Making Waves

A new marine science centre launched in July is aiming to provide solutions to some of the biggest challenges facing the world's seas and society, from climate change, to energy and food security. The Collaborative Centre for Sustainable Use of the Seas (CCSUS) brings together more than 40 scientists from the University of East Anglia (UEA) and The Centre for Environment, Fisheries and Aquaculture Science (Cefas). They will combine leading-edge marine science with practical expertise and the latest technological know-how to ensure that our seas and oceans are used sustainably for the benefit of people in the UK and world-wide. Scientists based at Cefas, [Lowestoft], and UEA will collaborate with policy makers, advisers and industry to support UK and international marine policy in a range of areas including, marine fisheries, energy and conservation.

Rachael Simpson, Editor of IET, spoke to Centre Director Professor Simon Jennings to find out more.

1. The CCSUS, Collaborative Centre for Sustainable use of the Seas, can you give me a bit of a background on this centre - history of how it came about and its aims?

Cefas[1] (Centre for Environment, Fisheries and Aquaculture Science) and UEA[2] (University of East Anglia) have had a longstanding and productive relationship. Many Cefas employees were trained at UEA and have held Honourary positions that enable them to contribute to teaching and research.

Back in 2008 we signed a strategic alliance together to formalise our relationship and appointed a joint lecturer between us to allow us to work even more closely. Through that process we learnt that the whole was really much greater than the sum of the parts – we started winning new income, increasing our publication rates, training more doctoral students, and increasing the impact of our science, and although we've invested in just one joint lecturer since 2008 we've bought in about £4 million in joint income and published around 190 joint research papers. But perhaps more importantly we drove new research on topics such as advanced monitoring and sensor technologies, impacts of climate change on fisheries and society, and the impacts of storm surges.

We were a natural partner for the School of Environmental Science (ENV) with which we signed the alliance. In the 2014 Research Excellence Framework - the system for assessing the quality of research in UK higher education institutions - ENV was identified as leading in the UK for Research Impact with 35% world leading and 53% internationally excellent research. ENV were also 3rd in the UK for the amount of world leading research achieved.

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ENV were also engaging more and more with industry and other stakeholders because Martin Johnson, our current joint lecturer in marine science, had established Marine Knowledge Exchange Network MKEN, a rapidly growing network of cross-sector marine stakeholders which was seeking to increase capacity in stakeholder relevant marine and coastal research, to ensure marine and coastal research is delivering collaborative impact and application, and to realise the social, economic and environmental potential of our seas and oceans. Some 29% of the 1100 people in the network are from industry and 49% from policy sectors.

ENV, UEA and the Norwich Research Park more widely have outstanding scientific track records and all want to demonstrate even greater impact from their research.

Cefas, a Government agency with a growing portfolio of international and commercial work in Food Security, Energy and other sectors, plays a direct role in marine management and policy support and wants to base their work on the best available research.

We could see that the development of a new centre would allow us to combine leading-edge marine science and technological know-how from UEA and the wider Norwich Research Park with practical and policy expertise to ensure that our seas and oceans are used sustainably for the benefit of people.

This is a win-win for the partners, because UEA grow the impact of their research and Cefas strengthen their own science-base by interacting with a wider spectrum of innovators.

The Centre will also create new opportunities for leverage with the Schools of International Development, Economics, Biological Sciences, Chemistry, Maths, Computing Science and Pharmacy as well as the Sainsbury Laboratory, John Innes Institute and Institute of Food Research on the Norwich Research Park.

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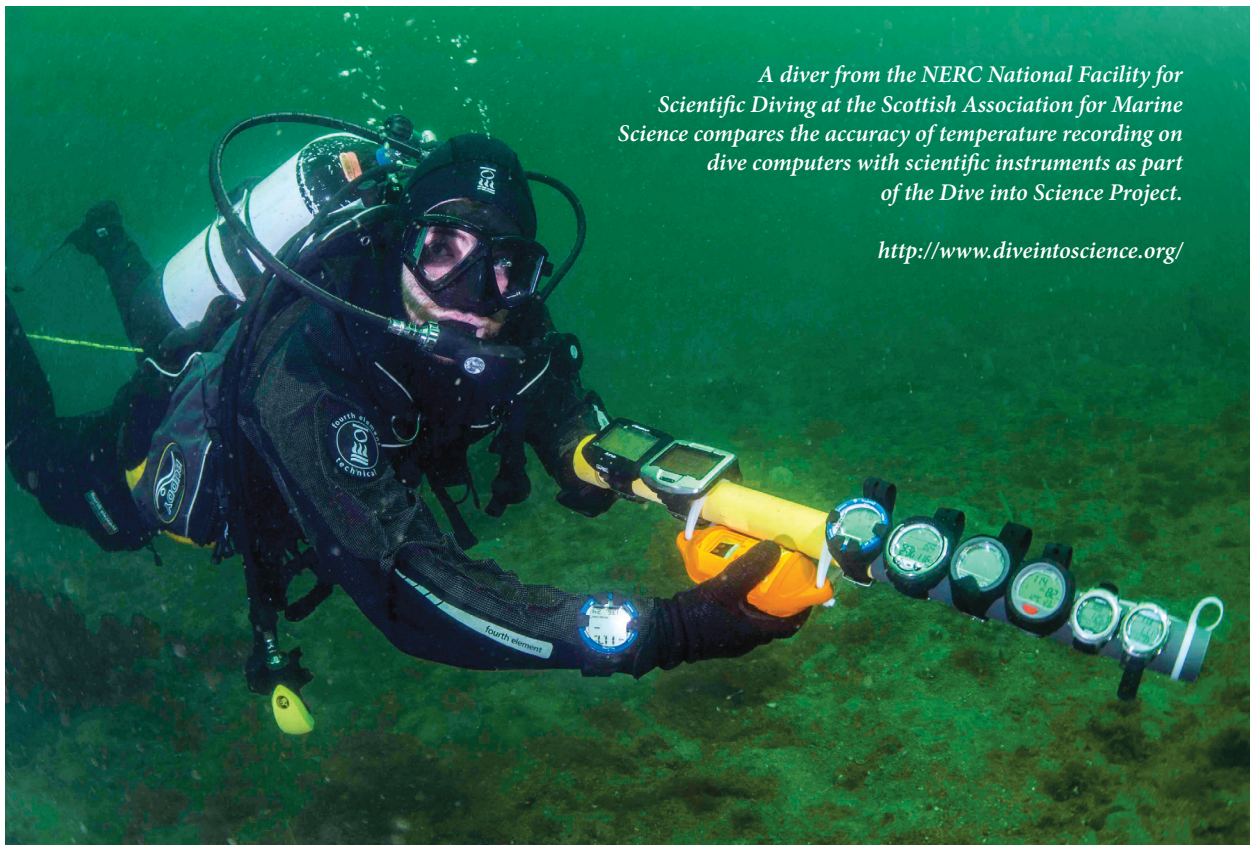
2. Why is a centre like CCSUS needed, and what are the main threats to marine habitats at the moment?

More than anything a centre like this is needed to ensure the rapid uptake of science into advice and management and to bring together the expertise needed to achieve this. This requires engagement of scientists, advisers, industry, policy makers and society in one place, something that is rarely being achieved at



A diver from the NERC National Facility for Scientific Diving at the Scottish Association for Marine Science compares the accuracy of temperature recording on dive computers with scientific instruments as part of the Dive into Science Project.

http://www.diveintoscience.org/

present.

Generally, in our area, we've seen reductions in pollution from land-based sources and sea-based activities. Inputs of nutrients, contaminants, key radioactive substances and pollution from oil and gas production have dropped. Adverse effects from some pollutants are being reduced. Fisheries management has brought fishing rates closer to sustainable levels and some stocks are increasing.

> ***"Some impacts of pressures such as noise, litter and non-indigenous species are only beginning to be understood. And beyond this there are always the ubiquitous risks: of deep water oil spills, of pollution incidents and jellyfish blooms"***

But the emerging impacts of climate change are leading to changes in the sea and a higher risk of some extreme events. Some impacts of pressures such as noise, litter and non-indigenous species are only beginning to be understood. And beyond this there are always the ubiquitous risks: of deep water oil spills, of pollution incidents and even jellyfish blooms.

Also, as the seas get more crowded, there are many interactions and trade-offs to address.

3. So what sets CCSUS apart from other, perhaps similar, research centres?

More than anything it will be the combination of the range of disciplines we can engage in our work through Norwich Research Park[3], the excellent science at UEA, our practical experience of monitoring, assessment, management and delivering large contracts Government to Government, for Industry and internationally at Cefas. Norwich Research Park effectively has about 2700 scientists and an annual research spend of £100 million or so, and is already regarded as one of Europe's leading centres for research on topics like food, health and the environment. The benefit of being a marine centre linked to a wider Norwich Research Park like this, is really the access to the extraordinary breadth of expertise that exists there. Since we set CCSUS up we have been working with the School of Chemistry developing methods to identify microplastics in the marine environment, and we've also been discussing links with the School of Pharmacy on antimicrobial systems – these are all the sorts of things you wouldn't obviously do if you were a pure marine centre.

Also our interest in translation and communication of knowledge, for example through MKEN[4], means we can access a wide stakeholder network, and we can provide training in an environment where science, advice and practical experience of solving challenges for industry really come together.

The other nice thing about our join up is really the capacity to boost the impact of the research that's going on at UEA. I think you'll know the framework they have for reviewing the excellence of research in the UK; one thing we can provide is real impact because the great majority of the staff at Cefas already work with and advise industry and government on the sustainability of marine industries and use of the seas. As a result of that it makes it extremely easy for us to take up the best science being conducted as UEA, and rapidly move that into an applied context where it can be used for monitoring, for management, and for understanding these trade-offs I mentioned earlier. From UEA's point of view that then allows them to show that their researchers have very high impact.

4. CCSUS have 6 complementary "work themes" – can you give an overview of what these cover?

The first is Climate Change Impacts and Adaptation, looking at the vulnerability and resilience of marine ecosystems and maritime industries as well as climate change, and really that's all about seeking to identify risks that result from climate change and also to help industries develop adaptation strategies to cope with the warming that we already see taking place.

The second theme is Marine Technology Monitoring and Risk. Monitoring is a massive part of our work at Cefas as statutory work for Government, and obviously we have to do this as cost effectively as possible. By working through CCSUS with UEA we are hoping to develop sensors and apply methods using things like wave gliders, other marine and autonomous vehicles, buoys, platforms, and passive samplers which we are generally developing with the School of Chemistry to allow us to improve our monitoring capacity.

Another thing that may be of interest is our work on citizen science. Recently you may have seen in the Guardian that work was published about using recreational divers to provide information on vertical temperature profiles in the sea, something that would be incredibly expensive to obtain with conventional research vessels but can be done very easily by citizens. It's a big interest of ours in the marine environment. We are actually using citizen science to look at Invasive species as well although we haven't done the work as yet, but yes, it offers huge opportunities especially in the UK and such places where there are a great many people visiting the beach.

The third theme is Ecosystem and Coastal Processes. A lot of this is about measuring and modelling the effect of tides and waves on coastal erosion. Both UEA and have a long track record in this and in fact Cefas, at the moment, is doing work on the Sizewell site (a nuclear facility on the Suffolk coast), using radar based methods to model the local waves and sediment movement which allows us to give advice on coastal protection. We are also deploying Remotely Piloted Aircraft (RPA) to investigate coastal geomorphology. The same methods can also be applied to coastal habitats and other infrastructure and RPA have been used to rapidly assess the impacts of storm surges, for example.

The fourth theme is Life in the Seas. This is about understanding marine life better in terms of its variety, quantity, distribution, and migration patterns which we are able to map very accurately with tracking devices developed by Cefas' commercial arm, Cefas Technology Ltd (CTL). Understanding where marine life is or moves to is really important; it helps management directly, either in terms of protecting them if you don't want to put them at risk for nature conservation, or to avoid catching them if you're a fisherman. Again, this theme is centred around improving trade-offs so that we can understand that perhaps by developing a slightly different management protocol you could avoid the migration route of an animal that depends on it.

> ***"The JellyMonitor project was established in response to the risks posed by jellyfish blocking water intakes, which can cause serious economic disruption (c. £5M / week) and gives rise to safety concerns for coastal power stations"***

The fifth theme is Energy and Food Security, and this is about providing an evidence base to support the role of marine related industries in generating sustainability and self-sufficiency both in energy and food. We are interested in nuclear, as I said in relation to the EDF project, but also wind, tidal and wave generation, and how those installations interact with other users of the sea, particularly fisheries and shipping. On the food security side we are interested in fisheries and aquaculture because that's core work already for Cefas and will be for many years to come. And, of course, there is strong complementarity with the focus on terrestrial food security by the John Innes Centre and the Institute of Food Research on the Norwich Research Park.

In the final theme, Marine Systems and Society, we quantify and value the interactions of coastal and marine environments and industries with people. This theme will build on the work of the Marine Knowledge Exchange Network I mentioned earlier.

5. What projects and research efforts are currently taking place or planned for the future?

We only just got going in July, and to get the centre underway we bought together about £7 million pounds worth of existing joint projects, largely from the strategic alliance I mentioned before. I'll give some examples.

Marine litter and microplastics are of international concern due to their potentially adverse effects on the environment, society and human health and have been identified at the G7 Science Minister Meeting in Berlin (May 2015) as a particular focus of

Roger Maes holds a Cefas Technology Ltd (CTL) G5 flotsam tag recovered on the Lofoten Islands, Norway. The tag held data describing the migration of an eel which was originally released in Sweden.

Photograph by Tycho Anker-Nilssen, Norwegian Institute for Nature Research.

research. Marine litter is largely composed out of plastics and originate mainly from terrestrial sources. Litter items are directly dumped or transferred into the oceans by forces such as wind and rivers. However, plastic items fragment in microplastics. As a result, the marine litter load and its fate in the oceans are very poorly constrained, and thus the ultimate flux of litter into the ocean and its consequent pathways are virtually unknown. Addressing these issues is therefore crucial for understanding of marine litter pollution, and the risks it may pose to the seas and to humans.

Systematic and detailed monitoring of marine litter and microplastic pollution in rivers, estuaries and shelf seas around the UK will therefore would provide the data on quantity and characteristics of litter in these domains, estimate the fraction of terrestrial litter entering the oceans and establish a system which can be used and developed in the future as sources of littering alter and the environment changes. Reliable and rapid monitoring tools for microplastics will provide much needed evidence that would help to develop a framework for the risk assessment of microplastic pollution and influence decision- and policy-making regarding the disposal of visible and invisible plastic waste into the environment on both national and international levels. Thus Cefas are working closely with the School of Chemistry at UEA to develop methods for rapidly identifying microplastics such as polythene, polypropylene, polyester, nylon, polyurethane etc. This is essential for monitoring and diagnosis.

Professor Simon Jennings, CCSUS Director

JellyMonitor is an Innovate UK co-funded project that is led by Cefas Technology Ltd and includes Cefas, UEA and EDF. The project was established in response to the risks posed by jellyfish blocking water intakes, which can cause serious economic disruption (c. £5M / week) and gives rise to safety concerns for coastal power stations.

To combat the unexpected arrival of clogging materials, this project is designing, building and testing an imaging system for the detection of jellyfish in low visibility coastal waters. The design phases include the capture of images (Cefas), which are processed with detection algorithms (UEA), the development of a new hardware platform (CTL / Cefas), and embedding the algorithms to predict jellyfish presence and abundance. The system will be used by power station operators (EDF) in the first instance, to provide an early warning of jellyfish blooms in their vicinity. But the technology is expected to have wider applications, around desalination plants for example.

In another joint project involving the Tyndall Centre for Climate Change Research at UEA and the Cefas Marine Climate Change Centre (MC3) we are combining data analysis, ecosystem modelling and economic valuation of bloom impacts to predict the drivers of jellyfish blooms, the risks and costs that arise and the effects of climate change on bloom frequency and distribution.

6. You have already mentioned the imaging of jellyfish blooms, but what other research methods are being used in the projects CCSUS is conducting?

For coastal processes radar is one, looking at the direction and height of waves in detail as they approach the seashore. The technology is being used for projects such as the EDF one I mentioned earlier.

Another area of collaborative research that will be further advanced by CCSUS is around seagliders, a passive device you can fit sensors to for monitoring the marine environment. They take an undulating path at slow speed, about 0.5 knots, allowing slower response sensors to be used. Gliders are great monitoring tools when little other infrastructure is available; they are portable and can communicate to satellite and cover whole water column

We've got these gliders deployed in the North Sea and in the Indian Ocean. UEA and Cefas scientists are particularly focussed at the moment on the subsurface-chlorophyll maximum, high concentrations of phytoplankton in the sub-surface regions- microscopic plants that turn sunlight, carbon dioxide and nutrients into energy that fuels marine food webs.

Fish tagging is also a method of interest, and something Cefas and CTL have played a massive part in, developing and manufacturing data storage tags which provide information on depth, temperature, light intensity, and they allow you to reconstruct the movement of fish when the tags are either washed up on the beach or recaptured on the animals.

And these are used in catch and release efforts as well as being located and picked up out in the field?

Yes, that's right, we work with them both ways. We have also had very high success rates with what are called pop-off tags, which at some stage will float to the sea surface and just bob along until they wash up somewhere. Some are just passive, and need to be found and returned to us when they wash up, but there are new developments that will enable us to use the mobile phone network to download their data. These 'flotsam tags' help us increase our data recovery over and above what we get back from fishermen, and they work very effectively.

We had been tagging eels to look at their migrations across the Sargasso Sea, and one of the tags which came back suddenly went from a very low temperature, which was the standard sea temperature, up to 37°c and stayed there for a while. It turned out that the tag had been eaten by a whale close to the Azores, and the tag had been registering the whale's internal body temperature while it remained in the whale's gut! We'd never have found out this information if we hadn't developed the flotsam tag concept, which is now used in tagging programmes worldwide.

7. Finally, what you can forsee for CCSUS 10 years from now?

We see advisory and capacity-building support for Governments and industry internationally as a growing part of our portfolio in the next 5-10 years, as the Centre can quickly draw on a very broad range of expertise. On issues like aquatic food security, for example, there are significant opportunities to develop better understanding of the interactions between fisheries, aquaculture, food safety, human health, fish and human welfare, the economy and the environment. This would help to strengthen advice on the food system. Many trade-offs and challenges in the food system are easily overlooked in sectoral analyses of fisheries, aquaculture, health, medicine, human and fish welfare, safety and environment.

The design of things like monitoring programmes at large scales for Government is important. Cefas has already been partnering the Kuwait Environment Public Authority to design a marine monitoring programme, with elements such as water and sediment chemistry, eco-tox, microbiology, fish disease assessments and so on, but again in a way the more links we can develop with different experts the wider international packages like that can be and that would be very important for us.

We would hope to have driven progress towards more comprehensive and more cost-effective monitoring, by increasing the use of new technologies, integrating technologies, surveys and data streams, and providing users with more rapid access to data.

In the next five years we hope to build on our existing cohort of 10 PhD students and embed Centre staff in teaching undergraduate and graduate students in their areas of expertise. In the longer term we would hope to see people we have trained playing a leading role in marine science and industries.

Related links and Further Reading

1 https://www.cefas.co.uk/

2 https://www.uea.ac.uk/

3 http://www.norwichresearchpark.com/

4 http://marineknowledge.org.uk/

5 http://www.ccsus.org.uk/

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