Ocean Science

SUBSEA ENGINEERING OPPORTUNITY
International Market Insights Report Series

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Scottish Enterprise

Contents

1. Introduction

This report is part of a series of reports considering the opportunities for the Scottish oil and gas (O&G) subsea supply chain in other subsea and related markets. The report is a desk review considering the particular synergies of the given sector and the subsea oil and gas supply chain. These opportunities cover where there is a direct cross over and also where there are opportunities for collaboration to provide innovative solutions.

Ocean science encompasses the biological, physical, chemical and geological observations of the ocean environment. Oceanographic work is largely carried out by consultants, research institutes and universities for subsea activities/installations and research purposes. Ocean science is used to underpin all subsea activities by providing specific project information, from the understanding of resource, monitoring of conditions, developing defence strategies and facilitating installations by analysing a localised environment. It also helps us to understand the changing climate through monitoring and understanding ocean circulation and trends and anomalies in the environment.

There is crossover from ocean science to all other sectors that require observation of the ocean environment. Specifically, the cross over with subsea oil and gas will be around the ocean science data, such as the understanding of marine geology; the infrastructure required for collecting the data, including ROVs and sensors; offshore operations experience and data analysis.

Globally there are well over 60 countries that have research institutes, that in total number in the hundreds (690 research institutes are networked within ICES) dedicated to ocean and marine sciences, across the continents. There are also a number of international groups, highlighted below.

International Ocean Science Institutes:

- The **International Council for the Exploration of the Sea (ICES)** is a global organization whose role is to coordinate and perform scientific research and provide advice to policy makers and competent authorities to support the sustainable use of the oceans. Their secretariat is based in Copenhagen, Denmark.[1]
- The **Intergovernmental Oceanographic Commission of UNESCO (IOC-UNESCO)**, is the only competent organisation for marine science within the United Nations (UN) system. Its role is to promote international cooperation and coordinate programmes on ocean science research. The IOC is recognized through the United Nations Convention on the Law of the Sea (UNCLOS) as the competent international organization in the fields of Marine Scientific Research (Part XIII) and Transfer of Marine Technology (Part XIV).[2]
- **Centre for Maritime Research and Experimentation (CMRE)** formerly the Undersea Research Centre (NATO). CMRE is located in La Spezia, Italy and operates two research vessels the NATO Research Vessel (NRV) Alliance and Coastal Research Vessel (CRV) Leonardo. Research areas include autonomous vehicles; littoral intelligence, surveillance and reconnaissance (ISR); Environmental Knowledge and Operational Effectiveness

[1] ICES website, http://www.ices.dk/explore-us/who-we-are/Pages/Who-we-are.aspx accessed May 2018.
[2] IOC website, http://www.ioc-unesco.org/ accessed May 2018.

(EKOE); and modelling and simulation.[3]

- The **Joint Programme Initiative Healthy and Productive Seas and Oceans (JPI Oceans)** is a European Union (EU) established long-term intergovernmental platform for research into the marine area. It began in 2011 and covers all the sea basins within Europe and has 21 participating countries.[4]
- Not a research group as above, but another relevant entity is the **International Hydrographic Organisation (IHO)** whose principle aim is to ensure that the world's seas and oceans are surveyed and charted. The IHO also produce standards by which those carrying out hydrographic surveys should adhere to, such as the *IHO Standards for Hydrographic Surveys*.[5]

[3] CMRE website, http://www.cmre.nato.int/about-cmre/history-and-vision accessed May 2018.
[4] JPI Oceans website, http://www.jpi-oceans.eu/about accessed May 2018.
[5] International Hydrographic Organisation, IHO Standards for Hydrographic Surveys, 5th Edition, February 2008 Special Publication No. 44

2. Subsea engineering needs

For ocean science experiments, an array of infrastructure is required for physical observations from vessels to moored instruments and drifters. Aspects of this work, and the market that surrounds it, relevant to the subsea oil and gas supply chain are outlined below:

2.1. Infrastructure and equipment

There is a varied requirement for infrastructure and equipment for the ocean science sector including:

- *Vessels*
  Research vessels need an array of functionality and will be designed for specific purposes, such as coastal, ocean going, icebreaking activities. They need to be equipped with equipment such as launch and recovery systems (LARS) for remotely operated and autonomous vehicles; cranes; winches; station keeping abilities, potentially high precision positioning; ability to tow; and deck space for containerised laboratories. Other types of research vessel can include drilling ships, for research drilling.
- Remotely Operated and Autonomous Vehicles (ROV/AUV)
  Many subsea activities can now be carried out by ROVs or AUVs. ROVs are tethered to the research vessel and can be inspection or work class, with a selection of tooling options available. AUVs are not tethered and can be propelled or use the movement of the ocean to carry them, these are known as 'drifters'. Drifters are often used to find out information about ocean currents, etc. There is a significant crossover with this technology between ocean science and subsea oil and gas, tooling options and the design of new tools in particular, along with piloting of the vehicles. ROVs can be used, for example, for the collection of samples. AUVs may be fitted with sensors to monitor physical or chemical properties of the water column.
- Acoustics and sonar
  Acoustics and sonar equipment are used for analysing the seabed, such as bathymetry and geophysical surveys. In subsea O&G these are used for prospecting and site characterisation. The crossover will be through the shared use of technology; technology development; and the development of data gathering and data analysis tools.
- Automation and robotics
  Partially covered by the ROV/AUV section, there is a move within O&G to automate systems and activities as well further utilise robotics, to minimise humans working in dangerous environments. Techniques and technology for this move to automation will cross over between the sectors, with potential for collaborative research.
- Shared requirements
  O&G is focused on the reliability of its infrastructure particularly in a deep-water context. Ocean Science also has a requirement of longevity and reliability particularly for long-term monitoring. An example is the 'Persistent Presence' technology used by the National Oceanographic Centre (NOC) and it collaborators for the RAPID project which is measuring the changes in the Atlantic Meridional Overturning Circulation through an array of sensors at 26°N from Morocco to Florida. Currently, data is collected from the array, which has been in place since 2004, every 18 months, the intention is to be able to achieve real-time

data capture from the array.[6]

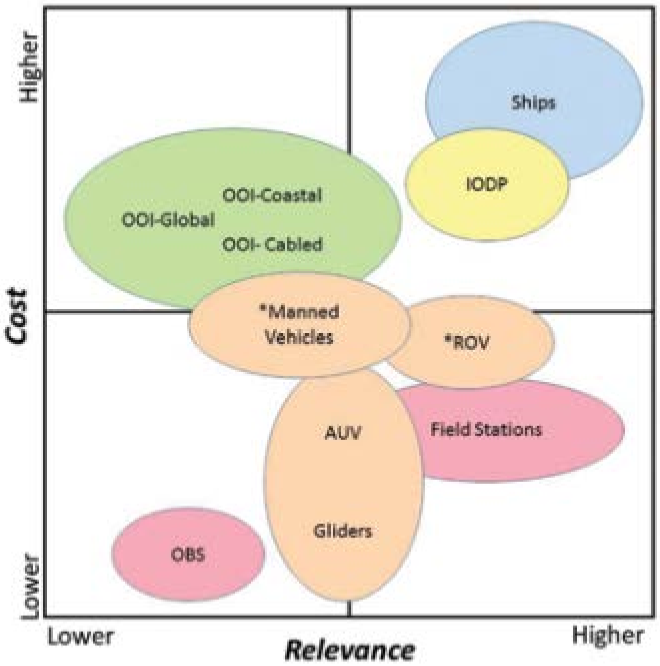

Figure 1: Chart showing the relative cost and relevance of various ocean science infrastructure. The green and yellow bubbles refer to specific projects in the US, but the remaining bubbles given an overview of the sector. Source: National Research Council

2.2. Sensors

Sensors, either mounted to vessels or vehicle, or those on remote access sampling stations, are used to develop our understanding of the sea. Sensors can be used to measure chemicals, oxygenation of the water column, biological activity, salinity and temperature, amongst others. Sensor development is required in areas such as measuring subsea biology, pH and nutrients. The synergies with sensors between ocean science and the subsea O&G sector is likely to be around the deployment of sensors, development of sensors, e.g. nano-sensors, as well as the gathering and analysis of data.

2.3. Data Analysis

With an increase in sensor technology and automation companies are now finding ways to manage vast swathes of data and analyse them effectively. There is crossover between the two sectors on data analysis, and the software and programmes that can manipulate and use the data.
From the ocean science side, there is a move to open source a lot of data, this includes the NOC data which is freely available for anyone to use. The UK also has the British Oceanographic Data Centre (BODC) in Liverpool, which has written records dating back to 1969, as well as an expanding online resource of data as well.[7]

2.4. Purchasing

For research applications equipment is often bought second hand from, for example, O&G companies who have used the equipment for specific projects and then sell on once they no longer

[6] RAPID: monitoring the Atlantic Meridional Overturning Circulation at 26.5°N since 2004, website http://www.rapid.ac.uk/rapidmoc/overview.php accessed May 2018
[7] British Oceanographic Data Centre, Our History, https://www.bodc.ac.uk/about/what_is_bodc/our_history/ accessed May 2018

are using it for that project. These sales are often done through brokers such as Seatronics there is also a rental market for such equipment. [8] The NOC also has a pool of equipment, the National Marine Equipment Pool (NMEP), which can be accessed by researchers carrying out projects with Natural Environment Research Council (NERC) funding as well as through commercial hire. The NMEP is the biggest repository of its kind in Europe, with over 10,000 instruments and technologies. [9] Equipment is also purchased from sales of salvaged equipment from liquidated companies. This shows that there is not a strong market for new equipment, based on funding restrictions for research projects.

2.5. Market Barriers

Significant technology development, including electronics, and data loggers are largely done by in-house engineers within research institutes. This therefore reduces the scope for technology manufacturers and service companies to access the market.

Purchasing of equipment is largely on an *ad hoc* basis as it depends upon research programmes, funding and availability of NMEP instruments. Within research institutes and universities, equipment is not frequently replaced and is used for long periods. It is therefore not a continuous stream of orders.

2.6. Priority Science Questions

Worldwide research institutes have laid out their strategic scientific questions for ocean science. These questions, the examples below are from the USA's National Research Centre; the JPI Oceans and the European Commission, give a sense of the type of research that will be undertaken over the coming decade and beyond:

- Priority Science Questions and Infrastructure for the Next Decade of Ocean Research[10]

  1. What are the rates, mechanisms, impacts, and geographic variability of sea level change?
  2. How are the coastal and estuarine ocean and their ecosystems influenced by the global hydrologic cycle, land use, and upwelling from the deep ocean?
  3. How have ocean biogeochemical and physical processes contributed to today's climate and its variability, and how will this system change over the next century?
  4. What is the role of biodiversity in the resilience of marine ecosystems and how will it be affected by natural and anthropogenic changes?
  5. How different will marine food webs be at mid-century? In the next 100 years?
  6. What are the processes that control the formation and evolution of ocean basins?
  7. How can risk be better characterized and the ability to forecast geohazards like mega-earthquakes, tsunamis, undersea landslides, and volcanic eruptions be improved?
  8. What is the geophysical, chemical, and biological character of the subseafloor environment and how does it affect global elemental cycles and understanding of the origin and evolution of life?

[8] Seatronics, Our Services, http://seatronics-group.com/services/, accessed May 2018
[9] National Oceanographic Centre, National Marine Equipment Pool, http://noc.ac.uk/facilities/national-marine-equipment-pool accessed May 2018
[10] National Research Council, Sea Change, 2015-2025 Decadal survey of ocean sciences, Report Summary, 2015

- Examples from the European Commission of research required for the marine environment.[11]

  1. Processes and functioning of the marine environment;
  2. The functional role, evolution, protection and exploitation of marine biodiversity;
  3. The impact of human activities (land-based and marine) on coastal and marine ecosystems and how to manage these (including via eco-efficient technologies);
  4. How to apply an ecosystem approach to resource management and spatial planning to come up with the best options for coastal and Maritime Spatial Planning;
  5. Many elements related to the deep-sea, such as deep-sea ecosystems and technologies to enhance deep-sea observation, sediments in continental margins and deep seas, gas hydrate behaviour, etc.

- The JPI Oceans have outlined their ten strategic research areas as: [12]

  1. Exploring Deep Sea Resources
  2. Technology and Sensor Developments
  3. Science Support to Coastal and Maritime Planning and Management
  4. Linking Oceans, Human Health and Wellbeing
  5. Interdisciplinary Research for Good Environmental Status
  6. Observing, Modelling and Predicting Oceans State and Processes
  7. Climate Change Impact on Physical and Biological Ocean Processes
  8. Effects of Ocean Acidification on Marine Ecosystems
  9. Food Security and Safety Driving Innovation in a Changing World
  10. Use of Marine Biological Resources through Development and Application of Biotechnology

[11] European Commission, Research – Our Oceans, Seas and Coasts, http://ec.europa.eu/environment/marine/research/index_en.htm accessed May 2018
[12] JPI Healthy and Productive Seas and Oceans, Strategic Areas, http://www.jpi-oceans.eu/introduction accessed May 2018

Annex: List of Acronyms

AUV	Autonomous Underwater Vehicle
ICES	International Council for the Exploration of the Seas
IHO	International Hydrographic Organisation
NMEP	National Marine Equipment Pool (UK)
NOC	National Oceanographic Centre (UK)
O&G	Oil and Gas
ROV	Remotely Operated Vehicle