shallow water probabilistic modelling of sea waves received from the Polish Academy of Sciences and the Technical University of Gdansk. She has been working in DNV Research Department with research projects on probabilistic modelling of waves, wave load analysis, response analysis, structural reliability analysis and Formal Safety Assessment (FSA). She has 10 years experience with joint long-term environmental modelling of wind, waves and current and uncertainty modelling of wave data and models. She has been a project manager for several internal and external research projects on environmental modelling and structure reliability analysis. She has experience with DNV ship rule developments through participating in FSA projects. Recently she was a DNV leader of the EU MAXWAVE and REBASDO projects on extreme waves as well as ESA projects ICEMON and CAMMEO. At present she is participating in the EU Marie Curie Network SEAMOCS “Applied Stochastic Models for Ocean Engineering, Climate and Safe Transportation”.

Recent publications:

Please send the completed form by e-mail to the facility provider:

- CNRS Coriolis/LEGI Grenoble: Joel Sommeria, sommeria@coriolis-legi.org
- DHI Water & Environment: Jens Kirkegaard, jkj@dhigroup.com
- Hamburg Ship Model Basin (HSVA): Karl-Ulrich Evers, evers@hsva.de
- Norwegian University of Science and Technology (NTNU): Alexandra Neyts, alexandra.neyts@bio.ntnu.no

1. Title of the proposal

WAVE AND CURRENT FORCES AND RESULTING RESPONSES OF MOORED MULTI-BODY FLOATING OFFSHORE SYSTEMS

2. Requested facility/facilities:

MARINTEK OCEAN BASIN, TRONDHEIM

3. Applicant's full name and title (User Group Leader)

Nuno Miguel Magalhães Duque da Fonseca (Dr.)

4. Affiliation

Centre of Marine Technology and Engineering, Instituto Superior Técnico, Technical University of Lisbon, Av. Rovisco Pais, 1049-001 Lisboa, Portugal

Male/Female: Male

Tel.: (351) 21 841 7905
Fax: (351) 21 847 4015
E-mail: nfonseca@mar.ist.utl.pt
Web-site: http://www.mar.ist.utl.pt/uetn/

5. Full name, titles, positions in institution, nationalities and gender of all other persons participating in the project (NB: only users who intend to access the facilities!) (enlarge the table if necessary):

<table>
<thead>
<tr>
<th>Name, titles and affiliation</th>
<th>Position</th>
<th>Nationality</th>
<th>M/F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuno Fonseca, Dr., Centre of Marine Technology and Engineering, Instituto Superior Técnico, Technical University of Lisbon, Av. Rovisco Pais, 1049-001 Lisboa, Portugal</td>
<td>Assistant Professor</td>
<td>Portuguese</td>
<td>M</td>
</tr>
<tr>
<td>João Pessoa, Mr., Centre of Marine Technology and Engineering, Instituto Superior Técnico, Technical University of Lisbon, Av. Rovisco Pais, 1049-001 Lisboa, Portugal</td>
<td>Research Assistant</td>
<td>Portuguese</td>
<td>M</td>
</tr>
</tbody>
</table>
6. Names and access period of those that made use of the access programme to this facility in previous EC framework programmes:
   Profs Downie and Incecik, FP5 and FP6 Programmes

7. Estimated number of access days requested: this includes the time needed for building the test setup, testing and calibration when necessary, experiments, and removal of the test setup:
   Two weeks (10 working days)

8. Estimated total number of the visiting person-days
   (sum of the days of presence at the installation of all the members of the visiting team);
   30-40 person-days.

9. Most appropriate period for the experiments?
   Are there any constraints for the period when you may or may not perform the experiments?
   No

10. Tentative list of instrumentation requested (contact us for information; if you also use your own instruments, please give the characteristics)
    Scale models of a production platform and a LNG tanker fitted with appropriate mooring systems.
    Equipment is required for measuring, first order and slow drift motions, the wave displacements in the gap between the model, the wave and current environment, and forces on mooring lines.

11. Description of the proposed work (maximum of four A4 pages).
    This must specify the installation needed and should contain a brief description of:
    - Scientific context of the study (incl. reference to the state-of-the-art)
    - Scientific aims
- Theoretical framework and methodology
- Proposed analysis of the results
- Publication plan
- Justification for access
- The role of each team member

12. Technical details and specifications of the planned experiments (maximum of one A4 page)

Appendix (please provide in a separate file)
CV of each group member (max 1 page per person)
WAVE AND CURRENT FORCES AND RESULTING RESPONSES OF MOORED MULTI-BODY FLOATING OFFSHORE SYSTEMS

Scientific Context of the Study

As the demand for offshore gas production increases around the world so does the requirement for offshore gas production and the transportation of the produced liquefied gas from a floating production platform to a LNG ship. An offshore gas production platform is a large moored floating structure which offloads the liquefied gas onto a LNG ship moored beside it. The accurate prediction of first- and second-order forces and resulting dynamic motion responses of such multi-body systems is essential for safe design of the floating gas production platform and its mooring system as well as for the safe operation of LNG ships during offloading of liquefied gas.

Recently a number of researchers have been developing numerical tools to predict the relative motions of two floating structures moored side by side and their mooring forces. Kashiwagi et al (2005) developed a numerical prediction method based on a high order boundary element method to calculate the first-order wave forces and responses as well as the mean wave drift forces on two ships moored side by side. Hong et al (2005) presented comparisons between first order responses and mean wave drift forces computed by a high order boundary element method. The results of the comparisons show generally good agreements for both first- and second-order forces and the resulting motions. However significant discrepancies between the predictions and measurements were observed for a frequency range where resonant motions of the trapped water between the two vessels occur. The accurate prediction of this resonance phenomenon is highly critical for the safe mooring design and the offloading operations of liquefied gas. Van der Valk and Watson (2005) presented a set of model test results for a floating production barge and an LNG ship. The test results concluded that the mooring arrangements selected for this system was not safe for the transfer of LNG from the barge to the tanker in severe sea states.

Further studies were carried out by Chen (2005), Fournier et al (2006), Pauw et al (2007) to improve the prediction of free surface elevation and resonance motions of the trapped water between the two vessels did not yield a unified solution to the problem when the gap between the vessels was small. A recent study reported by Pessoa et al (2008) correlated the first-order wave and mean drift forces acting on a rectangular barge and a modified Wigley hull moored side by side with those obtained from measurement by Kashiwagi et al (2005). The correlations were good except the overestimation of peak forces.

As far as the applicants are aware there is no results published on the combined wave and current forces acting on moored multi-body floating offshore systems and the resulting motion responses and mooring forces.

A considerable body of work in the area of numerical and experimental work concerning the behaviour of floating offshore platforms in waves has been carried out by the Centre for Marine Technology and Engineering (CENTEC) at the Technical University of Lisbon, the School of Marine Science and Technology (MAST) at Newcastle University, and the Department of Naval Architecture and Marine Engineering (NAME) which is a joint Department of the Universities of Glasgow and Strathclyde. The approaches adopted for modelling the hydrodynamic loading use potential flow techniques based on 3-D source distribution or high order boundary element methods for modelling the wave environment. MAST and NAME have focussed more on the former (see for example Lee et al., 2005), whilst CENTEC has concentrated more on the latter (see for example, Foncseca et al (2008-a and 2008-b) and Pessoa, 2008). Research groups at MAST and NAME have been involved in extensive experimentation in a variety of applications including TLPs (Downie et al, 1996), and semi-submersibles (Kazemi and Incecik, 2006). Collaboration of the three groups exploits their respective strengths: CENTEC in high order boundary element methods; MAST and
NAME in potential flow techniques common experience in experimentation. This proposal provides a unique opportunity for, CENTEC, MAST and NAME to collaborate on a project in an important subject area that is greatly enhanced by the use of large scale facilities and the provision of resources that neither would normally have access to.

Scientific Aims

The objective of the proposed study is to investigate the first- and second-order wave forces and responses of two floating structures moored side by side and their mooring forces when subjected to various environmental conditions due to combined waves and current. In particular, the following phenomena will be explored:

- First- and second-order forces and resulting motions of moored multi-body floating offshore systems
- The effect of current on first- and second-order forces and resulting motions and mooring forces.
- The effect of water depth on first- and second-order forces and resulting motions.
- Wave resonance motions as the gap between the floating vessels, current speed and water depth vary

The data gathered will be used to extend knowledge of the phenomena involved and for validating theoretical/numerical models. It will be a valuable source in its own right and will be of great interest to the wider academic and industrial community.

Theoretical Framework and Methodology

Froude-scaled model tests at the largest practical scale are likely to offer the most reliable and accurate means of investigating the first- and second-order forces and resulting motions. In the experiments, the motions of the models, the wave displacements between the model and the mooring forces will be measured, together with the wave and current environmental characteristics. The measurements will be carried out in regular and irregular waves with sea states ranging from moderate (Hs = 5m, Tp = 10s full scale, say) to severe (Hs = 15m, Tp = 15s, say) with and without current in three different water depths. The current will be of the order of 1m/s. The tests will be carried out at water depths of 30 m and 500 m in full scale. In addition, decay tests will be carried out in still water to measure damping coefficients. In order to establish the effect of gap between the two vessels on wave resonance in the gap and on relative motions and mooring forces, it is proposed to undertake measurements for varying gap values.

It is anticipated that the measurements will require two full weeks of access to the Ocean Basin including setup and calibration. The models, mooring system and measuring systems will be provided by MARINTEK.

Proposed Analysis of Results

The first-order wave, mean and slow drift forces will be estimated from the first-order, mean and slow drift motions. The data will be analysed following the procedures described by Stansberg (2001) in his papers on Data Interpretation and System Identification in Hydrodynamic Model Testing.

Statistical analysis will be carried out to obtain significant and extreme values of wave elevations; wave and low frequency motions in heave, surge, sway, roll, pitch and yaw; mooring line tension, and second-order low frequency drift force components. From various decay tests in calm water and in waves slow drift damping components and natural frequencies will be obtained. The second-order low frequency drift force component will be decomposed into viscous mean drift force and the potential mean drift force by subtracting
the latter from the total measured forces. The potential mean drift force will be calculated using a high-order boundary element method. The presented results will include basic time series for forces and resulting motions, as well as response spectra and damping coefficients as function of sea state, current conditions for varying water depths and gap between the vessels.

**Publication Plan**

The results obtained from the proposed large scale measurement project will be published in several conference and journal papers jointly with researchers from three universities and MARINTEK reporting on:

- The effect of current on first- and second-order forces and resulting motions and mooring forces and correlations with numerical predictions.
- The effect of water depth on first- and second-order forces and resulting motions, and correlations with numerical predictions.
- Wave resonance motions as the gap between the floating vessels, current speed and water depth vary and correlations with numerical predictions

**Justification for access**

A PhD student project at the CENTEC, Lisbon aims at the development of prediction tools to determine the hydrodynamic interaction and drift forces on a rectangular barge and a modified Wigley hull moored side by side. A PhD student project at the University of Newcastle has been studying the slowly varying motions an floating production, storage and offloading platform (FPSO) taking into account the coupling between the hull, the mooring system and risers in high sea-states with and without current. A PhD student to commence work in NAME at Glasgow will develop a numerical model to predict the effect of current on first- and second-order motions of coupled floating platforms moored side by side. Since there is no hydrodynamic testing facility at the Technical University of Lisbon and it is only possible to carry out small scale tests in towing/wave tanks of the universities of Newcastle and Glasgow/Strathclyde, it will be very difficult to model wave and slowly varying motions of a coupled floating vessel with and without current. Therefore this proposal, if approved, will provide a significant contribution to the successful development of numerical tools to predict the behaviour of single and multi-body floating structures in waves and current and the mooring and the mooring forces currently undertaking at three universities. Some of these numerical studies are collaborative investigations between the investigators from three different universities. The published results will be available for the whole hydrodynamics community for increasing the understanding of multi-body problems, and also for validating numerical models with data that does not currently exist.

**The role of each team member**

**Dr. Nuno Miguel Magalhães Duque da Fonseca:** As the user group leader Dr. Fonseca will liaise with the facility provider to organise the visit to MARINTEK, running the experiments and collecting the measurement data. He will also supervise the analysis and interpretation of measurements and the correlation of measurements with the predictions to be carried out at Lisbon.

**Mr. João Pessoa:** Mr. Pessoa will participate in the tasks of the data acquisition and analysis of data. He will also correlate the results of his predictions with the results of experimental measurements.

**Professor Martin J. Downie:** Prof. Downie will liaise with the group leader in specifying the experimental programme and supervise the setting up of the tests, data acquisition, analysis and interpretation of data and the correlation of measurements with the predictions to be carried out at Newcastle.
Mr. Tai Pil Ha: Mr. Ha will participate in the tasks of the data acquisition and analysis of data. He will also correlate the results of his predictions with the results of experimental measurements

Professor Atilla Incecik: Prof Incecik will liaise with the group leader in specifying the experimental programme and supervise the interpretation of data and the correlation of measurements to be carried out at Glasgow.

Miss Hauwa Raji: Miss Raji Ha will participate in the tasks of the data acquisition and analysis of data. She will also correlate the results of her predictions with the results of experimental measurements.

References

Wave and Current Forces and Resulting Responses of Moored Multi-Body Floating Offshore Systems

Technical details and specifications of the planned experiments

Model tests will be carried at MARINTEK in the Ocean Basin at approximately 1/50th scale. Two models will be used representing a floating gas production platform and a LNG carrier. The model of the gas production platform will be moored with a series of catenary mooring lines to the bottom the basin and the model of the LNG carrier will be moored along the side of gas production platform. The tests will be carried out in regular waves with and without current (current speed of 1 m/sec full scale, and current direction of 180 degrees) for different frequencies and amplitudes as the waves approach at 180 and 145 degrees. The tests will be repeated in two irregular sea states wave with and without current as the waves approach at 180 and 145 degrees. The irregular sea states will correspond to: $H_s = 5m$, $T_p = 10s$ full scale and $H_s = 15m$, $T_p = 15s$. All the tests specified above in regular and irregular sea states will be carried out for two spacing between the vessels The spacing parameters will be specified once the model dimension are advised by MARINTEK. Selected combination of the tests will be repeated for two different water depths as 10m and 500m.

Calm water pull-out and natural decay experiments will be carried out to determine mooring stiffness characteristics as well as the natural surge sway and yaw frequencies and damping characteristics. Decay tests will be repeated with current present to determine the effect of current on damping characteristics.

It is proposed that the following measurements will be made:

- Regular and irregular waves and the current in the ocean basin.
- Natural frequencies
- Damping characteristics of the system
- Stiffness characteristics of the mooring systems
- Wave elevations in the gap between the models at selected locations
- Wave and low frequency motion time series in heave, surge, sway, roll, pitch and yaw.
- Mooring line tensions in selected lines

In addition the dimensions of the models used and their mass and mass-moment of inertia values as well as the hydrostatic curves for each model will be required.
1. PERSONAL DATA

Name: Nuno Miguel Magalhães Duque da Fonseca
Institution: Instituto Superior Técnico, Technical University of Lisbon, Portugal
Date of birth: 17/6/1966
Nationality: Portuguese
Institutional address: Secção Autónoma de Eng. Naval, Instituto Superior Técnico, Pavilhão Central, Av. Rovisco Pais, 1096 Lisboa, Portugal
Telephone: (351) 21 8417 905/468   Email: nfonseca@mar.ist.utl.pt
Professional Position: Assistant Professor at Instituto Superior Técnico, Technical University of Lisbon.

2. ACADEMIC DEGREES

Doctor degree in ship hydrodynamics from Instituto Superior Técnico, Technical University of Lisbon, 2001.
Master of Science in ship hydrodynamics from the University of Glasgow, 1994.
Degree in Naval Architecture and Marine Engineering from Instituto superior Técnico, Lisbon, 1990.

3. AREA OF SCIENTIFIC ACTIVITY

The main area of scientific activity is the dynamics and hydrodynamics of ships and other floating structures in waves. The investigations include development of mathematical models, their implementation in computer programs, and also experimental work based on model tests. Subtopics of the main scientific area include: operability and seakeeping performance of ships in waves, nonlinear responses of ships in large amplitude waves, slamming and green water loads, multi-body hydrodynamics in waves, wave induced motions and structural loads on offshore wave energy converters, and probabilistic models for the calculation of structural loads.

4. PARTICIPATION IN INTERNATIONAL SCIENTIFIC ORGANIZATIONS (presently)

Member of the 17 ISSC “Specialist Committee V.4 – Ocean Wave and Wind Energy Utilization “, ISSC (International Ship and Offshore Structures Congress), 2006 - 2009.
Member of the Scientific Committee of the Ocean Eng. Symposium of OMAE (Offshore Mech. and Arctic Eng.), since 2001.

5. PARTICIPATION IN RESEARCH PROJECTS

Participation in 6 national funded research projects and 17 international research projects. Presently he is the coordinator of 2 national funded research project and 1 industry project.

6. SCIENTIFIC PUBLICATIONS

Around 80 published papers (22 papers in international scientific periodicals with referees, 42 papers in international conference proceedings and book chapters, and 15 papers in national conference proceedings).
Curriculum Vitae – Martin J Downie

Qualifications and Post Nominals

BSc, MPhil, PhD, CEng, MRINA

Position: Professor of Technology for the Marine Environment

Experience

Prof Downie has worked for about 20 years in the area of Marine Technology (hydrodynamics) and has participated in several of the UK Government funded Research Council Managed Programmes including the Behaviour of Floating and Compliant Offshore Structures (BOFCOS) and the Uncertainties in Loading on Offshore Structures (ULOS) programmes. His work has mainly been concerned with the numerical and experimental investigation of separated flows in the context of fixed and floating bodies in an offshore environment. His numerical work has concentrated on the development of vortex codes to simulate flow around bluff cylinders and the matching of viscous codes, based on vortex methods, with traditional inviscid seakeeping packages. Much of the latter work was carried out in collaboration with the Aeronautics Department at Imperial College, London. Examples of the applications of this work include prediction of hydrodynamic damping of floating structures such as Tension Leg Platforms (TLPs), semisubs and ship hulls and the measurement and prediction of forces on practical structures including those fitted with appurtenances. One of his current interests is the prediction of the influence of trailing vortices along a ship’s hull on the manoeuvring coefficients. In addition to experimental work carried out in Newcastle, he has been involved in experiments in facilities in France (Ecole Centrale, Nantes), Holland (De Voorst Flume), Denmark (DHI) and Norway (MARINTEK).

Recent Scientific Papers


Name: Miss Hauwa Onize Raji

Date of Birth: 15 October 1976

Nationality: Nigerian

Qualifications: BEng in Civil Engineering (2001)  
MSc in Civil Engineering (2006)

Education:


2006- to date: Postgraduate study towards PhD in Offshore Engineering, Department of Naval Architecture and Marine Engineering, Universities of Glasgow and Strathclyde.

Work Experience:

2002-2006: Assistant Lecturer, Department of Civil Engineering, Ahmedu Bellu University, Zaria, Nigeria.

Awards:
Schlumberger Scholarship to carry out a PhD study in the UK.
**Personal information**

<table>
<thead>
<tr>
<th>First name / Surnames :</th>
<th>João Machado Macedo de Melo Pessoa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address:</td>
<td>Rua Antero de Quental, lt. 14 3º A 2675-479 Odivelas Portugal</td>
</tr>
<tr>
<td>Mobile:</td>
<td>+351919125178</td>
</tr>
<tr>
<td>E-mail(s):</td>
<td><a href="mailto:joao.pessoa@mar.ist.utl.pt">joao.pessoa@mar.ist.utl.pt</a></td>
</tr>
<tr>
<td>Nationality:</td>
<td>Portuguese</td>
</tr>
<tr>
<td>Date of birth:</td>
<td>10/03/1980</td>
</tr>
<tr>
<td>Gender:</td>
<td>Male</td>
</tr>
</tbody>
</table>

**Education and training**

<table>
<thead>
<tr>
<th>Title of qualification awarded:</th>
<th>Naval Architect and Engineer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name of organization providing education:</td>
<td>Technical University of Lisbon - Instituto Superior Técnico</td>
</tr>
</tbody>
</table>

**Work experience**

| Dates:                  | 05/11/2007 → |
| Occupation or position held: | Marine Hydrodynamics researcher |
| Name and address of employer: | Centre for Marine Technology and Engineering – Instituto Superior Técnico, Av. Rovisco Pais, 1049-001 Lisboa |

**Domain of specialization**

Hydrodynamics and seakeeping

**Present investigation interests**

Multi-body hydrodynamics, linear and non linear theory of wave-floating body interaction

**Participation in research projects**

“Dynamics of floating platform and shuttle tanker during offloading operations”, financed by Fundação para a Ciência e a Tecnologia (FCT) under the contract PTDC/EME-MFE/74590/2006

**Publications**


Curriculum Vitae – Atilla Incecik

Qualifications
BSc, PhD, CEng MRINA MSNAJ MSNAME

Position:
Professor of Offshore Engineering and Head of Department of Naval Architecture and Marine Engineering, Universities of Glasgow and Strathclyde, UK.

Experience
Professor Incecik has been involved with teaching and research concerning the theoretical and experimental hydrodynamics and hydro-mechanics of floating offshore structures over the last thirty years. Since 1986 Professor Incecik has been responsible, as principal or co-investigator, for 52 research projects of which 16 are UK Research Council-supported, 11 are EC-supported, 2 US Navy supported and 27 are industry-supported. Professor Incecik has published over 70 papers in his area of research during the last 10 years. He was Lloyd’s Register Professor of Offshore Engineering and Head of School of Marine Science and Technology at the University Newcastle upon Tyne between May, 1996 and September, 2007. Professor Incecik was a member (1987-1993) and Chairman (1993-96) of ITTC Ocean Engineering Committee and Chairman (2002-05) and member (2005- to-date) of ITTC Executive Committee. (The International Towing Tank Conference (ITTC), which is the most prestigious in the field of hydrodynamics of ship and offshore structures, aims at stimulating research in specific topics, as well as reviewing research results in order to make recommendations to designers, builders and operators of ship and offshore installations) Professor Incecik is Chairman of the Association of the European Universities involved in teaching and research in marine technology and related subjects and Editor-in-Chief of Ocean Engineering

Recent Scientific Papers
Name: Mr Tai Pil Ha

Nationality: Korean

Qualifications: BEng in Naval Architecture and Ocean Engineering

Education:


2005- to date : Postgraduate study towards PhD in Offshore Engineering, School of Marine Science and Technology, Newcastle University, UK

Awards:

Ministry of Education Scholarship to carry out a PhD study in the UK.
Please send the completed form by e-mail to the facility provider:

- CNRS Coriolis/LEGI Grenoble: Joel Sommeria, sommeria@coriolis-legi.org
- DHI Water & Environment: Jens Kirkegaard, jkj@dhigroup.com
- Hamburg Ship Model Basin (HSVA): Karl-Ulrich Evers, evers@hsva.de
- Norwegian University of Science and Technology (NTNU): Alexandra Neyts, alexandra.neyts@bio.ntnu.no

1. **Title of the proposal**
   Drag and roughness characteristics of a Surface Treated Coating (STC)

2. **Requested facility/facilities:** Towing Tank  NTNU

3. **Applicant's full name and title (User Group Leader)**
   Maxim Candries, PhD

4. **Affiliation**
   Department of Research and Special Projects
   Hydrex NV / Subsea Industries NV
   Noorderlaan 9 - Haven 29
   2030 Antwerp
   BELGIUM
   Tel.: ++32 3 213 53 18
   Fax: ++32 3 213 53 21
   E-mail: mcandries@hydrex.be
   Web-site: www.ecospeed.be

5. **Full name, titles, positions in institution, nationalities and gender of all other persons participating in the project:**

<table>
<thead>
<tr>
<th>Name, titles and affiliation</th>
<th>Position</th>
<th>Nationality</th>
<th>M/F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr. Rosita Persoons, PhD</td>
<td>Project Manager of the Centre of Materials Analysis</td>
<td>Belgian</td>
<td>F</td>
</tr>
<tr>
<td>Materials Centre Of Expertise VITO NV</td>
<td>Boeretang 200</td>
<td>BE-2400 Mol</td>
<td>BELGIUM</td>
</tr>
</tbody>
</table>
6. Names and access period of those that made use of the access programme to this facility in previous EC framework programmes:
Not applicable..................................................................................................................................

7. Estimated number of access days requested; this includes the time needed for building the test setup, testing and calibration when necessary, experiments, and removal of the test setup:
6 days (cf. Section 12)......................................................................................................................

8. Estimated total number of the visiting person-days
(sum of the days of presence at the installation of all the members of the visiting team);
12 days. (cf. Section 11G)....................................................................................................................

9. Most appropriate period for the experiments?
Are there any constraints for the period when you may or may not perform the experiments?
Not applicable................................................................................................................................

10. Tentative list of instrumentation requested (contact us for information; if you also use your own instruments, please give the characteristics)
   - A friction plane with dimensions suitable to the facility (e.g. based on NSRDC models) preferably with known form factor, is needed to carry out three series of towing experiments in order to establish a full resistance versus speed profile for three different surfaces: uncoated reference surface, freshly applied STC and conditioned STC. (cf. details below)
   - Standard equipment is needed to measure the resistance (dynamometer…)
   - Equipment to record the generated wave profile would be optional but useful
   - The coatings and the equipment to measure the roughness characteristics will be provided by the applicant: at least one stylus instrument (i.e. Taylor and Hobson Surtronic 10, additionally possibly a BMT Hull Roughness Analyser and an Elcometer Surftest SJ 201). At least one optical measurement system (UBM Profilometer) will be used off-site to analyse sample plates coated alongside\(^1\).
   - Airless spray equipment to apply the coatings

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\(^1\) Since the User Group Leader’s Institution does not possess an optical measurement system, Dr. Persoons of VITO has been approached to collaborate on the proposed analysis of the roughness characteristics. The present research proposal thus involves two institutions, Hydrex NV and VITO NV of Belgium.
11. Description of the proposed work (maximum of four A4 pages).

11A. Scientific Context of the study

The deleterious effects of fouling on ship performance have long been known and it has been a cumbersome process to formulate effective antifoulings until coatings were developed that had an effective lifetime of up to 5 years. As a consequence, by the year 2000, an estimated 85% of the world fleet was coated with these tributyl tin-containing self-polishing co-polymers (TBT-SPCs). However, due to severe environmental concerns, the International Maritime Organization has decided to completely phase out the use of TBT-SPC by 2008 (Townsin, 2003).

Since then, the major challenge has been to look for antifouling strategies which are as effective as TBT-SPCs in order to keep the economic penalties due to fouling and the number of dry-dockings to a minimum. The obvious choice was to replace TBT by copper and booster biocides. From an ecological point of view, however, the continuing leaching of toxins by tin-free SPCs into the aquatic environment raises concerns and remains deplorable.

Non-toxic alternatives exist. Foul release coatings aim to prevent the settlement of fouling by providing a low-friction surface onto which organisms have difficulty attaching. In theory, the lifetime of foul release coatings is unrestricted but in practice they are easily damaged. Underwater cleaning needs to be carried out with soft brushes which may not remove all organisms that did settle (Holm et al., 2003).

A novel antifouling strategy is the concept whereby so-called “surface treated coatings” (STCs) are mechanically subjected to an in-water treatment which consists of a “conditioning” aspect that improves the surface characteristics and a cleaning aspect that removes any marine fouling in an early stage of development. The surface roughness of the coating is hereby reduced, which makes it more difficult for fouling organisms to re-attach. The in-water treatment is carried out in a limited amount of time on a regular and economically sound basis, whereby the integrity of the coating is maintained. Full-scale applications have shown good performance but also reduced fuel consumption compared to the coatings that were on before STC. It is therefore thought that the frictional properties of a STC are improved by the conditioning, as shown in Figure 1 (Van Rompay, 2008).

![Figure 1](image-url)

**Figure 1:** Sketch of a typical cross-section of a STC at different stages: (a) freshly applied (b) after conditioning (c) gradual exposition to re-attaching fouling organisms (d) after cleaning/conditioning (Van Rompay, 2008).
Pilot towing tank experiments conducted by Flanders Hydraulics and the Antwerp Nautical School have shown that the resistance of a 5.09m long plate coated with a STC (series A) exhibited 7.06% less frictional resistance than a plate coated with a conventional paint system (series B), whereby a conditioned STC (series C) exhibited further drag reduction when compared with a STC which is freshly applied and not yet conditioned (series A), as shown in Figure 2 (Vantorre et al., 2005).

![Figure 2. Total and frictional resistance coefficients against Reynolds Number from the pilot towing tank experiments (Vantorre et al., 2005).](image)

During the pilot tests, roughness measurements were taken with a stylus instrument that measures the average roughness amplitude over a 0.8mm cut-off length. It was found that these did not correlate with the measured drag, since the average measured roughness was lower for the conventional paint system than for the conditioned STC, which was in turn lower than for the freshly applied STC.

This indicates that additional parameters are required to correlate roughness with drag. A STC typically exhibits substantial waviness and it is thought that a comprehensive roughness analysis will reveal that its texture is significantly different from other antifoulings. It is known that surfaces which exhibit a wavy, open texture, such as foul release coatings, require more parameters than spiky, closed-textured surfaces, such as tin-free SPCs, for which the roughness may be characterized solely by an amplitude parameter in order to correlate with drag (Candries and Atlar, 2003; Townsin, 2003).

It is therefore proposed to compare the frictional resistance of an unconditioned and a conditioned STC with an uncoated surface and with a tin-free SPC surface by means of large scale towing tank experiments with a friction plane. The particulars of the plate may be taken from NSRDC Friction Plane 4125, which has been used in the past for different types of coatings (Todd, 1951; West, 1973; Candries and Atlar, 2003).

It may be noted that it was recommended by West in 1973 to conduct additional tests with this friction plane model to study the effects of reconditioning rough ship bottoms. To the Applicant’s knowledge, this has not yet been done, except for the pilot towing tank tests (Vantorre, et al., 2005). It will be interesting to study with high precision the effects of the conditioning operation on a STC,
which is specifically designed to undergo this treatment regularly. Unlike any other type of outer bottom coating where reconditioning is known to increase roughness, a STC is expected to become smoother.

In addition, a detailed study of the roughness characteristics of each surface is proposed by means of at least one stylus instrument and at least one optical measurement system.

Given the current bunker prices, an accurate estimate of through-life roughness of outer bottom hulls and its effect on resistance penalties is of great importance. With the advent of new antifouling coatings, the correlation methods between model and ship scale have recently come under revision (Schultz, 2007). Since STCs are entirely non-toxic, the potential benefit of conditioning would not only be economically, but also environmentally important.

References
Todd F H (1951) Skin friction resistance and the effects on surface roughness. Trans SNAME 59: 315-374.

11B. Scientific Aims

- To carry out friction plane towing tank tests for 5 different surfaces; two uncoated surfaces, one surface coated with a freshly applied STC, one surface with a conditioned STC and one surface coated with an antifouling, preferably a tin-free self-polishing co-polymer (SPC).
- To take comprehensive roughness measurements of each surface.
- To systematically compare the frictional resistance of the different surfaces and to correlate the differences with roughness characteristics.
- To contribute to model-ship correlation methods and the study of coating effects on ship powering.
- To study the roughness and drag effects of mechanical conditioning of a STC and its repercussions on reconditioning rough ship bottoms.

11C. Theoretical framework and methodology

The theoretical framework of towing tank experiments with planks and friction planes is well established within naval architecture. The recommendations and procedures of the International Towing Tank Committee (ITTC) will be followed.

The methodology used for the experiments will consist of executing five series of measurements of different surfaces (cf. Section 12 below). Runs over a range of speeds between 0 and 8m/s are carried out for each series to produce a curve of the total drag coefficient, CT, against Reynolds number, Re.
11D. Proposed analysis of the results

The differences in frictional resistance will be calculated by subtracting the wave resistance from the total resistance, assuming that the wave resistance is not affected by the coatings. A detailed uncertainty analysis will be carried out in order to achieve the highest possible precision.

The roughness characteristics will first be analyzed separately and the measurements of the different types of equipment will be compared. Building on past experience (Candries and Atlar, 2003), a correlation analysis between roughness and drag characteristics will be carried out subsequently.

11E. Publication Plan

At least one publication will follow in the open literature, either in the proceedings of an international conference or in a peer-reviewed journal.

11F. Justification for access

Very little is known about the frictional characteristics of surface treated coatings since they are only recently being considered as a non-toxic antifouling concept. Only pilot tests have been carried out in a small scale facility. Further experiments in a large scale towing tank are needed because:

1. The effective test length at steady speed was very short at under 50m and the maximal depth was 0.5m making it necessary to take undepth water corrections account and to test the plate in a horizontal position which is highly unusual. Comparisons with friction tests published in the literature for other coatings are therefore excluded.
2. No information was obtained beyond the small Reynolds number of 7 million.
3. The form factor of the plate in the pilot tests was not known and accurate determination by Prohaska’s method was not successful.
4. An uncertainty analysis was not carried out for the pilot tests.
5. Only one roughness amplitude parameter was measured during the tests. The surface texture and isotropy characteristics were not investigated.
6. Correlation of roughness and drag can more easily be compared at higher roughness Reynolds numbers, i.e. higher speeds and greater plate dimensions will facilitate the comparison of the correlation.
7. Underwater conditioning is a novel approach on which no data is available to the Applicant’s knowledge except for the pilot towing tank tests. If drag is reduced significantly by regular conditioning, full-scale application would result in environmental and economical benefits, such as fuel savings and reduction in greenhouse gas emissions for an entirely non-toxic coating.

11G. The role of each team member.

- Dr. Candries will carry out the analysis of the test results and be responsible for full reporting (access for the duration of the experiments)
- Dr. Persoons will carry out the roughness measurements and surface metrology analysis in collaboration with Dr. Candries (2 days access)
- Mr. De Bock will carry out the coating applications and the conditioning of the STC (4 days access)
12. Technical details and specifications of the planned experiments (maximum of one A4 page)

Pre-testing
It is proposed to manufacture a friction plane based on NSRDC model 4125, as shown in Figure 3. The advantage of this model is that it has been used extensively to study the frictional characteristics of coatings (Todd, 1951; West, 1973; Candries and Atlar, 2003).

![Figure 3. Proposed particulars of flat plate to be tested. Design based on NSRDC Friction Plane Model 4125 (Candries and Atlar, 2003)](image)

After consultation with the facilities’ manager, it is proposed to manufacture two plates that can be tested in parallel in order to optimize access to and utilization of the facilities. The dimensions and materials of the plate may be modified in order to optimize access.

A sufficient number of sample plates will be manufactured of the same substrate as the 2 large plates, some of which will be coated alongside during testing. These different surfaces will then be analyzed for their roughness characteristics after testing with an optical measurement system.

Proposed Test Program

- Day 1 and 2: Installation of uncoated plate 1 and calibration. Resistance profile of plate 1 at two different draughts and repeat runs at one velocity for the uncertainty analysis → Series A
- Day 3: Resistance profile of uncoated plate 2 to verify agreement with series A → Series B. Application of STC on plate 1.
- Day 4: Resistance profile of plate 1 with fresh STC → Series C. Application of SPC on plate 2.
- Day 6: Resistance profile of plate 1 with conditioned STC → Series E.

In addition to the detailed surface metrology analysis of the sample plates, roughness characteristics will be measured of the different surfaces of plates 1 and 2 with at least one stylus instrument.
Curriculum Vitae

Surname : Candries
First name : Maxim
Nationality : Belgian
Date of birth : April 20, 1974
Place of birth : Sint-Niklaas, Belgium
Address : Belseledorp 147
9111 Belsele
BELGIUM
E-Mail : Maxim_Candries@yahoo.com
URL: http://www.geocities.com/maxim_candries
Telephone +Fax: ++32 3 772 30 38

Work Experience:

• Research and Special Projects Leader (Present): Hydrex NV, Haven 24, 2030 Antwerp, Belgium
• Lecturer (2003): Faculty of Science, Naresuan University, Phitsanulok, Thailand.
• Free-lance Consultant (December 2002): Consulting on the coating of a propeller for Chevron-Texaco and International Coatings Ltd. at Jurong Shipyards, Singapore, with the objective of fuel consumption reduction.
• Post-doctoral researcher (January-September 2002): Environmental benefits of coating propellers, School of Marine Science and Technology, University of Newcastle-upon-Tyne, UK.

Education:

• PhD (2001), School of Marine Science and Technology, University of Newcastle-upon-Tyne, UK, Drag, boundary-layer and roughness characteristics of surfaces coated with marine antifoulings.
• MSc (Hons), 1998, Marine Technology, Faculty of Engineering, State University of Ghent, Belgium
• BEng (Hons, 1995), Civil Naval Engineer, Faculty of Engineering, State University of Ghent, Belgium.

Skills:

• Water tunnel testing using LDV and PDA, towing tank experimental experience
• Good knowledge of marine coating application procedures and standards.
• Experience in paint application supervisions and quality monitoring
• Flexible to work in challenging circumstances
• Able to organise and manage projects against tight deadlines

Key Publications (please see: http://www.geocities.com/maxim_candries for a full list or to view several papers)

Curriculum Vitae

Surname: Candries
First name: Maxim
Nationality: Belgian
Date of birth: April 20, 1974
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BELGIUM
E-Mail: Maxim_Candries@yahoo.com
URL: http://www.geocities.com/maxim_candries
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Work Experience:

• Research and Special Projects Leader (Present): Hydrex NV, Haven 24, 2030 Antwerp, Belgium
• Lecturer (2003): Faculty of Science, Naresuan University, Phitsanulok, Thailand.
• Free-lance Consultant (December 2002): Consulting on the coating of a propeller for Chevron-Texaco and International Coatings Ltd. at Jurong Shipyards, Singapore, with the objective of fuel consumption reduction.
• Post-doctoral researcher (January-September 2002): Environmental benefits of coating propellers, School of Marine Science and Technology, University of Newcastle-upon-Tyne, UK.

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• PhD (2001), School of Marine Science and Technology, University of Newcastle-upon-Tyne, UK, Drag, boundary-layer and roughness characteristics of surfaces coated with marine antifoulings.
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• Flexible to work in challenging circumstances
• Able to organise and manage projects against tight deadlines

Key Publications (please see: http://www.geocities.com/maxim_candries for a full list or to view several papers)
Administrative information :
Company : VITO ( Vlaamse Instelling voor Technologisch Onderzoek)
Legally authorized representative : Dirk Fransaer
Address : Boeretang 200, 2400 Mol
Telephone : 32 14 33 55 00
Scientific Contact : Rosita Persoons
Department : Material Centre of expertise
Telephone : 32 14 33 57 30
e-mail : Rosita.persoons@vito.be

Personal Information :
Birthday : 13 November 1961
Place of birth : Zottegem
Education : - Master in Science ( physics) , University of Gent (1979-1984)
- Phd in Physics, materials science, University Gent (1984-1990)

Employment : VITO, 1990 –

I have been working at VITO since 1990. I started my career within the materials department where I was initially involved as researcher on corrosion studies of ceramic materials and afterwards I was involved in the laser treatment of materials (laser coating and hardening). In 2005 I became project manager of the centre of materials analysis, responsible for the materials analyses in research projects within VITO as well as externally funded projects. Besides we also provide analyses on a service base to companies.

We perform chemical and micro structural analyses of materials. Therefore we have the most up to date equipment (scanning electron microscopy, X-ray spectroscopy, X-ray diffraction, ..). In order to characterize surfaces on nanometer scale, to identify surface defects and wear tracks, VITO has several techniques such as laser and contact profilometers, nano-indentation techniques, scratch testers, ... VITO has a large experience on wear phenomena and has several tribometers to simulate industrial wear processes. Mechanical properties of materials can be determined under different conditions.