THE FOUNDATION FOR SCIENCE AND TECHNOLOGY

**DEBATE SUMMARY**

Turning knowledge into value – adding value to the marine sector from research and innovation

Held at The Royal Society on 10th March, 2014

The Foundation is grateful to the Monterey Bay Aquarium Research Institute, California, the National Oceanography Centre and the Society of Maritime Industries for supporting this debate.

The hash tag for this debate is #fstmarine .

**Chair:** **The Earl of Selborne GBE FRS**
Chairman, The Foundation for Science and Technology

**Speakers:** **Professor Ralph Rayner**
Sector Director Energy and Environment, BMT Group, Chairman, Sonardyne International and Professorial Research Fellow, London School of Economics
**Professor Ed Hill OBE**
Executive Director, National Oceanography Centre
**Professor Rick Spinrad**
Vice President for Research, Oregon State University, and President-elect of the Marine Technology Society

**Panellist:** **Professor Richard Clegg**
Managing Director, Lloyd's Register Foundation

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Introducing the speakers, the Earl of Selborne welcomed the co-incidence of the Catch the Next Wave conference[1] held during the day at the Royal Academy of Engineering in London which had examined selected key disruptive technologies and where they were emerging in the marine sector. The United Kingdom had a long tradition of oceanographic research; the Foundation debate would illuminate how best to turn that knowledge into value to ensure the continuation of a thriving marine sector.

PROFESSOR RAYNER stressed the importance of inspiring successive generations of young people to take an interest in marine science and technology. He recalled the public impact of August Pickard's pioneering work (and he noted the presence at the debate of Captain Don Walsh who had co-piloted the Trieste to the deepest part then known of the ocean). His own experience of giving the annual Society for Underwater Technology Christmas lectures at Greenwich made him optimistic that young people could continue to be inspired by the need to look after planet ocean. He looked forward to the day when the Royal Institution's annual lectures for children were devoted to the marine environment.

Innovation in product, process or route to market was the key to economic value through the commercial exploitation of ideas, but did not necessarily have to involve scientific invention or discovery (the shipping container was an example). Innovation did not usually follow a linear model from research through development, production and marketing. A chain link model with multiple feed-back loops was closer to the reality of innovation. In the 19th century the lone inventor was the iconic figure; in the 20th century the corporate team within a single enterprise; but in the 21st century the model would have to be a networked social (and international) system that drew on different disciplines and had fluid open boundaries.

It was important to generate many ideas and then to be very selective about which to exploit. Connectivity would drive innovation through bringing to bear in the marine environment knowledge derived from research in other disciplines and sectors such as signal processing and materials science.

Concluding, Professor Rayner saw a continuing role for government in sponsoring high quality basic research whose future applications could not be predicted and that should not therefore be linked too closely to the expectation of the value creation through innovation. Government also should use its role as a customer to create market pull, and should help SMEs navigate the various 'valleys of death' to encourage innovation in detailed design and testing, redesign and production and in distribution and marketing.

[1] www.ctnwconference.com

Government also had to support the education of the next generation.

PROFESSOR HILL stressed the importance of marine research to the UK. The oceans made up 71% of the Earth's surface and contained 90% of the mobile carbon and 50% of the species on Earth with new species continuing to be discovered and many questions unanswered such as the role of viruses in the ocean. The oceans had a direct effect on climate and there were important scientific questions to be answered over where the excess heat was going, the ability of the ocean's to absorb excess $CO_2$, the limits of ecosystem resilience to warming, acidification and de-oxygenation, slowing of the ocean's heat conveyer belt circulation and the flux of methane and other gasses and fluids from the sea floor.

The UK was a leading player in the international governance of the high seas and had a keen interest in the impact of a new summer sea-ice free Arctic Ocean.

Although the UK research infrastructure had diminished in scale, the capability of the current research vessels (such as the RRS Discovery, RSS James Cook and the ISIS Remotely Operated Vehicle) was global and the UK marine science base was world class with a spend of £170m a year on marine science with around 30 universities engaged along with public sector research establishments and a number of important geographic clusters of activity that included the private sector.

The UK was well placed in Europe with by far the highest number of participations in marine-related proposals selected for funding in FP7. UK science had for example led the discovery of the world's deepest and hottest hydrothermal vents, the exploration underneath floating part of the Pine Island Antarctic glacier and the long term observation of the Atlantic meridional overturning circulation.

Continuing, Professor Hill saw the ocean as a vital UK national resource and stressed the importance of a healthy UK marine science and innovation ecosystem. We would need increasingly to draw on the resources of the ocean for energy and minerals, for food and for natural products and medicines. Marine hazards would require careful risk management. Marine environmental impact from this human activity included over-fishing, noise, pollution and habitat destruction

With the UK Marine Area three times its land area, important natural resources would be found adding to the current importance of the marine sector to the UK economy (£35.1bn gross value added to UK Gross Domestic Product and supporting 703,000 jobs across a wide number of sectors – to which had to be added the ocean's effect on the climate impacting on economic activity as a whole). He called for a real commitment to mapping the UK's seafloor with modern methods to create a UK 'big data' asset.

Looking ahead, and drawing on the work of the Marine Industries Liaison Group[2], Professor Hill described the common needs shared by public and private consumers of marine science in such areas as seabed and habitat monitoring, hydrographic and geophysical surveys, marine monitoring, modelling, remote sensing and instrumentation. More focus was needed on the need to generate longer term strategic applied scientific evidence.

Collaboration between public and private sectors could improve. There were examples where the UK had missed out but there were nevertheless many marine business opportunities requiring scientific evidence and technologies including wave and tidal energy, carbon capture and storage and aquaculture. Oil and gas decommissioning and deep seafloor mining would require new technology, such as in marine autonomous systems for monitoring and exploration.

Concluding, Professor Hill suggested that the UK should strengthen its marine research ecosystem, follow through on the capital investments made in research infrastructure and nurture its marine innovation clusters. The challenge was to join up the UK islands of capability by taking a longer-term rounded, strategic view of the opportunities across science, government and the industry.

PROFESSOR SPINRAD supported the conclusions of the previous speakers. He drew encouragement from the way that US and UK research communities joined together in tackling the common challenges. In marine science it was a case of back to the future in terms of the focus on scientific discovery, recalling the expedition of HMS Challenger in 1874 that had lasted 1,000 days and covered more than 68,000 nautical miles. The Cold War period had seen an emphasis on government funding for the rapid development of underwater detection systems such as SOSUS drawing on marine acoustic technologies with the imperative of national defence.

Now government was looking for a return on its investment in technology, with the pace of technological innovation being driven by sectors outside of the science community.

Continuing, Professor Spinrad described new paradigms being created in research for mixed models of public and private funding, with the users of technology looking for specific results that could be applied ('research by the pound'). Venture capital was investing in marine technology. Funding platforms such as Kickstarter were enabling the crowdsourcing of research funds and the internet was enabling international collaborative projects. Massive open on-line courses (MOOCs) were leading to the commoditisation of education and training, helping fill skills gaps. It was at least questionable whether the traditional technology readiness level model of government could be sustained amidst such a diverse ecology of research. US

[2] www.defra.gov.uk/mscc/groups/marine-industries-liaison-group/

universities such as Oregon State were having to become less reliant on government funding for research. A risk was that academic research could become too beholden to industry, and thus to short-term operational drivers. It was not clear who would then pay for long term exploration, and persistent monitoring and observation of the ocean that would provide the 'big data' from which future generations would make their discoveries.

Accountability pressures and risk aversion could end up dominating research selection and crush innovation. The tradition of much hypothesis-based research might become unaffordable, especially given the cost of starting the investigative process with the replication of earlier results. Another casualty could be traditional peer review where the process occupied much valuable time of key researchers and was in danger of collapsing under its own weight.

In conclusion, Professor Spinrad emphasised the value of engaging with the public to create a supportive opinion and to foster citizen science exploiting such areas as web access to real-time exploration. Despite the difficulties, there were exciting prospects to exploit.

Commenting on the earlier presentations, PROFESSOR CLEGG suggested a number of questions and themes for discussion:

a. If the UK marine infrastructure was of high quality but limited resources then did it not make more sense to 'pick winners' in order to be able to focus on the highest possible quality science? There were more ideas around than resources to take them forward so choices would have to be made.

b. Given the pace of innovation in other fields such as nanotechnology and sensor technology then should the maritime sector become more outward facing, taking advantage of such developments as open innovation, MOOCs, big data techniques, and citizen science?

c. With reduced resources, a lower tolerance for failure of research projects was to be expected. Would a low appetite for risk screen out too many potentially high value ideas and would the demand for milestones and targets inhibit creativity?

d. Would it be sensible to pick an area such as autonomous marine systems to focus on, given the advances made in micro-sensors and in the ability to harvest energy to allow long cruise times for AUVs?

e. Should more research and development be more clearly mission-led? As US Army General Sullivan had written, 'hope is not a method'. Clarity in what research was intended to achieve would help the case for funding.

In discussion, several participants drew attention to the distinction that had to be made between fundamental research that provided the essential intellectual foundation for the future and goal driven technological innovation that drew on the results of the research of the past. The history of science showed how hard it was to predict in advance the outcome of basic research and the often surprising directions in which it could take future generations.

Spend, and luck, were the most important determinants of research coming up with interesting results ('picking the race, not the winner'). Unlike fundamental research, technological innovation could be directed to specific ends, particularly when there was a need to short circuit some barrier to a new product or process and it was possible to pick likely winners to invest the limited funds available to government or the private sector.

Not all research could be driven by such expectations of predicted impact. It was recognised in discussion that there was a particular problem in justifying long term monitoring. For the atmosphere the case had long been accepted given the immediate needs of weather forecasting. For the monitoring of the marine environment (and its climate impact) a strong case could also be made, but its future operational value had not yet been accepted. Falling costs of sensors and the availability of autonomous systems should make the case easier to sell.

There were differing views as to how far it was helpful to use the label of 'marine science' as a distinct discipline, and how far it was better talk of the underlying fields of sensor technology, materials science, autonomous systems and so on. But there was general agreement that there was value in taking a wider rather than narrower perspective, and a distinct cultural value in talking of the need for global care of the oceans. This could be made highly motivational for young people. The multidisciplinary nature of marine science enabled old barriers between disciplines to be broken down.

Taking that broader view, some participants questioned whether the traditional metrics of academic success – publish or perish – fitted the nature of much marine exploration and technological innovation where impact on the economy and on the commercial world might be significant. It could be to the disadvantage of many marine technologists that promotion and tenure still largely rested on the publication record. On the other hand, the bedrock of academic excellence remained the ability of peers to access and critique work through the journals of repute.

Private sector or not for profit organisations rather than government laboratories were funding exploration in the expectation of returns, for example through new forms of aquaculture or medical products. Co-production of scientific

knowledge was becoming a reality given the ability of the internet to allow broad cooperative programmes and citizen science. There was useful knowledge in the wider marine community, and from users of the seas, to be tapped. There was more too that could be contributed on the marine environment when government was planning overseas economic development assistance programmes.

There was widespread agreement among participants that it was little short of scandalous that less than 20% of the UK Exclusive Economic Zone (EEZ) had been properly mapped, a situation that was paralleled in the US. There was a need for bold steps to be taken in public education to explain that the collection of digital data was essential if we were to make sustainable use of our marine environment and need to educate the public on how best to manage the risks of the new technology. The task could be done for £250 million and would generate a healthy return on the investment, as shown by the Irish example in mapping their EEZ.

Further discussion also showed support for the mission of inspiring a generation with the challenges of marine science. There were skills gaps, for example in marine engineering, but participants took encouragement from the number of bright young researchers that could be seen at ocean science conferences.

Marine research in the UK universities and research institutes was in vibrant good health as was commercially driven applications development. If there was a gap it was in what could be called strategic research linking the two communities. More could be done to create platforms where academia and industry could get together.

In concluding discussion, there was general agreement that the deep sea represented a frontier that demanded more vision from government working in partnership with academia and the private sector.

More ambition was needed and less humility from the marine research community. The fascination of the sea was not just for those who lived by it: Its importance for the future could not be overestimated. The public needed to recognise the pervasive influence of the ocean on the climate and thus our everyday lives and our increasing dependence on resources from the sea bed and marine life to sustain wealth creation.

Sir David Omand GCB

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**Interesting Talks:**
Roger Ballard: The astonishing hidden world of the deep ocean
www.ted.com/talks/robert_ballard_on_exploring_the_oceans?language=en

Don Walsh: Going the last seven miles - Talks at Google
www.youtube.com/watch?v=2tjOd7cBmZo

**Useful Links:**
Click on the link to go to the URL

Blue Growth Strategy, Europe
www.europa.eu/rapid/press-release_MEMO-13-615_en.htm

Biotechnology and Biological Sciences Research Council
www.bbsrc.ac.uk

BMT Group
www.bmt.org

Cefas
www.cefas.defra.gov.uk

Department for Environment, Food and Rural Affairs
www.defra.gov.uk

Engineering and Physical Sciences Research Council
www.epsrc.ac.uk

The Foundation for Science and Technology
www.foundation.org.uk

Government Office for Science
www.bis.gov.uk/go-science
Lloyd's Register Foundation
www.lrfoundation.org.uk

London School of Economics, Centre for the Analysis of Time Series
www.lse.ac.uk/CATS/Home.aspx

Marine Biological Association
www.mba.ac.uk

Marine South East
www.marinesoutheast.co.uk

Marine Technology Society
www.mtsociety.org

Monterey Bay Aquarium Research Institute, California
www.mbari.org

National Ocean Council, USA
www.whitehouse.gov/administration/eop/oceans/implementationplan

National Oceanography Centre
www.noc.ac.uk

National Environment Research Council
www.nerc.ac.uk

Oregon State University
www.oregonstate.edu

Research Councils UK
www.rcuk.ac.uk

The Royal Society
www.royalsociety.org

The Scottish Association for Marine Science
www.sams.ac.uk

Sir Alister Hardy Foundation for Ocean Science
www.sahfos.ac.uk

Society of Maritime Industries
www.maritimeindustries.org

Sonardyne International
www.sonardyne.com

UK Marine Industries Alliance
www.ukmarinealliance.com

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