



Cefas Quinquennial Science Review 2018



Review Panel Report

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Summary and Recommendations

1. A Science Review was undertaken in June 2018 to provide the Cefas Management Board with an external assessment of the sustainability, capabilities, quality and impact of the science and scientific programmes carried out by the Centre for Environment, Fisheries and Aquaculture Science (Cefas) over the period since the last Science Review in 2012.
2. The science was evaluated under six themes: Aquatic Animal Health, Aquatic Food Safety, Sustainable Fisheries, Ecosystem Change, Innovative Monitoring and Forecasting Change. Overall, we concluded that Cefas' science is of high quality and impact, delivering essential statutory monitoring and inspection services, information and advice together with national emergency response capability. In addition, Cefas supports its researchers to deliver fundamental and applied scientific research to underpin its wider activities.
3. The Review Panel was impressed by the resilience of Cefas and its staff, and the extent to which the organisation has embraced change whilst maintaining science outputs and quality, given the continuing and wide-ranging changes over the last five years in terms of the policy environment, funding, staff numbers, management organisation, infrastructure and the internationalisation of Cefas.
4. **Sustainability.** Cefas has, over the last few years, developed a successful working model that centres on government and government-to-government research, advisory tasks and monitoring needs. Cefas' support from and interactions with core Defra lie at the heart of this successful structure. Staff numbers have increased, Seedcorn investment is highly effective and research infrastructure is effectively maintained and developed. The successes, both in terms of income and the international remit of the organisation, together with EU exit are placing Cefas under a range of pressures that need to be addressed going forward if science quality is to be maintained and enhanced.
5. **Capabilities.** Cefas continues to have the capabilities to meet the needs of its core customers, whilst expanding its co-operation and capabilities, especially in the areas of environmental monitoring technology, eDNA and data. Having already made substantial amounts of data available, substantially more could be done in this increasingly data-driven world to exploit those data, deploy risk assessments and improve forecasting techniques. It is timely to revisit the Cefas' Science and Evidence Strategy to make sure it is fit for purpose in addressing new international priorities and to prioritise Seedcorn investments.
6. **Quality Assurance.** Cefas' science activities reflect current science thinking with international leadership in several areas. Feedback indicates that these activities are appropriate to meeting the needs of business and especially government. The quantity and quality of Cefas science outputs is good, but more needs to be done to encourage science outputs through more flexible time management, and more to encourage quality through mentoring and narrative development.
7. **Use and Impact.** The Review Panel identified a range of science highlights and welcomed the case studies and presentations on the site visits, which provide clear evidence of impact of Cefas' science in a range of areas.

There is a clear impact of Cefas science on policy development and implementation, which is becoming increasingly global in its context. However, in the context of EU exit, a continued national focus is required as well, and this was evident from the case studies and the site visits. Cefas' collaboration with other organisations is well received. The developing university partnerships should, with careful stewardship, significantly enhance the quality and quantity of Cefas science. Recommendations are made into how Cefas might further improve its science, surveillance and monitoring, use of data, reporting and publications.

8. The Review Panel was impressed by the measures that had been put in place by Cefas since the 2012 review to ensure the sustainability, relevance, quality and impact of its evidence activities. A number of these measures are further addressed in the current Recommendations.
9. The Review Panel makes a number of general recommendations within the report to Cefas that are listed below. In addition, we make note of a number of **issues requiring attention** in **Appendix F**, which arose during our meetings with the individual science themes. Some of these issues relate to the general recommendations, while others are more specific to the themes.

Recommendation 1: We recommend that as a consequence of Cefas' success in generating new, large international programmes, a more strategic approach to international investments should be developed to ensure that the programmes fit within the Cefas Science and Evidence Strategy and enhance the science capability for government. **See 2.4**

Recommendation 2: The larger overseas research programmes should develop dissemination strategies to ensure scientific impact and output, especially, but not only with respect to, high quality publications. This will require significant time budgeting. **See 2.5**

Recommendation 3: Research & Development (R&D) funding should be at least 20% of Cefas delivered turnover, and preferably closer to 25%. **See 2.6**

Recommendation 4: At an organisational level we support the efforts to maintain per capita turnover, and to review the efficacy of the current project management/science structure/business model to ensure that it is delivering. This would include analysis of per capita turnover for the R&D and other Science components, more flexible time management and further training in science and project management within teams. **See 2.8**

Recommendation 5: Seedcorn should continue to be grown to an agreed target and should continue to be used flexibly to support emerging science needs. The Cefas Science Advisory Committee should be involved in advising which investments are best used to develop and deliver the Cefas Science and Evidence Strategy and in monitoring the impact of the investment. **See 2.9**

Recommendation 6: The new build at Lowestoft, with its open plan environment, will require expert change management and close monitoring of impacts. Flexible ways of working will need to be adopted to accommodate the needs of individual members of staff to ensure continuity of delivery. **See 2.10**

Recommendation 7: Options should be left open, if possible, for the redevelopment of aquaria facilities at Lowestoft should the need arise. **See 2.12**

Recommendation 8: Uptake of innovative observation technology in international monitoring programmes is relatively slow and can only be achieved through co-ordination and agreements in international fora, such as International Council for Exploration of the Seas (ICES) and Oslo/Paris convention (for the Protection of the Marine Environment of the North-East Atlantic (OSPAR). Consequently, engagement of Cefas in these organisations, often in a leading role, should be continued. [See 2.13](#)

Recommendation 9: A ‘one size fits all’ approach will not meet the needs of all those using computing facilities, especially those involved with mathematical modelling and non-standard statistical analyses, or with the remote operation of specific monitoring hardware. Flexible support needs to be provided on a range of platforms. [See 2.14](#)

Recommendation 10: The development of high performance computer-based ocean and biogeochemical modelling, underwater noise modelling and monitoring, bioinformatics, molecular eDNA analysis, ecological and fisheries modelling, satellite remote sensing and advanced data management all require high-end technological infrastructure to match these tasks. Much of the development of these activities, however, appears rather piecemeal, and in the case of computing, somewhat inadequate for the needs of the science. We recommend consideration of something like a technology division in this burgeoning area to ensure the co-ordinated development of technological infrastructure. Advice on solutions and detailed implementation should also be sought from university partners and others in the Defra group. [See 2.14](#)

Recommendation 11: Cefas is an attractive employer, but more could be done to ensure recruitment and retention of highly numerate scientists (modellers, statisticians and data scientists) who are needed for delivering future computational and modelling innovations. This could include work conditions allowing close co-operation with relevant universities, exchange programmes with leading international institutions, targeted Seedcorn funding (e.g. to form a cross-disciplinary research focus) and work allocations to foster high levels of scientific production. [See 2.15](#)

Recommendation 12: Clear succession planning with a spreading of the risk needs to be developed for key roles within the organisation. Monitoring of gender pay gap and staff progression through the organisation, from selection to promotion and progression, should be routinely reviewed. We recommend development of a clear action plan for the organisation with annual reporting on progress against agreed targets. [See 2.16](#)

Recommendation 13: Preparation for Horizon Europe (e.g. through H2020 Co-ordinated Support Actions, JPI Oceans or other international organisations) is recommended. However, a replacement of the European Maritime & Fisheries Fund (EMFF) operational programme, including its financing, needs to be put in place by government. Further regional co-ordination of monitoring, advisory and scientific activities through international organisations, such as ICES, OSPAR and Regional Fisheries Management Organisations (RFMO’s) as replacement of central EU commission services, is recommended. [See 2.19](#)

Recommendation 14: The Review Panel supports and commends moves towards replacing EU Reference Laboratory status with international designations using, for example, the Food & Agriculture Organisation (FAO) as an accrediting organisation for an international role. It also suggests conducting a horizon scanning exercise for international/global funding, including from large private foundations. [See 3.4](#)

Recommendation 15: A co-ordinated plan needs to be developed on how the Centres of Excellence will fit in to the current organisational structures and for how they will be structured and delivered. [See 3.5](#)

Recommendation 16: Given the rapid international developments in Cefas science, it is apparent that the current Cefas Science and Evidence Strategy is now considerably out of date. We strongly support the development of a new five-year plan that clarifies structures and opportunities, with an intermediate refresh if necessary, to take account of changing needs. [See 3.6](#) and [3.7](#)

Recommendation 17: Consideration should be given to reconfiguring the overarching Food Security/Blue Growth framework around a Food Security/Natural Capital framework. This better reflects the need for science to protect and enhance natural capital for blue growth, rather than optimisation of Blue Growth related marine activities. [See 3.8](#)

Recommendation 18: We recommend in developing the Science and Evidence Strategy that careful consideration is given to the structure of the Science Directorate, so it is transparent that the customer needs are being met within a secure scientific framework. Acknowledging the importance of utilising expertise across research disciplines and themes, we recommend a clearer description of the cross-cutting working style, the structures in place and their benefits in the new Science and Evidence Strategy. There should be caution about adding more complexity to the organisational structure without reviewing and streamlining the current structures. [See 3.9](#)

Recommendation 19: Consideration should be given to how marine and socio-economic policy research could be further developed, building on existing partnerships with universities and the economics team within Defra. Consideration should also be given to which themes are suited for wider dissemination to relevant stakeholders and the public, and to how that should be done. [See 4.2](#)

Recommendation 20: Cefas should explore how more time can be made available to incentivise paper writing along with a greater focus on outputs and outcomes, rather than time management processes. [See 4.3](#)

Recommendation 21: Cefas management should consider resourcing a communications position in Weymouth to enhance support on this site, with respect to narrative and communications. Better use should also be made of training opportunities, particularly in relation to the development of narrative, perhaps with university partners. [See 4.8](#)

Recommendation 22: It is recommended that the case studies are used across a wide range of marketing/communication activities, that they are shared and developed with university partners, and that they continue to be refreshed with new ones added each year. Cefas Science Advisory Committee could potentially provide some form of peer review and quality control. [See 5.2](#)

Recommendation 23: Clear succession planning/deputisation needs to be developed for key posts. For advisory posts we would recommend spreading the risks associated with illness/resignation etc, by ensuring that several people are in a position to provide advice where practicable. [See 5.3](#)

Recommendation 24: It is recommended that greater emphasis is given to Cefas' government and government-to-government interactions (including international government-to-government), and to recognise and publicise more widely the key role that core Defra plays in this activity. This should not be to the detriment of Cefas' broader commercial activity. **See 5.4**

Recommendation 25: The development of the two collaborative centres has made a promising start. As the centres develop it is essential that they, together with other university partnerships, meet both Cefas and university needs. From a university perspective it will be essential that clear pathways to impact are developed alongside joint publications; this applies to the two centres and Cefas' wider university partners. Cefas Science Advisory Committee could potentially be used more actively to help monitor the development of the centres and pathways to impact. More widely, we would also urge that Cefas' collaboration with their partners be reviewed regularly to assess science outputs, impact and research income (from grants, government contracts or commercial contracts) together with the scientific benefits to Cefas in, for example, technological developments and big data analysis. **See 5.6 and 5.7**

Recommendation 26: Alongside plans to make further data sets available, Cefas should prioritise and outline how it is going to make best use of the unique data sets that it holds. This should happen via Cefas' discipline-specific expertise, and through external collaborations. Delivery of data to the wider community could also be enhanced, especially in areas that require the involvement of citizen science, as in the case of invasive species. **See 5.9**

Recommendation 27: Cefas should explore with its customers how report production can be modified to better meet the customer's and Cefas' needs, and in particular to maximise incentives and time available for the production of quality journal papers. **See 5.10**

Recommendation 28: We recommend that Cefas consult with Cefas staff and the Cefas Science Advisory Committee to develop a wider range of science metrics that better reflects the outputs and quality of outputs across Cefas' science activities (e.g. publications, reports, media), which should then be monitored across Groups. **See 5.11**

1. Introduction

1.1 The aim of this review is to provide an independent, external assessment of the sustainability, relevance, quality, and impact of the science and scientific programmes carried out by the Centre for Environment, Fisheries and Aquaculture Science (Cefas) over the period since the 2012 science audit.

Terms of Reference of the Review

1.2 Unlike the 2012 Science Review of Cefas, the 2018 review was not set up independently, but was requested by the Cefas Chief Scientist in consultation with the Cefas Science Advisory Committee and two external reviewers. It was designed to be lighter in touch and in scope, concentrating predominantly on Cefas science. The full Terms of Reference are given in **Appendix A** and summarised below. **See 1.3-1.6**

1.3 The Terms of Reference covering **Sustainability** focus on the quality and sustainability of the resources available to Cefas, the ability to attract and develop the skills of exceptional scientists, and success in generating income for its scientific work.

1.4 **Capabilities** relate to the extent to which Cefas meets the requirements of government, industry and society and how the Cefas' Science and Evidence Strategy supports the delivery of Cefas' strategic objectives and its capacity to identify emerging scientific issues and deliver the future needs of its major customers.

1.5 **Quality Assurance** focuses on whether the evidence activities are fit for purpose and reflect up-to-date scientific thinking together with an assessment of the quality of the science delivered by Cefas.

1.6 Finally, the Terms of Reference on **Use and Impact** are concerned with an evaluation of the science outputs, highlights and key achievements relating to Cefas science together with a consideration of the effectiveness of Cefas co-operation and interaction with other organisations. They also consider the mechanisms used to provide scientific advice, scientific publications, open data and the exploitation of Intellectual Property and whether these are appropriate in meeting customer objectives.

Review Background

1.7 Members of the Review Panel are listed in **Appendix B**. They are drawn from the Cefas Science Advisory Committee together with two additional independent scientific assessors and the Deputy Chief Scientific Adviser from Defra.

1.8 The Review Panel visits to meet staff and view facilities took place on 5-6 June 2018 at the Cefas Weymouth laboratory and on 12-14 June 2018 at the Cefas Lowestoft Laboratory. Telephone interviews with key customers took place on 23-24 July 2018.

1.9 Prior to the Review Panel visits Cefas staff prepared the following documentation

- Cefas Science and Evidence 2018: a self-assessment document based on the Terms of Reference incorporating a number of metrics relating to science output, research performance, science quality, income, staff numbers and publications.

- Supporting documentation that included the Terms of Reference, organisational structure, organisational accreditations/certifications, the Science and Evidence Strategy 2014-2018, career paths, PhD students and publications.
- Briefing documents giving an overview of the research themes to be reviewed, including CV's of affiliated staff.
- Case studies: a compilation of 33 case studies outlining the science, expertise, new knowledge, economic or societal impact and future expectations.

These documents were made available to the Review Panel online via collaboration software (Huddle), together with a number of other supporting documents such as details of the 2012 Science Review.

1.10 During the visits the Review Panel met and had short presentations from the Cefas Directors and met with scientists from the following themes: Aquatic Animal Health, Aquatic Food Safety, Sustainable Fisheries, Innovative Monitoring, Forecasting Change (including Emergency Response) and Ecosystem Change (including International Science Impact). In addition, we had presentations on the Cefas Data Hub and University Alliances, and met with early career scientists, graduate and placement students in two poster sessions at Weymouth and Lowestoft.

1.11 During the visit to Weymouth the Review Panel toured some of the laboratory facilities (e.g. molecular diagnostics, virology, bacteriology) together with the aquaria. This was not possible at Lowestoft because of the extensive ongoing demolition, building and refurbishment work. The Review Panel was, however, given an overview of the plans for laboratory refurbishment and new building.

1.12 The Review Panel is grateful to all the scientists, early career researchers and visiting students we met during the review. The Review Panel was impressed by their enthusiasm, especially when faced with a variety of challenges including funding and organisational changes, EU exit, and the demolition and refurbishment work at Lowestoft. The Review Panel is also grateful to the Cefas Chief Scientist together with his support team for facilitating the Review.

1.13 This Report addresses each of the main areas outlined in the Terms of Reference (Sustainability, Capabilities, Quality Assurance and Impact). It also provides a brief summary of our discussions around case studies (**Appendix C**), customers (**Appendix D**), PhD students and early career researchers (**Appendix E**), and the science themes (**Appendix F**).

2. Sustainability - Resource Flow & Prioritisation

To consider the quality and suitability of the resources available to Cefas (including staff, Seedcorn investment, equipment and facilities) and whether the organisation and management of science are appropriate to achieve customer requirements now, and into the future.

2.1 We recognise that there has been a considerable change in the organisation since the last review in 2012 with a) pressures on traditional funding streams and a substantial effort to develop new funding sources, b) an increase in personnel associated with these new funding streams, c) a change in management structure, d) preparation for EU exit (“Brexit”) which requires some replacement/adaptation of EU policies and directives and e) the current demolition and rebuild of a substantial part of the Lowestoft building.

2.2 All of these changes have impacted, and will continue to have an impact on, the resources available to Cefas in terms of its staff, Seedcorn investment, equipment and facilities, while the changes in management structure have the potential to impact on science delivery and customer satisfaction.

Financial sustainability

2.3 The Review Panel was impressed by the financial resilience that has been achieved through diversification of funding sources, new commercial contracts, a broader Her Majesty’s Government (HMG) portfolio and of course the continued core Defra funding. Following the 2012 review, there has been a continuing decline in core Defra funding, which initially led to a decrease in annual turnover from £52.1m to £47.4m in 2015/16. This turnover has since increased to £53.2m in 2016/17, as a result of securing new funding sources. Not only has turnover returned to 2012 levels (+2%), but the proportion of UK Government funding has also returned to the same level of 84%. This apparent stability, however, masks a considerable increase in the range of government customers, which has also led to a broadening of the science and advisory tasks that are being delivered by Cefas, particularly in the international arena.

2.4 Whilst this financial resilience is to be welcomed, it must also be recognised that there is a need to strike a balance between agility/diversification and over-stretching the limited resources in some areas. Currently, Cefas strengths are being exploited wherever possible, but inevitably an increased international research focus will require some areas of scientific endeavour to be strengthened within Cefas, and others to be brought in via collaborations and partnerships.

Recommendation 1: We recommend that as a consequence of Cefas’ success in generating new, large, international programmes a more strategic approach to international investments should be developed to ensure that the programmes fit within the Cefas Science and Evidence Strategy and enhance the science capability for government.

2.5 Overseas research also almost invariably comes with a substantial overhead of time. If the international engagement that Cefas is developing is to provide high quality science outputs that enhance the reputation of Cefas, then it is essential that dissemination strategies are developed for the larger programmes, including peer review publications and project narratives for customers and the broader public.

This will help to ensure sufficient confidence, where there might otherwise be concerns over whether Cefas is expending too much effort on non-central areas and, will increase Cefas' reputation in those areas which it is now starting to work for government.

Recommendation 2: The larger overseas research programmes should develop dissemination strategies to ensure scientific impact and output, especially but not only with respect to high quality publications. This will require significant time budgeting.

2.6 When Cefas became an executive agency in 1997, more than 40% of income was classified as R&D. This had declined to around 30% at the time of the 2012 Science Review and the forecast for 2018/19 is 24%. The 2012 review recommended that Cefas should plan to keep R&D funding above 20% of Cefas delivered turnover. We endorse this recommendation but would prefer to see current levels (24%) maintained or increased, as this is delivering a level of research output and impact that is currently maintaining Cefas' capabilities and capacities in research, advisory and environmental monitoring functions.

Recommendation 3: R&D funding should be at least 20% of Cefas delivered turnover, and preferably closer to 25%.

2.7 Over the last five years Cefas has had considerable success in securing funding through partnerships with universities and other research institutes to further enhance its R&D. The Review Panel recognised that it is a source of considerable frustration that Cefas is not able to bid directly for UK Research and Innovation (UKRI) funds. We would encourage Cefas to continue in its endeavours to become eligible to apply for funding, not least to ensure Cefas ownership and openness for more transfer of ideas and data to universities. However, we would caution that UKRI funding is extremely competitive and much of Cefas' research is too applied to be successful. Given Cefas' success in other funding competitions and the strong links that it has with university partners, a better return on investment might be to concentrate on these avenues of funding.

Staff

2.8 An exceptional increase in staff occurred between 2016/17 and 2017/18 with the number of Full Time Equivalents (FTEs) increasing from 509 to 555, a 9% increase, and has since risen further to approximately 600. The increase was necessitated by the science and evidence demand that resulted from an increase in funding. Cefas is to be applauded in being able to make such a rapid adjustment to FTE numbers in order to deliver the increasing science demand. However, as the number of FTEs has increased at a slower rate than income, staff have inevitably come under more pressure, both in terms of time and also skills. In discussions with staff, time pressure and time management regularly emerged as critical issues, particularly for early career scientists. The issue of project management was also raised, especially in relation to small projects, where it was felt that the current administrative structure with both a science lead and project manager was unnecessary. In order to ensure that science outputs are maintained we would recommend that continuing efforts are made to maintain the per capita turnover so that time does not come under even more pressure, to reduce administrative burdens where possible, and to consider further training to increase the effectiveness of science and project management within teams.

Recommendation 4: At an organisational level we support the efforts to maintain per capita turnover, and to review the efficacy of the current project management/science structure/business model to ensure that it is delivering. This would include analysis of per capita turnover for the R&D and other Science components, more flexible time management and further training in science and project management within teams. **See 4.3**

Seedcorn

2.9 Presentations and interviews with staff indicated that self-generated strategic self-investment (Seedcorn) is highly valued in supporting a range of activities such as paper writing, PhD students and new areas of research. The year-on-year growth in Seedcorn (from £0.8m in 09/10 to £2.1m in 16/17) has clearly provided a significant return on investment and underpinning to future Cefas scientific capability, staff competences and reputation. We recommend that every effort should be made to maintain and ideally grow this resource so that it can be invested in line with the Cefas Science and Evidence Strategy. Some suggestions for investments made during the site visits are included in **Appendix F** but the Review Panel was not in a position to prioritise them. We note that the Cefas Science Advisory Committee has had some involvement in advising on Seedcorn investments but would recommend that it should have a more substantial role in advising on investments in future.

Recommendation 5: Seedcorn should continue to be grown to an agreed target, if possible, and should continue to be used flexibly to support emerging science needs. Cefas Science Advisory Committee should be involved in advising which investments are best used to develop and deliver the Cefas Science and Evidence Strategy and in monitoring the impact of the investment.

Facilities and equipment

2.10 The question of the ageing estate at Lowestoft was addressed by the 2012 Science Review and we are delighted that the funds have now been made available for a refurbishment of the northern laboratory wing, the demolition of the other buildings and the provision of a new building that will largely contain offices. At the time of our review this work was ongoing. It represents a major upgrade of the laboratory space at Lowestoft and provides a considerable change in the working environment for staff as the new build is open plan and will require hot desking arrangements. There are valid concerns amongst the staff about the change to open plan working and the loss of the library, but there is also considerable anticipation. We recognise that staff will need time to adjust to their new working environment and that some will need support. It should also be recognised that a 'one size fits all' approach will not necessarily provide the right working environment for all staff. We recommend that change management and monitoring will be required before and during the initial occupancy of the new building and that creative solutions are looked for to enable those who are having difficulty in adjusting to the new working environment to remain productive.

Recommendation 6: The new build at Lowestoft with its open plan environment will require expert change management and close monitoring of impacts. Flexible ways of working will need to be adopted to accommodate the needs of individual members of staff to ensure continuity of delivery.

2.11 At Weymouth the Review Panel formed a positive view of laboratory facilities together with staff capability, and of the procedures in place to update equipment. With such a radical overhaul of the Lowestoft laboratories it was not possible for us to get a clear impression of the analytical laboratories there.

2.12 A very positive impression of the aquarium facilities and the way they are run was obtained at Weymouth. With the refurbishment at Lowestoft the Review Panel understands that the facilities at Weymouth will become the major aquarium facilities for Cefas as a whole, with reduced facilities at Lowestoft.

We support this development in the current scientific climate but would recommend that options be left open to redevelop the aquarium at Lowestoft should the scientific need arise in the future.

Recommendation 7: Options should be left open, if possible, for the redevelopment of aquaria facilities at Lowestoft should the need arise.

2.13 The evolution of biological and environmental monitoring, from site-specific measurements of a small range of parameters toward integrated data collection programmes, is acknowledged across all the scientific themes. This involves the development of innovative methodologies (e.g. molecular techniques, assays for plastics, data storage tags) and the implementation of a broad variety of modern methodologies in routine programmes. New monitoring programmes, such as on marine noise, are also being developed, with Cefas' own monitoring requirements, and are being implemented in collaboration with university and industry partners. Data generated by earth observation systems are also being increasingly used, while innovative monitoring programmes on Research Vessel Cefas Endeavour include real-time continuous measurement of a range of environmental parameters. Despite general progress in autonomous observation technology, a state-of-the-art research vessel is still a pre-requisite for multidisciplinary monitoring and research programmes. However, the increasing utilisation of research vessels as a multi-sensor platform contributes to their high operational costs.

Recommendation 8: Uptake of innovative observation technology in international monitoring programmes is relatively slow and can only be achieved through co-ordination and agreements in international fora, such as ICES and OSPAR. Consequently, engagement of Cefas in these organisations, often in a leading role, should be continued.

2.14 Computing facilities, especially in terms of modelling and data management, was an issue raised by a number of members of staff in discussions at both sites. There is clearly frustration among some staff over the imposition of a Windows 10 environment across the organisation. We recognise the administrative reasons for this, but different scientists have different needs, and these must be addressed, especially in the context of the plans to increase flexibility in working environments. For example, those involved in gene sequencing and evolutionary studies frequently work in an Apple environment because of the availability of specific software, whilst modellers and large data handlers (e.g. ocean and biogeochemical modelling) use Linux and R and may need routine administrative rights to change programs and install software. More generally we gained the impression that a number of computational developments were not being thought through sufficiently and were not well co-ordinated.

Recommendation 9: A ‘one size fits all’ approach will not meet the needs of all those using computing facilities, especially those involved with mathematical modelling and non-standard statistical analyses, or with the remote operation of specific monitoring hardware. Flexible support needs to be provided on a range of platforms.

Recommendation 10: The development of high performance computer-based ocean and biogeochemical modelling, underwater noise modelling and monitoring, bioinformatics, molecular eDNA analysis, ecological and fisheries modelling, satellite remote sensing and advanced data management all require high-end technological infrastructure to match these tasks. Much of the development of these activities, however, appears rather piecemeal and in the case of computing somewhat inadequate for the needs of the science.

We recommend consideration of something like a technology division in this burgeoning area to ensure the co-ordinated development of technological infrastructure. Advice on solutions and detailed implementation should also be sought from university partners and others in the Defra group.

To assess Cefas’ ability to attract, retain and develop exceptional scientists, to cultivate and utilise their skills, and manage succession of key senior scientists.

2.15 The recent increase in staff numbers (9%) and relatively low turnover in staff (8%), demonstrates that Cefas has the ability to attract and retain staff. The annual surveys indicate that staff satisfaction remains high, except in terms of salary. We were impressed by the early career scientists that we met and the potential desire of many of the PhD and placement students to consider a career in Cefas (see Appendix D). We were also impressed with the number of staff developing their capability through taking on part-time PhD projects. There were, however, some concerns over the loss of a number of senior staff in fisheries and ecosystem change and whether this had been compensated for by recruitment and increased co-operation with universities. There is a need for further expertise in spatially explicit modelling that incorporates the drivers of change and which also considers structural model uncertainty together with machine learning. These topics require staff with skills which are in high demand across a wide range of research disciplines and organisations. This makes it challenging to recruit and to retain staff.

Recommendation 11: Cefas is an attractive employer, but more could be done to ensure recruitment and retention of highly numerate scientists (modellers, statisticians and data scientists) who are needed for delivering future computational and modelling innovations. This could include work conditions allowing close co-operation with relevant universities, exchange programmes with leading international institutions, targeted Seedcorn funding (e.g. to form a cross-disciplinary research focus) and work allocations to foster high levels of scientific production.

2.16 The Review Panel appreciated the procedures that have been put in place in terms of staff development as laid out in the Career Paths framework. The recent restructuring has also demonstrated the willingness of staff to take on new roles.

We, however, witnessed evidence of a reluctance on the part of some staff to take on senior scientific management roles, a lack of clear succession planning or at least documented succession planning for these key roles, and a need for further training in team building around project management and scientific leadership. See 2.8. Gender and diversity issues were also raised by some staff. Whilst there has been considerable progress in this area since the 2012 review, it is clear that there is still work to be done in relation to pay and achieving gender equality at senior grades.

Recommendation 12: Clear succession planning with a spreading of the risk needs to be developed for key roles within the organisation. Monitoring of gender pay gap and staff progression through the organisation from selection to promotion and progression should be routinely reviewed. We recommend development of a clear action plan for the organisation with annual reporting on progress against agreed targets.

To assess Cefas' success in generating income and attracting funding for its science from external customers nationally and internationally, and how external funds complement and enhance the science capability for Government.

2.17 It is clear that the considerable effort directed at generating income has been successful with 84% of income continuing to come from the UK Government, but now from a broader range of departments. Significant funding in terms of research also continues to be generated from the EU, business and public sector, including the Research Councils, the latter in the form of sub-contracts. The win/loss statistics for grant applications over the last year (2017/18) are an impressive 72%/28% and even when Core Defra is excluded win rates remain above 60% in all customer sectors (2017/18 "Win/Loss" Review). There are valid concerns over EU exit and its implications both for EU research funding and the data collection framework, including fish stock assessments.

2.18 One consequence of the increase in the Cefas funding base from Core Defra to other UK government departments (e.g. Foreign & Commonwealth Office (FCO) and overseas governments (e.g. Kuwait) rather than private business has been the consolidation of a working model that focuses on government and government-to-government orientated research rather than commercially orientated business research. We believe that this has the potential to strengthen the research reputation of Cefas more than consultancy work for business. Another consequence is the potential for Cefas to now deploy its scientific expertise, developed primarily in Europe, in a much wider international context. This could stimulate new opportunities for long term research and provide opportunities for intensifying training activities in developing countries. These opportunities have considerable potential for societal impact but are associated with the real danger of scientists spreading themselves too thinly unless there is strategic oversight. See 2.4 and 2.5.

2.19 It is expected that the UK will continue to participate in EU programmes financed by the multiannual financial framework (MFF) 2014-2020, as a result of the Her Majesty's Treasury (HMT) funding guarantee for all H2020 projects submitted to the Commission before the UK leaves the EU.

However, for MFF activities financed through the 2021-2027 programme (e.g. Horizon Europe, the new EU Research Framework Programme, and the EMFF there is some uncertainty depending on the outcome of the EU exit negotiations, although the UK's preferred position is to continue to participate in EU Research Framework Programmes. Following EU exit there is the expected reduction of advisory work for the EU, which will free resources.

However, involvement in other international organisations will likely increase, which suggests that the problem of managing workloads will persist [see 2.8](#), both as a result of time pressures and the complexity of a more diverse portfolio.

Recommendation 13: Preparation for Horizon Europe (e.g. through H2020 Co-ordinated Support Actions, JPI Oceans or other international organisations) is recommended. However, a replacement of the EMFF operational programme, including its financing, needs to be put in place by government. Further regional co-ordination of monitoring, advisory and scientific activities through international organisations, such as ICES, OSPAR and Fisheries RFMO's as replacement of central EU commission services, is recommended.

3. Capabilities – Meeting Defra and Other Customer Objectives

To assess the extent to which Cefas meets the requirements of government, industry and society, by providing evidence, scientific support services, policy and regulatory functions, advice and emergency response capability in the marine and freshwater environment.

3.1 As an executive agency Cefas continues to play a key role in supporting core Defra and other government departments with Cefas Management Board ensuring that leadership and resources are in place to deliver the requirements of government. With the recent increase in funding from government departments other than Defra, Cefas has shown that it has the capacity to meet the requirements of government in for example areas such as the Southern Ocean, Small Island States and Commonwealth. Cefas has also shown, through the recent challenges of EU exit, that it has the capacity to meet changing demands from Defra.

3.2 The relatively high consistency ($\approx 90\%$) of seventeen customers in its Top 10 customer rankings over the period 2012/13 to 2017/18 indicates that Cefas continues to meet the needs of those customers by providing evidence, scientific support services, policy and regulatory functions and advice in the marine and freshwater environments. Customer satisfaction generally remains high (approximately 90%) and on target, and interviews with four of the highest-ranking customers (see [Appendix D](#)) across government, agencies and business indicate a high level of satisfaction with Cefas science and science quality. It is noteworthy from the perspective of this review that science quality ranks consistently higher than the other measures of customer satisfaction at 91-94% over the last five years.

3.3 Cefas provides a national emergency response capability for marine incidents (e.g. chemical spills and releases of radioactivity) and all aquatic fish disease. We were impressed by the emergency response capacity that was outlined to us (see [Appendix F](#)) and emphasise that it should continue to be sustained and underpinned by a specific R&D budget.

3.4 The Weymouth laboratory has been the EU Reference Lab for Monitoring Bacteriological and Viral contamination of Bivalve Molluscs and the EU Reference Lab for Crustacean Diseases. With EU exit, the Reference Laboratory status will be lost.

Recommendation 14: The Review Panel supports and commends moves towards replacing EU Reference Lab status with international designations using, for example, the FAO as an accrediting organisation for an international role. It also suggests conducting a horizon scanning exercise for international/global funding, including from large private foundations.

3.5 The option of establishing Centres of Excellence was introduced to the Review Panel as a way of catalysing new funding opportunities in the following five areas: Seafood safety, Anti-microbial resistance, Emerging diseases in aquaculture, Fisheries science and Climate change. Although we did not hear about these Centres in detail, we would advise that their introduction should not further complicate the newly established organisational structures within Cefas.

Recommendation 15: A co-ordinated plan needs to be developed on how the Centres of Excellence will fit in to the current organisational structures and for how they will be structured and delivered.

To assess Cefas' Science and Evidence Strategy including how it supports delivery of Cefas' strategic objectives and its capacity to identify emerging scientific issues and deliver the future needs of its major customers nationally and internationally.

3.6 The Cefas Science and Evidence Strategy (2014-18) has served Cefas well in providing a framework for the challenges in 1) Sustainable blue growth, 2) Intelligent monitoring of risks, 3) Accessible evidence for decision making, 4) Understanding and forecasting aquatic ecosystem change, and 5) Meeting food security and food safety targets. This was the framework around which the presentations were made to the Review Panel (see **Appendix F**). It has, however, provided little strategic guidance for Cefas' increasingly international remit and limited guidance for Seedcorn investment. It is also underlain by a complex and at times confusing Directorate and Operational structure, and a matrix structure of the Science Directorate consisting of Groups and Teams operating in Themes with cross-cutting new initiatives (e.g. One Health, Centres of Excellence).

3.7 We are aware that Cefas is embarking on the development of a new Science and Evidence and Strategy and would recommend that this is written in generic terms with annual updates to take account of changing evidence needs in the national and international arenas.

Recommendation 16: Given the rapid international developments in Cefas science, it is apparent that the current Cefas Science and Evidence Strategy is now considerably out of date. We strongly support the development of a new five-year plan that clarifies structures and opportunities, with an intermediate refresh if necessary, to take account of changing needs.

3.8 The Review Panel found the restructuring around Food Security and Blue Growth, evidenced in the Strategy, provided a useful way of summarising Cefas' activity to external audiences, but was not wholly bought into internally, where many staff members struggled to articulate their contribution to Blue Growth in particular. Certainly, the Food Security programme with its component elements of Sustainable Fisheries, Aquatic Food Safety and Aquatic Animal Health makes a coherent package. However, contributions to the Blue Growth programme are mainly concerned with the protection and enhancement of Natural Capital and contribute only to a limited extent directly to Blue Growth. Given that the UK Government also uses the language of Natural Capital we would recommend that consideration be given to using the term Natural Capital rather than Blue Growth in the next Science Strategy. We also believe that staff might feel more comfortable using this framework, but would advise wider consultation with, for example, Defra.

Recommendation 17: Consideration should be given to reconfiguring the overarching Food Security/Blue Growth framework around a Food Security/Natural Capital framework. This better reflects the need for science to protect and enhance natural capital for blue growth, rather than optimisation of Blue Growth related marine activities.

3.9 With consideration of the health aspect of Cefas' work being branded under a 'One Health' framework and active plans being considered for the development of a number of Centres of Excellence (Aquaculture, Food safety, Antimicrobial resistance, Fisheries, Climate change) there are real concerns that Cefas' scientific and operational structures are becoming too complicated and confusing. They are certainly not immediately transparent from an external perspective.

Recommendation 18: We recommend in developing the Science and Evidence Strategy that careful consideration is given to the structure of the Science Directorate so it is transparent that the customer needs are being met within a secure scientific framework. Acknowledging the importance of utilising expertise across research disciplines and themes, we recommend a clearer description of the cross-cutting working style, the structures in place and their benefits in the new Science and Evidence Strategy. There should be caution about adding more complexity to the organisational structure without reviewing and streamlining the current structures.

4. Assurance of Scientific Processes – Including scrutiny and Quality Assurance

Science Activities

To assess whether the evidence activities undertaken by Cefas are appropriate-to-purpose, and reflect up-to-date scientific thinking to meet the objectives of their customers nationally and internationally.

4.1 Much of Cefas science is operational in nature, with only 24% of the current income being classified as research and development. That income, however, derives from an increasingly wide range of sources that allows Cefas to take an increasingly multi- and inter-disciplinary approach to 1) Ensure safe and sustainable food, 2) Support sustainable blue growth, 3) Develop innovative monitoring, 4) Forecast ecosystem change and 5) Provide open and transparent data.

4.2 The Review Panel was provided with a wide range of evidence (see Appendix F) to indicate that the science is up-to-date and meets the objectives of customers both nationally and internationally. We see the partnerships with other organisations, in particular the university sector, as being particularly important in refreshing and challenging Cefas' scientific thinking. Partnerships allow Cefas to explore new technologies and new approaches, and also to be involved in the development of wider interdisciplinary and multidisciplinary programmes. In the area of blue growth we feel that this could be further exploited in the social science area, in for example, marine policy where partner involvement potentially allows the confidential government-Cefas relationship not to be compromised. The socio-economic research team in Lowestoft is growing, becoming a valuable asset to a number of work areas and an interesting outside co-operation partner, delivering into fisheries management, blue carbon, cultural services (tourism) and natural capital accounting. There will be useful parallel expertise elsewhere in Defra, and these links should be made. Other policy areas are suitable for broader collaboration and communication as well, such as the conservation work done on recreational fisheries as well as sharks and rays. A concise overview of stock assessment methodologies deployed for producing advice on fisheries management would be of benefit for scientific and policy co-operation partners as well as interested stakeholders in industry and Non-Governmental Organisations (NGO's).

Recommendation 19: Consideration should be given to how marine and socio-economic policy research could be further developed, building on existing partnerships with universities and the economics team within Defra. Consideration should also be given to which themes are suited for wider dissemination to relevant stakeholders and the public, and to how that should be done.

4.3 The Review Panel has already welcomed, and commented on, the Career Paths framework see 2.11, but would add in this context, with the growing number of staff that adequate time needs to be made available for staff training and also for the production of science outputs, especially scientific papers. Time management came across as an area of considerable concern for staff, with pressure to deliver on contracts and consequent pressures on training and science outputs (see also 2.8). The Review Panel would welcome more time being made available for the production of science outputs.

It recognises that this is a challenge but would urge consideration of an increase in Cefas' Mytime, allocation of time within project tenders for paper writing, a change in report writing (see 5.10) and a greater focusing on outputs and outcomes rather than on processes such as time management. A slight loosening of the time management controls with a renewed emphasis on excellent outputs and outcomes, as is often recommended in Government and by the Research Councils, also has the potential to increase staff engagement, currently sitting stubbornly at about 65%, and provide more time for development of excellent scientific outputs.

Recommendation 20: Cefas should explore how more time can be made available to incentivise paper writing along with a greater focus on outputs and outcomes, rather than time management processes.

Science Quality

To assess whether the science delivered by Cefas is of high quality, in light of measures of science quality and performance including benchmarking against similar organisations. Also to evaluate the accreditation and other proficiency assessment processes in place at Cefas.

4.4 Customer Satisfaction is consistently close to 95%, which indicates that customers are generally very satisfied with the quality of science in the reports they commission from Cefas. Interviews with key customers also indicated a high level of satisfaction with science quality. Most other aspects of customer satisfaction with performance also rate very highly, apart from perhaps value for money. Project reports clearly involve a huge amount of work and many are quite lengthy. It is recommended that consideration be given to discussing with customers whether report writing can be modified to better meet their needs. See section 5.10

4.5 We were reassured by the quality assurance processes that are in place in relation to the various international standards designated by International ISO, including oversight from the Audit and Risk Committee.

4.6 Cefas is on target in relation to the number of Institute for Scientific Information (ISO) publications it produces and now also has measures in place to increase the average impact factor score of the journals it publishes in. There are some groups within Cefas that are, however, consistently producing papers in higher ranking journals and with more impactful narratives. It is important to learn from these groups and to ensure that staff are aware of the measures of success in terms of science quality and impact, which should continue to be assessed in staff appraisals

4.7 The Review Panel applauds the increase in the quantity and quality of publications. In terms of bench marking against similar organisations, Cefas analysis indicates that it scores well in terms of impact, whilst having a lower research output than some other organisations. Over 50 staff have over 1000 citations, but only a handful have over 5000, and there are only approximately 15 with an H-index over 30. It is difficult to guarantee high quality papers, but they require time, ambition, a compelling narrative and high quality science. We have already identified that time is under considerable pressure.

4.8 The issues of science quantity, in terms of publications, and science quality, are key in terms of maintaining and enhancing the scientific reputation of Cefas ([see 5.11](#)). The barrier most frequently raised by staff to the production of more papers was time management ([see 4.3](#)). Quality and impact depend in part on the science, in part on the journal selected for publication and in part on the narrative ([see 4.5](#)). We also advise that narratives in other media are important in ensuring that core customers and the wider public are aware of the quality of Cefas science, and especially the benefit of new international activities. There was some concern expressed at Weymouth over the lack of a communications position there.

Recommendation 21: Cefas management should consider resourcing a communications position in Weymouth to enhance support on this site, with respect to narrative and communications. Better use should also be made of training opportunities, particularly in relation to the development of narrative, perhaps with university partners.

5. Use and impact – Outcomes for Government, Partnerships and Knowledge Transfer

To identify science outputs, highlights and key achievements and evaluate the impact that Cefas has had on UK, EU and International policy development and delivery.

5.1 We recognised numerous science highlights and achievements (see Appendix F) and here identify particular areas that resonated with individual members of the Review Panel:

- **Forecasting change:** An impressive range of modelling activities around environmental change and the quantification and communication of uncertainty. A strong multidisciplinary perspective, scientific papers with strong narratives, links to the wider climate change community, and strong outreach work through the Marine Climate Change Impacts partnership.
- **Data archive:** releasing data is an excellent asset for scientists and users. The compilation of 130 years of sea temperature data is the sort of evidence that is crucial to demonstrate to the public, industry and government what is happening. Cefas is in an excellent position to build on this and clearly demonstrate the impact on fish/life, economic impact of sea level rise and the impacts in changing water chemistry. Modelling future change, exploring new possibilities for ecosystem change and future food supply options is a key area for more research.
- **Pioneering work in marine eDNA and the pathobiome concept:** work in this area is driven by necessity, but Cefas' expertise, facilities and collaborations make it ideally placed to exploit and to lead in this rapidly developing area. Despite the applied context, there is a need, and an opportunity, to answer high-impact fundamental science questions in this context.
- **Indicators and ecosystems:** this work synthesises Cefas' rich data resources and diverse modelling expertise, to develop practical predictions of stability and resilience based on ecologically motivated principles e.g. community-level size spectra.
- **Aquatic animal health:** the clear conduit between science, industry and regulation and inspection services is unique in an organisation such as Cefas and is enabled by the co-location and strong close working between the novel science diagnostics, new developments and the Fish Inspectorate teams in Weymouth.
- **Methods for managing data limited fish stocks:** Cefas has led on the development of scientific methods for assessing the status of fish stocks lacking key data about exploitation and population dynamics in support of international policies for achieving maximum sustainable yield.
- **Work on the spatial distribution and migration of fish is ground breaking,** comprising of coupled field investigations and experiments deploying enhanced technologies and data analyses techniques. This delivers important information for fish stock assessment and spatially explicit management.

- Work on the detection of toxins is state of the art and uses a nice balance of targeted and semi-targeted analytic technologies that have effectively replaced the traditional animal-based toxicity tests. It is recognised that exploring unbiased and in vitro based approaches may be a very powerful future development. This could be achieved with a broader use of functional genomics approaches.

5.2 The Review Panel welcomed the 33 case studies in demonstrating how a broad range of Cefas science impacts in a range of areas. These provide a valuable resource in demonstrating how Cefas science achieves impact and will be valuable for both internal and external communications. We recommend that these are regularly refreshed, with a number of new ones being produced each year.

Recommendation 22: It is recommended that the case studies are used across a wide range of marketing/communication activities, that they are shared and developed with university partners, and that they continue to be refreshed with new ones added each year. Cefas Science Advisory Committee could potentially provide some form of peer review and quality control.

5.3 It is clear from the case studies and interviews with key personnel that Cefas has a major impact on International, EU and in particular UK policy development, delivering high quality evidence for science advice on various national and international management issues. We would note its long-standing advice to Defra on fisheries and its current work on EU exit, as well as its long-standing high quality scientific contributions to ICES, OSPAR and other international organisations. A number of individuals are clearly key to providing and communicating advice, but we saw little evidence for succession planning or reducing the risk of over-reliance on key personnel.

Recommendation 23: Clear succession planning/deputisation needs to be developed for key posts. For advisory posts we would recommend spreading the risks associated with illness/resignation etc by ensuring that several people are in a position to provide advice where practicable.

To consider the effectiveness of Cefas co-operation and interaction with other organisations in the UK and overseas (e.g. UK Government departments and their network bodies, devolved administrations, research institutes, universities, non-governmental organisations and industry).

5.4 The nature of the co-operation with government has changed considerably over the last five years, such that while the percentage of UK Government total turnover has returned to 2012/13 proportions, the range of customers has expanded well beyond core Defra, although core Defra remains the largest single funder of Cefas. From a science perspective this broadening of customers is to be welcomed as it allows Cefas science to be used in a much broader context and also enhances the science capabilities of Cefas. There is now a need to place this science within a more strategic context within the Science Strategy recognising the critical role that being an Executive Agency of Defra has played in enabling this diversification of support for wider government. We also note that the terms 'Commercial Director' and 'Business Hub' do not altogether reflect the fact that most Cefas' business is with government rather than the commercial sector.

Recommendation 24: It is recommended that greater emphasis is given to Cefas' government and government-government interactions (including international government-government), and to recognise and publicise more widely the key role that core Defra plays in this activity. This should not be to the detriment of Cefas' broader commercial activity

5.5 The advice and support received by the UK Government is clearly highly valued, ranging from the advice on fisheries policy during EU exit to the involvement of the Commonwealth on ways to reduce plastic pollution. There is, however, scope to alter the nature of reporting so that it better meets the needs of government and also potentially enhances the possibility of publications, whether orientated towards science, technology or the social sciences.

5.6 Cefas has productive relationships with approximately 30 UK universities and is involved in nine doctoral training programmes with Cefas supervised students in four. Placement, Masters and PhD students provide an extremely effective method of engaging and training students in marine science. We were impressed by the quality and enthusiasm of the students we met. This investment undoubtedly pays dividends in terms of training the next generation of students and allowing exploration of new scientific ideas and technological developments (e.g. functional genomics, big data analysis), as well as providing a pipeline of new staff recruits that are fit for the organisation.

5.7 Over the last five years Cefas has also chosen to strengthen its relationships with two of the universities with which it has long standing relationships: the 'Collaborative Centre for Sustainable Use of the Seas' (CCSUS) at University of East Anglia (UEA) and the 'Sustainable Aquaculture Futures' (SAF) at the University of Exeter. These provide Cefas with access to facilities, student training and a wider range of science. They provide the universities with access to more applied science and pathways to impact. The Centre with Exeter is in the early stages of development, but the one at UEA is now established and is clearly valued by them (**see Appendix D**). Now that the UEA Centre has been established it is essential that the six science themes start to deliver more on science, grant applications and pathways to impact. This will also have the benefit of spreading the burden of the Centre from the Director and Deputy Directors.

Recommendation 25: The development of the two collaborative centres has made a promising start. As the centres develop it is essential that they, together with other university partnerships, meet both Cefas and university needs. From a university perspective it will be essential that clear pathways to impact are developed alongside joint publications; this applies to the two centres and Cefas's wider university partners. Cefas Science Advisory Committee could potentially be used more actively to help monitor the development of the centres and pathways to impact. More widely, we would also urge that Cefas' collaboration with their partners be reviewed regularly to assess science outputs, impact and research income (from grants, government contracts or commercial contracts) together with the scientific benefits to Cefas in, for example, technological developments and big data analysis.

5.8 Apart from the government departments and universities, Cefas has ongoing collaborations with a range of government agencies (e.g. other Defra agencies Joint Nature Conservation Committee (JNCC), Marine Management Organisation (MMO) and also with industry (e.g. EDF Energy). On the whole, these co-operations work well, the Food Standards Agency and EDF Energy work particularly well (**see Appendix D**). Evidence of science outputs and quality from these collaborations was limited.

To consider whether the mechanisms used by Cefas to provide scientific advice, scientific publications, open data and exploitation of Intellectual Property (IP), are timely, effective and appropriate in meeting customers objectives.

5.9 The commitment to make data openly available through the Cefas Data Hub has gone extremely well, with 5564 data sets available to download in April 2018. However, whilst there is a strategy to make data available, we believe that more could be done to utilise the invaluable data resource that Cefas holds to best effect through, for example, a team of data analysts. We saw evidence of the excellent use that can be made of long term data in the 130 years of seawater temperature data (CS 25) and would argue that more resource should be made available to make use of these data both internally and in collaboration with partners.

Recommendation 26: Alongside plans to make further data sets available, Cefas should prioritise and outline how it is going to make best use of the unique data sets that it holds. This should happen via Cefas' discipline-specific expertise, and through external collaborations. Delivery of data to the wider community could also be enhanced, especially in areas that require the involvement of citizen science, as in the case of invasive species.

5.10 Reports are highly valued by Customers, but for staff represent a very considerable time commitment that takes priority over scientific journal publication. Given the time pressures that staff are under and the value of committing more time to scientific publications we would recommend that discussions are held with customers to see if more concise reports would meet their requirements, potentially allowing more time for scientific papers or other dissemination. With a greater focus on the requirements of customers, executive summaries would communicate the messages that need to be heard by the customers, while technical/scientific annexes could be structured as draft papers. Interviews with key customers indicate that there is a willingness to review the nature of reporting so that it is more valuable for both sides. **See 4.4 and Appendix C.**

Recommendation 27: Cefas should explore with its customers how report production can be modified to better meet the customer's and Cefas' needs, and in particular to maximise incentives and time available for the production of quality journal papers.

5.11 Scientific publications together with reports are the key outputs used by Cefas to communicate its scientific results. It is, however, the reports that are more valuable to government, while Cefas' reputation within the scientific community is more dependent upon journal publications. Only the journal publications and a measure of their quality are reported to Cefas Management Board. We recommend that a broader portfolio of outputs should be reported, including for example reports, forming a more inclusive view of the science outputs. We would also note that policy report cards such as those developed by Cefas through the Marine Climate Change Impacts Partnership are extremely valuable. Cefas Science Advisory Committee should advise on the portfolio of reporting measures and also monitor the variability in outputs between Groups. **See also 4.3 and 4.8.**

Recommendation 28: We recommend that Cefas consult with Cefas staff and the Cefas Science Advisory Committee to develop a wider range of science metrics that better reflects the outputs and quality of outputs across Cefas' science activities (e.g. publications, reports, media), which should then be monitored across Groups.

6. 2012 Science Review Recommendations

Evaluate progress made and actions taken in response to the recommendations of the 2012 science audit.

6.1 The Review Panel was impressed by the measures that have been put in place since the 2012 review to ensure the sustainability, relevance, quality, and impact of its evidence activities.

6.2 The Review Panel recognised the improvements that have been made to the Management Information System and the recording and reporting of scientific output data. (Recommendation 4/2012)

6.3 The development of a five year cross-cutting evidence strategy was welcomed. We recommend that this is now refreshed (**see 3.7**) with the support of Cefas Science Advisory Committee, with the potential to update more frequently to take account of rapidly changing events in policy and science. (Recommendation 5/2012)

6.4 The target of 150 ISI journal papers with an additional target on impact factor has clearly provided a useful impetus for increasing the quantity and quality of publications. This however gives only a partial picture of science outputs for the Science Director and Cefas Management Board. We recommend that a broader portfolio of outputs should be reported (**see 5.11**), including, for example, reports, to be more inclusive of the science outputs provided by Cefas. Cefas Science Advisory Committee should advise on the portfolio of reporting measures. (Recommendation 13/2012)

6.5 With the recent restructuring of the Science Directorate, Cefas Science Advisory Committee should assess and comment on the variability of outputs across the new science groups (**see 5.11**) so that all groups are seen to contribute towards science excellence. (Recommendation 14/2012)

6.6 The development of the Cefas case studies for this science review were seen by the Review Panel as a valuable contribution to the Review process, providing evidence on the quality and impact of the science (**see Appendix C**). It is recommended that the provision of the case studies is seen as an ongoing process (**see 5.2**) so that a culture of 'impact' develops within the Cefas community (Recommendation 15/2012). Cefas Science Advisory Committee could be used effectively to provide independent assessment of the case studies, and university partners ought to be involved in their production. It is recommended that the case studies are also used more widely for communication and outreach.

6.7 The Review Panel notes that there is now a process in place that allows the Cefas Science Advisory Committee to be refreshed, although there is still work to be done on its gender balance and international representation. We affirm that Cefas Science Advisory Committee should play a stronger role in strategic thinking, the evaluation of the Seedcorn programme (**see 2.9**) and Cefas' scientific performance indicators (**see 5.11**), and other recommendations made elsewhere in this report aim to highlight and strengthen those contributions. (Recommendation 18/2012)

6.8 The Review Panel noted the strategic work that has been done in the area of ecosystem modelling as part of the Marine Science Co-ordination Committee (MSCC) programme. It also noted that a Head of Profession for Modelling has recently been appointed. This role is not yet clearly articulated. Strong junior appointments have been made recently, but the Review Panel noted that staff retention in this area is problematic. **See 2.15**

More flexible provision of computing facilities (**see 2.14**), mentorship and interdisciplinary working (including with economists and social scientists), and strategic time management are needed to retain staff and to ensure high quality science in the long term. (Recommendation 19/2012)

7. Conclusions

To comment and make specific recommendations for the future development of Cefas science programmes, as appropriate, and to draw an overall conclusion on the sustainability, relevance, quality, and impact of its evidence activities

7.1 Our overall impression was of a dynamic and vibrant research community that, over the past five years, has addressed and embraced a range of challenges, and continues to do so. In a changing funding environment, a changing political environment, a changing scientific environment and a changing physical environment there is now a clear articulation within Cefas of movement from a national and legacy approach to forecasting and advice on the international stage.

7.2 Sustainability: Cefas has developed over the last few years a successful working model that centres on government and government-to-government research, advisory tasks and monitoring needs. Staff numbers have increased, Seedcorn investment is highly effective and research infrastructure is effectively maintained and developed. At the heart of this model lies a healthy relationship with core Defra, which needs to be widely appreciated. All the indications are that the demands on Cefas by Defra and other governmental organisations will increase after EU exit. For example, fisheries management will likely demand more input from Cefas in terms of the negotiations with the EU, EU member states and other coastal states of the North Atlantic. Contributions to international organisations such as ICES and RFMO's are also likely to increase, rather than decrease, in importance. Similarly, the demand for science and monitoring underpinning national environmental and health directives aligned to international standards will likely increase. We recognise the uncertainties over EU exit and potential future uncertainties over funding in the international arena and commend the Cefas Management Board in its continuing attempts to minimise the risks to the organisation.

7.3 Capabilities: Cefas continues to have the capabilities to meet the needs of its core customers, whilst expanding its co-operation and capabilities, especially in the areas of environmental monitoring technology, eDNA and data. Whilst having made substantial amounts of data available, substantially more could be done in this increasingly data driven world to exploit those data, deploy risk assessments and improve forecasting techniques. Cefas needs to consider how international it wants to become in terms of its remit and to develop a more strategic approach to international investment.

7.4 Quality Assurance: Cefas' science activities reflect current science thinking with international leadership in several areas. Feedback indicates that these activities are appropriate to meeting the needs of business and especially government. The quantity and quality of Cefas science outputs is good, but more needs to be done to encourage science outputs through more flexible time management, and more to encourage quality through mentoring and narrative development.

7.5 Use and Impact: The Review Panel identified a range of science highlights and welcomed the case studies and presentations on the site visits, which provide clear evidence of impact of Cefas' science in a range of areas. There is a clear impact of Cefas science on policy development and implementation, which is becoming increasingly global in its context. However, in the context of EU exit, a continued national focus is required as well, and this was encouragingly apparent from the case studies and the site visits. Cefas' collaboration with other organisations is well received.

The developing university partnerships should, with careful stewardship, significantly enhance the quality and quantity of Cefas science. Recommendations are made into how Cefas might further improve its science, surveillance and monitoring, use of data, reporting and publications.

7.6 The Review Panel welcomed the positive and constructive responses Cefas had made to the recommendations from the 2012 Science Review, outlining where further developments of the responses are still needed in relation to the constantly changing funding, policy and science environments.

Appendix A Terms of Reference for CEFAS Quinquennial Science Review 2018

A. Purpose & Remit

To provide an independent, external assessment of the sustainability, relevance, quality, and impact of the science and scientific programmes carried out by the Centre for Environment, Fisheries and Aquaculture Science (Cefas) over the period since the 2012 science audit.

The Review Panel will report to Cefas CEO and highlight any areas in the management or delivery of Cefas science and evidence that may require further consideration by the Cefas Management Board.

The Review Panel will provide recommendations to help steer Cefas science and scientific activities in the coming 5-year period.

B. Work Streams

Resource Flow & Prioritisation - Sustainability

1. To consider the quality and suitability of the resources available to Cefas (including staff, Seedcorn investment, equipment and facilities) and whether the organisation and management of science are appropriate to achieve customer requirements now, and into the future.
2. To assess Cefas' ability to attract, retain and develop exceptional scientists, to cultivate and utilise their skills, and manage succession of key senior scientists.
3. To assess Cefas' success in generating income and attracting funding for its science from external customers nationally and internationally, and how external funds complement and enhance the science capability for Government.

Capabilities - Meeting Defra and Other Customer Objectives

4. To assess the extent to which Cefas meets the requirements of Government, industry and society, by providing evidence, scientific support services, policy and regulatory functions, advice and emergency response capability in the marine and freshwater environment.
5. To assess Cefas' Science and Evidence Strategy including how it supports delivery of Cefas' strategic objectives and its capacity to identify emerging scientific issues and deliver the future needs of its major customers nationally and internationally.

Assurance of Scientific Processes – Including Scrutiny and Quality Assurance

6. To assess whether the evidence activities undertaken by Cefas are appropriate-to-purpose and reflect up-to-date scientific thinking to meet the objectives of their customers nationally and internationally.
7. To assess whether the science delivered by Cefas is of high quality in light of measures of science quality and performance, including benchmarking against similar organisations. Also, to evaluate the accreditation and other proficiency assessment processes in place at Cefas.

Use and impact – Outcomes for Government, Partnerships and Knowledge Transfer

8. To identify science outputs, highlights and key achievements and evaluate the impact that Cefas has had on UK, EU and International policy development and delivery.
9. To consider the effectiveness of Cefas co-operation and interaction with other organisations in the UK and overseas (e.g. UK Government departments and their network bodies, devolved administrations, research institutes, Universities, non-governmental organisations and industry).
10. To consider whether the mechanisms used by Cefas to provide scientific advice, scientific publications, open data and exploitation of Intellectual Property (IP), are timely, effective and appropriate in meeting customers objectives.

C. Responsibilities

11. Evaluate progress made and actions taken in response to the recommendations of the 2012 science audit.
12. To comment and make specific recommendations for the future development of Cefas science programmes, as appropriate, and to draw an overall conclusion on the sustainability, relevance, quality, and impact of its evidence activities
13. To provide recommendations and a concise report by 6th July 2018 to the CEO and Chief Scientist.

Appendix B Members of the Review Committee

Professor Andrew Watkinson (Chair)	University of East Anglia
Professor Fritz Köster (Deputy Chair)	Technical University of Denmark
Professor Rachel Mills (Deputy Chair)	University of Southampton
Professor Francesco Falciani	University of Liverpool
Robert Gatliff	British Geological Survey
Dr Tara Marshall	University of Aberdeen
Dr Jon Pitchford	University of York
Dr Iain Williams	Defra

Appendix C Case Studies

The Review Panel appreciated the effort that Cefas staff put into creating 33 impact case studies. These formed a very helpful basis for Review Panel discussions. It was agreed that they are an excellent showcase, exemplifying the breadth and the quality of Cefas science and its delivery to customers. The Review Panel recommends that the Case Studies should be made publicly and prominently available on the Cefas web site, provided commercial interests and client confidentiality allow this.

The Review Panel noted that, in preparing the case studies, Cefas scientists showed considerable care and creativity in crafting narratives and in synthesising results across multiple smaller studies. In some cases, this work could be exploited in developing more holistic manuscripts for submission to higher impact journals.

The Review Panel supported the plan to periodically refresh case studies and to add new examples as appropriate. This needs to be a time-efficient process.

The Review Panel noted that Cefas' university partners may be interested in building collaborative work with Cefas into their own Research Excellence Framework (REF) submissions. Experience and expertise from the university sector may be very helpful for Cefas to capture and quantify "impact" in ways beyond simple publications and citations, and the Review Panel encouraged university links to be exploited in this respect. [See 5.7](#)

Appendix D Consultation with Key Customers and University Partners

Customers

Telephone interviews were held with representatives from four of the top ten customers: Defra, Food Standards Agency, Marine Management Organisation and EDF Energy. All four were either very or extremely positive about Cefas and the work that it does for them. Comments made about Cefas included 'Exceptional organisation', 'impressive' and 'extremely productive and progressive'.

Most of the comments about the science quality and project management were very positive and it is clear that all four organisations valued the approachability and professionalism of Cefas staff. Regular dialogues and Cefas' attendance at organisational meetings were much appreciated.

It was not the purpose of these interviews to delve into the details of operational procedures, but to assess the satisfaction of Cefas' customers with the quality of the science. All four saw that there was no real alternative to the breadth of science that Cefas had to offer and were pleased with the quality of the advice and the science carried out for them. Where there was a mismatch in expectations, as for example in the generality or specificity of advice, customers indicated that differences were generally resolved speedily and efficiently.

One area that was explored in a little more detail given its importance for science delivery was the production of reports. These were generally regarded as high quality, but there was a little concern over some aspects of report production (e.g. spelling errors, the use of technical language and overly long, passive sentences) and the unwillingness of Cefas to share early drafts. A move towards shorter reports with executive summaries and annexes dealing with methodologies and detailed results would be appreciated by some. We also explored the possibility of producing reports where interesting science worthy of publication could be presented in the annex in paper format. This would hopefully aid the conversion of high quality science in reports into journal papers. Given the time constraints on writing papers, we recommend that this aspect of report writing be explored further with customers.

University Partners

Cefas has a wide range of relationships with university partners but is specifically developing more in depth partnerships with the Universities of East Anglia and Exeter between, although not exclusively, Lowestoft and Weymouth respectively. The formal partnership with Exeter is in its early days, but that with East Anglia has been running a little longer. An interview was therefore held with the Head of School in the School of Environmental Sciences at UEA.

With a joint appointment between Cefas and UEA, the establishment at UEA of a physical space for the CCSUS, 33 joint publications in 2017, the sharing of facilities, and Cefas participation in the Doctoral Training Programme, the Head of School communicated strong support for the Partnership.

Joint meetings had been held at a variety of levels. From a UEA perspective, future success would be measured by the quality of the science and the pathway to impact. With the establishment of six themes (Energy and food security; Life in the seas; Ecosystem and coastal processes; Marine systems and society; Marine technology, monitoring and risk; Climate change, impacts and adaptation) it was felt that it was not yet possible to construct convincing narratives from a UEA perspective on pathways to impact.

Further grants would also be welcome, which could potentially be aided (especially for small amounts) by a Framework Agreement to reduce complex procurement processes.

It is recommended that CCSUS, in consultation with Cefas Science Advisory Committee should review the ongoing development of the CCSUS themes.

Appendix E Meeting with students and early career scientists, Cefas students and early career researchers

The Review Panel benefitted from events allowing them to meet with PhD students, placement students and early career scientists. These informal events included an evening poster session (Weymouth) and a lunch session (Lowestoft). The Review Panel engaged with undergraduate students on the Defra-funded placement scheme, PhD students supported through Seedcorn funding, a Natural Environment Research Council (NERC) funded research fellow and several Cefas staff undertaking a PhD in-post.

The calibre of science being undertaken by these young students was excellent. The students were knowledgeable, articulate and enthusiastic about the skills they were developing. They felt well supported by their supervisors and had access to appropriate training opportunities. They are clearly benefitting from the opportunities to undertake applied research.

These young scientists are important contributors to Cefas' scientific output. PhD students normally achieve two or more publications during their degrees which compares very well with the wider university population of PhD students. They also benefit Cefas through being a means of recruiting new staff with appropriate skills. Approximately 10% of the students who completed PhDs at Cefas were subsequently recruited as employees.

As the post-PhD period is normally very productive in terms of publications the Review Panel recommends that students who are transitioning to full-time employment be provided with work opportunities that are commensurate with their individual aspirations for publications.

In-post PhD students benefit Cefas in allowing qualified and motivated staff to achieve their career ambitions. It can be very challenging to complete a PhD in a timely way given the many demands on staff time. PhD supervisors should assist in-post PhD students in managing their workloads and goal setting.

Appendix F Theme Reports

a. Theme: Aquatic Animal Health

Review Team: Rachel Mills, Bob Gatliff, Jon Pitchford, Iain Williams

With: Stuart Rogers, Grant Stentiford, David Bass (CS#4), Ronny Van Aerle, Tim Bean (CS#3), Kelly Bateman/Richard Paley/Irene Cano (CS#2), David Verner-Jeffreys, Ed Peeler, Angela Trent/Kevin Denham (CS#5), David Stone, Steve Feist/John Bignell (CS#1), Eliza Capuzzo (CS#34)

Disease is a barrier to sustainable aquaculture

Innovative and new monitoring capabilities were showcased including an overview of the One Health approach to working and the context for the work at the Weymouth laboratory. Strengths include the use of an eDNA toolbox to enhance understanding of the pathobiome in various aquatic systems (CS#4) through integration of novel techniques with tried and tested ecology approaches. The bioinformatics approach at Cefas is a pragmatic balance of specialist in-house expertise enabling scientists to up-skill through collaboration and engagement along with outsourcing of some elements where appropriate through collaborations with e.g. the Roslin Institute. Innovative case studies include the use of genetic data to understand bred resistance to specific viruses (CS#3), rapid in-field molecular diagnostic tool kits for deployment in LMICs (CS#2), anti-microbial resistance in waterways and commercial fisheries, and the epidemiology of aquatic animal diseases.

Laboratory visits and Fish Health Inspectorate

Tours of the laboratories provided clear insights into the capabilities, and excellence of the science delivered by Cefas. There is a clear link between the specialist pathology, microbiology, molecular diagnostics and the Fish Health Inspectorate at Weymouth (CS#5). The co-location of these teams, the attendance at team meetings, the aligned strategies all lead to good integration of new techniques with emerging policy and delivery. The digitising pathology project (CS#1) is a great example of capturing the organisational memory and providing a globally important service using emerging technology and data sharing.

Issues requiring attention

- include a clearer articulation of the service provided to the main funder, Defra, as most of the case studies focused on novel, innovative projects delivered for other stakeholders. [See 5.4](#)
- There is good evidence of published science outcomes, but less attention to impact in the wider sense, yet it is clear that there is significant impact arising from the work undertaken (e.g. policy impact of fish health inspectorate work). [See 2.5 and 4.8](#)
- Cefas is doing good work in the international arena but it is not clear how the various areas of activity are prioritised, nor how the balance of international and UK-based activity is set in the strategy. [See 2.4](#)

b. Theme: Aquatic Food Safety

Review Team: Andrew Watkinson, Fritz Köster, Tara Marshall, Francesco Falciani

With: Ewan Hunter, Craig Baker Austin, Andrew Turner (CS#6), Rachel Hartnell, Ionna Katsiadaki (CS#8), James Lowther, David Walker, Carlos Campos, Jaime Martinez-Urtaza (CS#7), Myriam Algoet, Monika Dhanji-Rapkova, Ben Maskrey, Alison O'Neill

Introductory presentations focussed on scientific and advisory work within i) microbiological hazards and mitigations, both of present and emerging risks and ii) harmful algal toxins and their impact on shellfish production as well as iii) the function and future of the EU Reference Lab for monitoring bacteriological and viral contamination of bivalve molluscs. Presentations demonstrated high level microbial and biotoxin research capabilities and laboratory facilities addressing:

- a wide range of statutory activities, e.g. classification and improving sanitation in shellfish production areas, *E. coli* monitoring and testing, algal toxins monitoring, sanitary surveys/provisional assessments,
- internationally leading research on Norovirus and marine *Vibrio* species, including outbreak investigations and risk assessments considering climate change,
- commercial services, such as analysis, proficiency testing and reference materials.

Despite a clear focus on the primary production of shellfish, both the entire production chain and other seafood, e.g. seaweed, are addressed. The research theme is internationally leading in its core area, evidenced by both the international impact on European Food Safety Authority (EFSA) work, contributions to issuing of guidelines and legislations, international co-operations as well as scientific productivity. With respect to the latter, bibliometric measures evidence substantial progress in scientific output since the last review. Both advisory and supporting research are quality assured and the laboratories quality accredited.

Scientists displayed a clear awareness, develop plans and conduct activities to:

- extend the scope in monitoring to wider environmental aspects, i.e. broadening from shellfish to the environment they live in and other biota including humans,
- strengthening the analytical and predictive capabilities, the latter based on physiological requirements and oceanographic conditions, for example, from satellite imagery and/or hydrodynamic modelling, also considering climate change,
- and deploying a risk assessment approach.

The Review Panel supports the approach presented, as it fosters co-operation across themes within the organisation and strengthens the provision of evidence, scientific support functions, advice and emergency response to the main customers, while at the same time extending market possibilities.

EU Reference Lab. for monitoring bacteriological and viral contamination of bivalve molluscs

As a consequence of BREXIT, Cefas will lose the status as EU Reference Lab at the end of 2018. The EU does not immediately intend to establish the EU Reference Lab in another member state, and thus Cefas is in the process of establishing an FAO Reference Centre focussing on bivalve mollusc sanitation and developing shellfish aquaculture, being indeed of global importance.

This work is complemented by external contracts with Food Standards Agency/Food Standards Scotland sustaining the function of a corresponding national reference lab.

Issues requiring attention:

- The Review Panel supports this proposed way forward, recognising that focussing on both national needs and international possibilities is potentially most rewarding and notes that this requires continued support from Cefas, Defra and Food Standards Agency. [See 2.9](#) and [3.5](#)
- Horizon scanning for international/global funding, including from large private foundations, is encouraged for these research and advisory activities. [See 3.4](#)

Laboratory visits

Visits to the laboratories for virology, bacteriology and biotoxins included introductions to Norovirus and Vibrio research as well as the biotoxin monitoring programme, supplemented by a number of case studies. Successful and well published work on Norovirus includes methodology development, research addressing the prevalence of norovirus in food and in the environment, and management strategies.

A case study on Vibrio gave an overview on the pioneering multidisciplinary research effort drawing on expertise in micro- and molecular biology, epidemiology, genomics as well as oceanographic and climate sciences. Objectives are to assess and predict the occurrence of Vibrio species in warming low salinity waters (CS#7). Output encompasses method standardisation, modelling frameworks and risk assessment tools that enhance the understanding of past and future occurrence for public health authorities and industry to act and adapt to increasing risks.

Another case study (CS#6) addressed pufferfish poisoning as an example of how the monitoring programme on marine biotoxins contributes to new and emerging threats. Findings demonstrated that the toxin Tetrodotoxin (TTX), which was thought to be confined to warmer water regions, is also present around the British Isles and elsewhere in Europe. Research provided strong evidence that marine Vibrio bacteria are responsible for TTX production and that production will increase with the rise of sea water temperature. Based on the scientific findings, methods and risk assessment developed, the issue is now formally assessed in Europe, North America and Oceania.

Issues requiring attention:

- An increasing focus on predictive capabilities and risk assessment implies a focus on epidemiology and modelling, which the groups are confident they can handle in co-operation with other research groups in- and outside Cefas. [See 3.9](#)

- Similarly, the arising social and economic aspects of the work are planned to be handled in co-operation with others. Here co-operation with the developing socio-economic assessment team in Lowestoft should be considered. [See 5.6](#) and [5.7](#)
- In addition, the Review Panel recommends the biotoxin monitoring programme explores possibilities for extending into functional genomics, metagenomics and an e-DNA approach. [See 2.9, 2.13](#) and [5.1](#)

Chemical and contaminants

Bioaccumulation of human sex steroids in mussels and their potential effect on consumers were dealt with in another case study (CS#8), exemplifying the complexity and limited knowledge base on pathways of pharmaceuticals and chemicals in aquatic animals and the seafood production chain.

Issues requiring attention:

- Results are well published and of considerable concern for consumers and also demonstrate the necessity for the allocation of long-term funding and risk assessments, not least to prioritize allocation of effort. The strategy is to improve on the risk assessment of shellfish waters, both in terms of chemical pollution and microbiological contamination, in co-operation with other government departments. This is a sound approach and Cefas management and Defra should consider providing necessary seed funding. [See 2.9](#)

General issues

- Seedcorn investment was highlighted in all presentations and case studies as important for both scientific and technical development (PhD student support, methodological development, international co-operation). [See 2.9](#)
- The focus on external contracts lies with Food Standards Agency/Food Standards Scotland and EU Reference Lab, while project acquisition from shorter-term competitive funding is less obvious and could be enhanced. In general, the research theme has difficulties in generating new income, as the identification of new safety issues lies in practice with Cefas itself, and potential customers are reluctant to take them up, unless Cefas is able to deliver realistic solutions or mitigation in parallel.
- Direct application for Research Council funding would be an advantage for sustaining research income, although difficult. At present, there is limited ownership of Research Council projects run in collaboration with universities, and neither is there a full transfer of ideas and data. [See 2.7](#)
- However, recruitment through collaboration with universities appears to work well, both at an undergraduate (industrial placement programme) and PhD level. The number of PhD students could be enlarged through collaboration with a wider range of partners as a CASE partner or alternative co-funding mechanisms, see table below.

Number of peer reviewed publications 2013-2017 and PhD students in 2018						
Research themes	2013	2014	2015	2016	2017	Phd's
Aquatic Food Safety	15	9	19	34	37	6
Aquatic Animal Health	36	24	41	36	36	20
Ecosystem Change	61	56	84	55	62	17
Forecasting Change	13	12	14	17	8	9
Innovative Monitoring	4	6	14	12	13	10
Sustainable Fisheries	45	49	64	46	42	31
Sum	174	156	236	200	198	93

- Communication of activities, results and impact to stakeholders and the public should be enhanced. As work addresses human health, in some areas with considerable risks, enhanced communication requires information of and co-ordination with responsible governmental agencies. To facilitate this, Cefas management should consider resourcing a communications position in Weymouth to enhance support for activity on this site. [See 4.8](#)

c. Theme: Sustainable Fisheries

Review Team: Andrew Watkinson, Fritz Köster, Tara Marshall, Jon Pitchford

With: Ewan Hunter, Carl O'Brien, Jose De Oliveira (CS#10), Stuart Reeves, Tom Catchpole, Jeroen Van der Kooij (CS#15), Rosana Ourens, Alan Walker, Chris Darby, Marta Söffker (CS#13), David Righton (CS#17), Chris Lynam (CS#14), Robert Thorpe (CS#9), Stuart Hetherington (CS#11), Jim Ellis (CS#16), not present Kieran Hyder (CS#12)

Presentations comprised overarching introductions to scientific and advisory work within i) an international context, focussing on ICES and EU, but also other international commissions, like Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR) in the Southern Ocean, and International Whaling Commission (IWC) and ii) a national context, targeting inshore marine living resources, including shellfish and diadromous species. During recent years, the geographical scope of activities has been extended, for example, to British Oversea Territories, in parallel with a broadening of the objectives to consider:

- status of fish stocks which do not sustain a full analytical fish stock assessment;
- recreational fisheries with respect to their management, impacts on commercial fish stocks and importance economically;
- interactions between species, fleets and the environment driven by the need for implementing the ecosystem approach to fisheries management;
- extension of stock assessment methodology to risk-based approaches and considering trade-offs of management decisions using management strategy evaluation frameworks;
- expansion of monitoring activities to cover data limited, sensitive and protected species as well as other ecosystem components.

EU and international fisheries advice

The ability of Cefas to deliver high quality output on basically all of the above listed fronts is impressive and includes outstanding contributions to ICES work, through participation in advisory activities and science-based expert groups, but also contributions to Scientific, Technical & Economic Committee for Fisheries (STECF), CCAMLR and IWC. Examples of scientific excellence in sustainable fisheries were presented in case studies. These include developing data-limited stock assessment methods, an area where Cefas has taken the lead internationally (CS#10), rational exploitation of sharks, skates and rays (CS#16) and the development of fish stock indicators within OSPAR (CS#14).

Issues requiring attention:

- There is a need for further model development to address the above challenges. Cefas has the expertise to contribute to model development at a high international level despite some key persons having left in recent years.

Plans for developing and implementing integrated models addressing multispecies and multi-fleet interactions and considering structural model uncertainty were presented (CS#9). The Review Panel suggests consideration be given to spatially explicit approaches that involve the representation of climate and human drivers of ecosystem change. [See 2.15 and 6.8](#)

- The Review Panel was informed that recruiting and retaining staff in advisory related work is problematic. This is caused by i) good candidates being able to pursue a scientific university career without heavy advisory work and with higher salaries and ii) high work load in international fora and accompanying reporting both at a national and international level. In addition, difficulties exist in recruiting numerate scientists who are highly sought after in other fields. A high work load, in part caused by the rapid take-up of new work areas and large-scale contracts, obviously increases difficulties in generating peer reviewed publications, although there is a clear recognition that it is an advantage also for advisory work and outcome, e.g. documenting the methodology deployed. [See 2.15](#)
- While work for the EU Commission can be expected to decrease in future and work load in relation to the EU exit will reduce, involvement in other international organisations and commissions will likely increase. This suggests that the problem of managing workloads will be persistent and that Cefas management should consider potential solutions for improving the situation. [See 2.8 and 2.19](#)

Inshore fisheries

In the case of nationally managed resources, a new policy for inshore (e.g. shellfish) fisheries is needed. Monitoring systems are presently in place and assessment methodologies are under development. Recreational fisheries are increasingly important, both in terms of the impact on stock assessments of commercially important species and as an activity driving the economy, as demonstrated in a Cefas led European-wide study (CS#12).

Issues requiring attention:

- Policy development to manage inshore fisheries requires input to/from Defra. Through enhanced collaboration with industry it might be possible to secure funding for a portion of the management costs. In general, and as noted in the 2012 Science Review, there appears to be a disproportionate focus on commercial stocks assessed by ICES and managed through the EU, rather than stocks managed nationally and which, in the case of shellfish, are economically more important.

From observation to integration

Cefas has a clear focus on generating the necessary data from strong field programmes, including data handling and quality assurance. These data underpin advisory work, but also inform biological and ecological studies of commercially important, sensitive and endangered as well as understudied species.

The field programme was exemplified in a number of case studies, including a multidisciplinary survey targeting the small pelagic fish community in the Western Channel/Celtic Sea (CS#15) and a monitoring programme on by-catch of spurdog in the Celtic Sea, a potential “choke” species, conducted in close co-operation with the industry (CS#11). The latter case study feeds into an internationally leading contribution on the conservation and rational exploitation of sharks, skates and rays (CS#16).

Another case study focussed on the interaction of long-line fishing and killer whales in the Southern Ocean, delivering both concrete actions to reduce the impact of killer whale predation on long-line catches and interesting scientific results (CS#13). Work on the spatial distribution and migration of fish is ground breaking (CS#17), coupled to field investigations, experiments and the development/implementation of enhanced technologies (CS#17).

Issues requiring attention:

- Despite general progress in autonomous observation technologies, a state-of-the-art research vessel is still a pre-requisite for multidisciplinary monitoring and research programmes, especially when sampling larger organisms. Research vessels are increasingly the deployment platform for autonomous vehicles. [See 2.13](#)
- In the case of fish behaviour and migration, a combination of different approaches to resolve life histories is suggested, e.g. coupling functional genomics and micro-chemistry of calcified structures.

General issues

- The Review Panel feels that the communication of results at a non-specialist scientific level should be improved. Within the fisheries theme it is important to improve the narratives to demonstrate world-leading research and impact. For example, the Cefas leadership role in the development of assessment methodologies for data-limited stocks has directly led to an increasing proportion of fish stocks being managed consistently with Maximum Sustainable Yield objectives. [See 4.5-4.8](#)
- The Review Panel is aware that communication may be controversial in certain policy areas, e.g. fisheries, and this needs careful consideration and communications with customers, first of all Defra.

However, there are areas of research that would be suitable for communication to the public, such as the conservation work done nationally to enhance recreational fisheries. [See 4.2](#)

- The Review Panel would have appreciated a concise overview of deployed stock assessment and projection models. Such an overview would be of benefit for scientific and policy co-operation partners as well as interested stakeholders in industry and NGO's. [See 4.2](#)

d. Theme: Ecosystem Change

Review Team: Fritz Köster, Jon Pitchford, Bob Gatliff, Iain Williams

With: Stuart Rogers, Dave Carlin, Michelle Devlin, Adrian Judd, Jemma Lonsdale, Tiziana Luisetti (CS#27), Sue Ware, Clare Leech, Michaela Schratzberger (CS#26), Gordon Copp, Paul Stebbing (CS#28), Ruth Parker, Silke Kröger, Karema Randall

Science evidence and advice

Activities addressing ecosystem change and underpinning Blue Growth focus on i) the use of the marine space and the interactions between uses and ii) the resources of marine environments, both novel and well defined.

They target societal needs, values and choices considering political drivers - trade, growth, soft diplomacy as well as international legislation. Driven by the need to introduce the ecosystem approach to management, activities cover three general areas:

- Environmental sustainability and social well-being, including biodiversity conservation,
- Environmental sustainability and economic prosperity, i.e. sustainable use,
- Social well-being and economic prosperity, i.e. equitable sharing.

While there are clear connections to other research themes, such as sustainable fisheries as well as contaminants, the major areas of work are centred around i) biodiversity, ii) blue carbon, iii) non-native species and iv) valuing natural capital. All areas were addressed by presentations and the first three also by case studies. These presentations were complemented by outlining contributions to different regulatory frameworks, with a specific focus on OSPAR dealing with environmental status and impact assessments. Activities support the UK Marine Monitoring and Assessment Strategy and the licensing and regulation within the Marine and Coastal Access Act, for example, dealing with extraction and offshore constructions. Activities feed into maritime spatial planning, conducted for example in support of the Welsh National Marine Plan.

Monitoring

The monitoring programme supporting this diverse range of activities as well as Cefas activities was presented. In addition, aspects of marine litter, habitat mapping, noise propagation/impact and Marine Protected Areas (MPA's) were also considered, including their design, monitoring and performance.

Issues requiring attention:

- The Review Panel raised the question of whether the introduction of new observation technologies is having an impact, including the use of AUV's, smart buoys and airborne/satellite. The response showed that both the monitoring team and collaborating research groups have a strategy (see parallel session on Ecosystem forecasting) but acknowledged that the up-take of modern technology is relatively slow, especially in internationally co-ordinated monitoring programmes. Close co-operation with the Cefas Head of Profession in modelling needs to be established for this to change. The Review Panel acknowledged that co-operation with modelling groups in Cefas and/or university partners is important and also suggests consideration of the deployment of more modern molecular and computational methodologies. [See 2.13](#) and [2.14](#)
- The UK's seabed habitat mapping is making only slow process; Defra should perhaps consider making more use of Cefas (and others) to speed up this process.
- The UK remains one of the countries without a programme to map the entire seabed based on multibeam data to underpin understanding and monitoring ecosystems and ecosystem change.
- Data delivery into the Cefas data hub and to other customers appears to be well structured and functioning, but delivery to the wider community could be enhanced, a process which is required in any case when involving citizen science, as in the case of invasive species. [See 5.9](#)

Socio-economic assessment

The socio-economic assessment team is growing as the result of a suite of external projects funded by the FCO, the Research Councils and EU together with various well-established collaborations with various Cefas teams and UEA. The team reported start-up problems in establishing well-functioning communication with natural science disciplines, which is to be expected, but has now successfully passed this stage of development, making the team a valuable asset to central Cefas work areas. The team delivers into, for example, fisheries management, blue carbon, cultural services (tourism) and conducts natural capital accounting.

Issues requiring attention:

- Interaction with the governmental economic network is established, but the Review Panel recommends intensification of the co-operation with economists in Defra. [See 4.2](#)

Biodiversity science in support of decision making

Biodiversity science focuses on defining functional diversity and includes interactions between biodiversity and food-webs, understanding the drivers of biodiversity and assessing the quantity and distribution of marine fauna and habitats. Understanding the impact of natural change and human pressures is a prerequisite to support marine national and international policies and thus a key objective. Science links i) theoretical concepts to empirical biodiversity patterns, ii) habitat type and complexity to biodiversity, iii) demersal fishing effort to benthic species and habitats and iv) design and implementation of ecologically coherent and effective MPA's.

Measuring and projecting changes in biodiversity together with ascertaining the value of biodiversity in management decisions requires assessment and projection tools as well as automation in data analyses to cope with new observation technologies generating large amounts of high resolution data. Consequently, the team sees an advantage in introducing new data exploration and machine learning methodologies and advocates an interdisciplinary approach to quantitative ecology including its socio-economic aspects.

Issues requiring attention:

- The Review Panel noted the strong track record of the team, but was concerned about the loss of principal scientists, and wanted reassurance that the recruitment of quantitative scientists was in place and collaboration in and out of house (UEA, York and Sheffield) was developed further. Work, especially with respect to MPA's has been extended to both British Overseas Territories and Small Island Developing States. **See 2.15**

Non-native species: risk analysis and management

Research on non-native species and the forecast of current and future non-native species threats to freshwater and marine ecosystems under current and future climate conditions was described. Risk analyses are informed by evidence on i) hazard identification, ii) introduction pathways, iii) establishment, iv) dispersal and v) impact on native species, ecosystem function and ecosystem services.

For each of these steps more or less generic tools have been developed, such as an Aquatic Species Invasiveness Screening Kit for hazard identification and a GIS based tool for introduction vectors for shipping, boating and importing. Besides focus groups such as fish, shellfish and crustaceans, the introduction of diseases is also being addressed. Pathway analyses include both external and internal vectors such as unintentional releases from aquaculture. Biological research informing the risk analyses is based on field and experimental studies and informs fish life-history and habitat suitability models. These efforts are complemented by contributions from monitoring activities and include e-DNA methods to detect non-native species. All aspects of this work contribute to the development of tools for assessing potential and realized management options. Collaboration exists with, and results are used across, Defra units and are internationally influential. They have been used, for example, in helping develop EU regulations. Co-operation between Lowestoft and Weymouth is well-established and the suggestion was made to establish a non-native species unit, furthering Cefas' standing as a national and international centre of excellence and serving as single point of entry.

Issues requiring attention:

- The Review Panel acknowledged the excellent work done in the area, sustaining both high scientific output and deploying a versatile risk analysis concept with an advanced tool box to support management. There is no doubt that the area is internationally leading and could be further developed in terms of modern observation and modelling methodologies.

Shelf sea biogeochemistry and Blue carbon

Shelf sea biogeochemistry deals with physical, chemical and biological cycles between and within the water column and the seabed, temporal and spatial variability in these processes and how storage of carbon in marine ecosystems (blue carbon) functions and can be assessed and valued. The primary work areas comprise i) water column biogeochemical cycles dealing with nutrient loading and cycling as well as related oxygen conditions, ii) seabed status and functioning, iii) seabed response to environmental and human pressures, specifically climate change and demersal fishing and iv) blue carbon stock-take and valuation. Results feed into both the hypoxia and ocean acidification debates, both on a national and international level (OSPAR). Funding is obtained from Defra, NERC and the EU, which has allowed the expansion of the group, broadened collaboration with a range of UK universities and helped develop the use of new technologies for sediment observations. Future strategic objectives include streamlining the uptake of results into policy and extension to overseas work.

Issues requiring attention:

- The Review Panel found the scientific results on seabeds impressive and acknowledged the positive development of the group into areas such as valuation. It was less clear about contributions to curtail nutrient loading and wondered whether extension into overseas work will overstretch personnel. [See 2.4](#)

General issues

- The Review Panel was impressed by the diversity of tasks covered by the theme, requiring co-operation between different groups at Cefas, and the good knowledge of activities ongoing in other units of the organization.

Activities are partly conducted for other European countries, as in the case of the oil and gas regulatory authorities in the Netherlands and also in the Gulf Region and Commonwealth regions, the latter focusing on small islands and the British Overseas Territories. While the Review Panel recognises the variety of emerging business opportunities, co-ordination of the miscellaneous activities in several geographic regions is a challenge for the management and requires prioritization. Scientific output and impact of groups working in UK/European waters are very good to excellent. It was less clear how much science output the international activities will produce, in part because these are still in an expansion phase. [See 2.4 and 2.5](#)

International science impact

Review Team: Fritz Köster, Jon Pitchford, Bob Gatliff, Iain Williams

With: Stuart Rogers, Dave Carlin, Ed McManus, Michelle Devlin, Adrian Judd, James Bell

The session covered activities addressing the blue economy and sustainable development overseas with a specific focus on the Gulf region and Commonwealth Small Island States and British Overseas Territories. Besides science, focus is on the dissemination of knowledge, expertise and advice as well as capacity building. Focus areas are i) disaster preparedness and response, ii) habitat and species mapping to describe biodiversity, iii) food security, iv) water quality, pollution and human health, and v) the impact of climate change including vi) economic consequences of the above.

Issues requiring attention:

- The Review Panel recognises the various contributions Cefas can make to this broad scope of international activities but was somewhat concerned about whether the scientific output from these activities would be sufficient without considerable strategic planning. [See 2.4](#)
- It was also concerned about whether the justification for accepting contracts in these areas is sufficiently communicated both within Cefas and beyond, where there might be concerns over whether Cefas is expending too much effort on non-central areas. The response to this was a clear awareness that partnership with local research and education institutions is essential for success and sustainability, in terms of capacity building and advisory tasks and also for generating scientific output and the communication of activities and their impact, not least in the UK. [See 2.5](#)

e. Theme: Innovative Monitoring - Observations for Decision Making

Review Team: Rachel Mills, Bob Gatliff, Francesco Falciani, Iain Williams

With: Stuart Rogers, Sophie Pitois, Phil Davison (CS#18), Tiago Silva, Rebecca Faulkner (CS#22), Veronique Creach, David Pearce (CS#19/20), Jon Barry (CS#23), Thomas Maes (Gordon Copp joined the Q&A session in the pm)

Evolution of monitoring programmes from site-specific single parameter measurements to integrated data collection

Innovative and new monitoring capabilities were showcased, including the capabilities and limitation of eDNA for monitoring especially in terms of its use in presence/absence studies for invasive species monitoring. CS#18 was a good example of the use of eDNA to solve a longstanding problem related to early Roman carp import to the UK.

Earth observation data is used in a variety of ways on a range of scales, coupled with ground truth data to complement and enhance Cefas outputs/products and services. The noise team was set up during the last review period (2015) and is generating a baseline assessment of ambient marine noise, although initial models of noise distribution seemed to lack data and it remains unclear what the impact of different noises is on the environment. Partnership working with Bangor and Plymouth Universities has allowed development of a UK monitoring network for the next 6 years. This new team provides data that inform policy and marine spatial planning. Innovative monitoring programmes on RV Cefas Endeavour include real-time continuous measurement of a range of parameters. International collaborations with EU nations provides access to regional data sets. Machine learning plankton image identification is novel capability. New autonomous platforms are being deployed for significant periods to monitor the North Sea region – this programme provides exciting opportunities for PhD/collaboration, deployment of new sensors. CS#20 describes how Wavenet meets operational, coastal planning and research needs of the organisation and wider community. The new Marine Online Assessment Tool which launches in Autumn 2018 is an exciting new portal for access to Cefas data. This is key to the future delivery of the combined, statistically robust assessment of the marine environment. Marine litter is an area where Cefas has a significant track record which has been tapped for time series records back to 1992 allowing high profile publications in the marine plastics area. Development of low-cost assay for plastics has reset the quantitative data globally and the Cefas technique has been widely adopted.

Issues requiring attention: The Review Panel raises the following questions, these are reflected in our overall recommendations elsewhere in the report:

- Is the statistics/machine learning/AI capability sufficient for future challenges and opportunities over the next period? [See 2.15](#)
- Does the IT strategy support the science base appropriately? [See 2.14](#)
- How can the new project management/science structure/business model bed in more quickly to realise the benefits of the new structure? [See 2.8](#)
- Should the international strategy be broken down into various components – capacity building/achieving Defra aims/achieving FCO/Commonwealth Marine Economies (CME) aims/doing high impact world-class science for reputational benefit. [See 2.4 and 2.5](#)

f. Theme: Forecasting Change - Predictability: impacts and options for adapting to future challenges

Review Team: Rachel Mills, Andrew Watkinson, Tara Marshall, Francesco Falciani

With: Ewan Hunter, Stephen Dye, Luz Garcia (CS#32), Liam Fernand (CS#31), David Haverson, Elena Couce, Bryony Townhill, John Pinnegar

Models and Tools: from hydrodynamics to habitats

This cross-cutting theme draws on all areas of expertise within Cefas and through extensive collaboration with external stakeholders such as Met Office, National Oceanography Centre (NOC), Higher Educational Institution (HEI's and international partners. The EDF contract at Hinkley C is an excellent example of real impact on a multi-£bn development. Cefas ecosystem modelling has made great use of a range of archive datasets and EU collaborations to study a range of habitats and ecosystems.

Strengths include: modelling capability and a strategy that was very clearly articulated with a range of modelling tools being used at a range of scales. Cefas has made significant contributions to e.g. developing the benthic biogeochemistry component within European Regional Seas Ecosystem Model (ERSEM). There is a wide diversity of modelling capability delivering a moderate but consistently high quality published output during the review period. The habitat modelling capability has developed significantly over the review period with a clear strategy to develop talent through the PhD scheme and recruitment and retention to build the team. Good, close collaboration with Met Office partners (again through PhD co-supervision) led to excellent outputs. The R and python user groups are examples of good practice, allowing a wide range of Cefas scientists to learn collectively and build on best practice.

Issues requiring attention:

- The one size fits all approach to computational architecture does not suit specialist users/modellers. Users were generally satisfied with new provision of Virtual Machines which are tooled for specific needs, and understood direction of travel/need, but noted that the pinch point often then became download capability for huge files produced by model runs. [See 2.14](#)

- The Review Panel noted the good progress with the development of a strategy for ecosystem modelling but noted a lack of succession planning for the new role of Head of Profession for modelling. [See 2.16 and 5.3](#)

Managing Marine Climate Change Impacts

Review Team: Rachel Mills, Andrew Watkinson, Tara Marshall, Francesco Falciani

With: Ewan Hunter, Paul Buckley, Bryony Townhill, Silvana Birchenough (CS#30), John Pinnegar (Georg Engelhard (CS#24) joined Q&A session following presentation)

Strengths include significant contributions to the UK Climate Change Risk Assessment including leading on the MMO and Seafish chapters. Ocean acidification is considered at the regional scale and there is good and close collaboration with a range of partners. Seedcorn funding for the state of the art facility in Weymouth has initiated a range of exciting international programmes (e.g. Belize and other CME activity). Work with stakeholders and practitioners and particularly the work on public perception across the EU to the impact of climate change on our coasts and the sea was noted.

The Cefas report cards and new initiatives for equivalent in the Caribbean and Pacific islands areas are well received and a good example of a policy/stakeholder relevant output. The MC3 group have published a significant number of papers in a wide range of journals during the review period along with 12 major climate assessments across the North Sea, North Atlantic and Caribbean regions. There is a clear ambition to move to capability to make predictions for future impacts rather than merely creating future scenarios for policy makers to work with. The work with parametric insurance industry is a good example of diversification of stakeholders. The examples of using archive data from the datahub have led to high quality published outputs. Accreditation under the Green Climate Fund (led by the Business Director) will allow Cefas to bid for new collaborative contracts in the CME region and is part of the emerging internationalisation strategy.

Emergency Response: method development and fate and effect of pollutants and monitoring

Review Team: Rachel Mills, Andrew Watkinson, Tara Marshall, Francesco Falciani

With: Ewan Hunter, Stephen Dye, Mark Kirby, Jon Barber (CS#29), Dave Sheahan, Jan Brant, Jon Rees

Overview of Cefas emergency response capability was provided. Strengths include: Cefas chair of the 26 Govt Agency PREMIAM consortium which provides oversight, and recommendations/advice for emergency response actions in UK waters. The case study on cetacean stranding provided good insight into the quality and impact of the team's work. Polychlorinated biphenyls (PCB) contaminant levels in cetaceans correlated with increased stranding deaths in higher food chain species such as Killer Whales, indicating possible impact on immune response. International contracts include deployment of passive water samplers in Vanuatu and Solomon islands for the FCO. The group have good capability in detection and quantification of hazardous and noxious substances and collaborate closely with citizen science activity. New areas of development include capacity in subsea oil spills through joint PhD supervision at UEA. This theme cuts right across multiple groups in Cefas, many of which underpin the modelling and analytical capability required for effective response.

Emergency preparedness is maintained through agency-wide scenario testing at least on a biennial basis and preparedness is identified as a priority for continued development to ensure the team are ready for immediate and effective response.

GLOSSARY

Cefas	Centre for the Environment, Fisheries and Aquaculture Science
CEO	Chief Executive Officer
CCSUS	Collaborative Centre for Sustainable Use of the Seas
CME	Commonwealth Marine Economies
EFSA	European Food Safety Authority
EMFF	European Maritime & Fisheries Fund
EU	European Union
ERSEM	European Regional Seas Ecosystem Model
FAO	Food & Agriculture Organisation
FCO	Foreign & Commonwealth Office
FTE	Full Time Equivalents
HEI	Higher Educational Institution
HMG	Her Majesty's Government
ISI	Institute for Scientific Information
ICES	International Council for the Exploration of the Sea
IP	Intellectual Property
JNCC	Joint Nature Conservation Committee
MSCC	Marine Science Co-ordination Committee
NERC	Natural Environment Research Council
NGO	Non-Governmental Organisation
NOC	National Oceanography Centre
OSPAR	Oslo/Paris convention (for the Protection of the Marine Environment of the North-East Atlantic)
PCB	Polychlorinated biphenyls
R&D	Research and Development
REF	Research Excellence Framework
RFMO	Regional Fisheries Management Organisations
RV	Research Vessel
SAF	Sustainable Aquaculture Futures
UKRI	UK Research and Innovation
UEA	University of East Anglia