Institution: University of Glasgow

Unit of Assessment: Unit 5; Biological Sciences

Title of case study: Revision to codes of practice in commercial langoustine industry – improving yields, quality and sustainability

1. Summary of the impact

The UK fishing industry for *Nephrops norvegius* (Norway lobster or Scottish langoustine) is estimated to be worth £100 million annually. Caught animals are either maintained for live transport to Europe or frozen for use in food products; however, survival rates and meat quality were poor, respectively. University of Glasgow research has provided key insights into the basic biology and survival of *Nephrops* after capture and driven pioneering reform of the codes of practice of two major UK seafood companies. This reform has directly resulted in improved yields and quality, and led to a Scottish fishery being the first in the UK to be granted an internationally recognised sustainability accreditation.

2. Underpinning research

The University of Glasgow Langoustine Lab offers support to the fisheries and seafood industries that exploits over 25 years of research expertise in the population biology and health status of *Nephrops*. Working under the direction of animal physiologist Professor Douglas Neil, the Langoustine Lab has collaborated with colleagues at the University Marine Biological Station Millport (UMBSM), University of London and the Centre for Environment, Fisheries & Aquaculture Science (CEFAS) to investigate (i) the recovery potential of *Nephrops* destined for the live transport market in association with Scotprime Seafoods Ltd and (ii) the post-capture handling of tail meat for the raw product market with Young's Seafood Ltd.

Recovery potential of product destined for the live transport market

Research by the University of Glasgow led team conducted in the mid-2000s compared stress-related metabolic parameters in creel (lobster pot)-caught and trawl-caught *Nephrops*. Two established indicators of stress within skeletal muscle were quantified: i) the adenylate energy charge (AEC) ratio, which describes the balance of energy sources ATP, ADP and AMP within biological cells and ii) the pH level. Significantly lower AEC ratios and pH values were observed in trawl-caught than in creel-caught animals,[1,2] indicating rapid development of extensive muscle stress with a switch to anaerobic metabolism (i.e. without oxygen) while the animals struggled to escape from the net. In addition, trawl-caught animals exhibited significantly greater physical damage than did creel-caught specimens.[3] Due to the labour intensiveness of creel-capture methods, Scotprime Seafoods Ltd were routinely employing the trawl-capture process to meet the market demands for *Nephrops.* Commonly, the first catches of the day were reserved for meat products whilst the later catches were maintained on deck in air for the live transport market as these animals were perceived to be the strongest. A follow-on study by the team rapidly placed freshly trawl-caught animals into on-board tanks with continuously circulating seawater and measured stress parameters at varying times post-submersion.[4] These experiments showed that the AEC ratio returned to pre-submersion levels within 4–6 hours, showing for the first time that *Nephrops* can recover from the extreme metabolic stress of trawl capture. Crucially, measurements taken after the animals had been transferred to local on-shore tanks for 24 hours indicated that recovery was maintained after capture, thus confirming the metabolic stabilisation of the animals.

Post-harvest handling of tail meat destined for the raw product market

Parallel research on early post-mortem *Nephrops* characterised product deterioration and spoilage between capture and the onset of ice storage. In two papers published in 2011, the University of Glasgow led team quantified microbial spoilage in tail meat from fresh carcasses over a range of delay times (0, 4, 8 and 24 hours) at a holding temperature of 16^{o}C (the mean air temperature

during the *Nephrops* fishing season).[5,6] Measurements were taken over the subsequent week of ice storage to quantify relative deterioration; findings at each time-point were correlated with meat quality data obtained from an expert trained panel from the Food Innovation Institute (Roslin, UK), a commercial enterprise providing consultancy services to the UK food and drink industry. Tail meat that was frozen after 4 hours rather than immediately following capture showed no significant detriment to quality 5 days after freezing. By contrast, meat that was kept at 16°C for more than 4 hours after capture showed substantial biochemical degradation and increased bacterial load, making it unpalatable.

Bycatch composition

Due to the small mesh size of the nets used for trawl-capture of *Nephrops*, bycatch of at-risk species (such as doc haddock rays) is a significant issue. At 2-month intervals over an 18-month period (2009/2010), the research team measured and recorded the details of the entire catch of a Young's Seafood Stornoway fisheries vessel, yielding a highly focussed and geographically mapped inventory for monitoring bycatch composition. These data were then logged into the 'YoungsTrace' system (an existing on-board GPS system to monitor the position of the vessel when trawling). Further amendments to this resulted in the adaptation of the 'YoungsTrace' system into a validated self-assessment system which the skippers could routinely use to monitor bycatch.[SE reports (i)&(ii)]

Key University of Glasgow researchers: Douglas Neil (Senior Lecturer [1975–2006]; Professor of Animal Physiology [2007–2011]; honorary staff [2011–present]); Graham Coombs (Professor of Biochemical Parasitology [1974–2006]; moved to University of Strathclyde in 2007); Amaya Albalat (Postdoctoral Research Assistant [2005–2010]); Simon Sinclair & Sebastian Gornik (Research Assistants [2005–2010] and [2004–2007] respectively). **External collaborators:** Jim Atkinson (Professor of Marine Biology, UMBSM) and Grant Stentiford (Director, Crustacean Disease, CEFAS, Weymouth)

3. References to the research

1. Ridgway ID *et al*. Morbidity and mortality in Norway lobsters, *Nephrops norvegicus*: physiological, immunological and pathological effects of aerial exposure. *J. Exp. Mar. Biol. Ecol.*, 2006; 328, 251–264 doi:10.1016/j.jembe.2005.07.015.
2. Albalat A *et al*. Effect of capture method on the physiology and nucleotide breakdown products in the Norway lobster (*Nephrops norvegicus*). *Mar. Biol. Res.* 2009; 5, 441–450. doi:10.1080/17451000802603637.
3. Milligan RJ *et al*. The effects of trawling on the physical condition of the Norway lobster *Nephrops norvegicus* in relation to seasonal cycles in the Clyde Sea area. *ICES J. Mar. Sci.* 2009; 66, 488–494 doi:10.1093/icesjms/fsp018.
4. Albalat A *et al.* Targeting the live market: Recovery of Norway lobsters *Nephrops norvegicus* (L.) from trawl-capture as assessed by stress-related parameters and nucleotide breakdown. *J Exp. Mar. Bio. Ecol.*, 2010; 395, 206–214 doi:10.1016/j.jembe.2010.09.002.
5. Albalat A *et al*. Quality changes in chilled Norway lobster (Nephrops norvegicus) tail meat and the effects of delayed icing. *Food* Sci Technol Int. 2011; 46, 1413–1421 doi:10.1111/j.1365-2621.2011.02650.x.
6. Gornik SG *et al*. The effect of temperature on the bacterial load and microbial composition in Norway lobster (Nephrops norvegicus) tail meat during storage. *J Appl Microbiol.* 2011; 111, 582–592 doi:10.1111/j.1365-2672.2011.05081.x.

Grants: The research above was supported by over £1 million from the European Union (EU) Financial Instrument for Fisheries Guidance (now the European Fisheries Fund) schemes. These grants have resulted in a series of reports, which were returned to the Scottish Executive including:
(i) Neil DM *et al*. The Scottish *Nephrops* Survey Phase II. A joint venture to generate high quality *Nephrops* products from a sustainable fishery (2008)
(ii) Milligan R & Neil DM. The Scottish *Nephrops* Survey Phase III. Evaluation of measures for reducing bycatch and discards in a *Nephrops* fishery (2013)

4. Details of the impact

The Nephrops fishing industry

Once considered part of the cod 'bycatch' (that is, caught unintentionally), *Nephrops* have become increasingly popular among consumers over the past 50 years. *Nephrops* are delivered to the food chain as either live animals or raw meat for subsequent freezing or cooking. The increased demand for *Nephrops* has led to the use of mass-fishing methods such as trawl-capture using nets, which is largely unregulated within the commercial industry. Boats commonly collect sequential trawl catches over an 18-hour day with little standardisation of methods and frequently no understanding of *Nephrops* biology or the damage exerted by capture methods.

Scotprime Seafoods Ltd.

Lack of understanding of the consequences of trawl-capture were highlighted when one of the major UK commercial seafood exporters, Scotprime Seafoods Ltd attempted to branch into the lucrative live *Nephrops* market.[a] This company found wide variations in the survival rates at destination of the *Nephrops* exported by live "vivier" transport to continental Europe. The company partnered up with University of Glasgow whose research showed that the animals caught later in the day were in fact exhausted and near physiological collapse from the trawl methods used but crucially that the potential existed to allow them to recover by resting in seawater tanks. As a direct result of these findings, recommendations were made to Scotprime Seafoods Ltd to reform their post-capture handling and transport working practices.

> *"[The] benefits of collaboration between our company and the University of Glasgow have been numerous and diverse. [The] results of trials at sea have shown the need to physically alter the set-up of catching vessels in order to make them more successful at capturing and maintaining live Nephrops. To date approximately 15 vessels have invested in this way and have boosted their income as a result. This is ongoing with the latest being completed in April 2013."…*General Manager, Scotprime Seafoods Ltd.[a]

Following the installation of the on-board recovery tanks on boats in the Scotprime Seafoods Ltd fishing fleet, the first catch of the day, instead of the last, is now placed to recover for the remainder of the day. Following a short transport (<1 hour) to an on-shore facility, animals are placed into recovery tanks overnight for further physiological stabilisation prior to transport to market. University of Glasgow research also revealed that there is a minimum time which animals should be kept in the holding facility before onward shipping to customers. This allows animals the best chance to recover to pre-capture physiological state and affords them the greatest chance of arrival in good condition. The University of Glasgow research also showed that it was possible to relate the physiological status of *Nephrops* to visual cues in the behaviour of the animals. This finding allowed the development of a "Vigour Index"; training staff to spot these cues has allowed animals to be graded more efficiently and with a greater degree of accuracy. Since 2008, this practice has been used by all Scotprime Seafoods Ltd staff and all new staff are trained in its use.[a]

These improvements in handling at source saw survival rates at destination of *Nephrops* following transport increase, with marked improvements in product quality (as reported by customers) leading to uniformity in supply. Production at Scotprime Seafoods Ltd prior to University of Glasgow involvement was on average 65 tonnes per year; this value has since risen to 100 tonnes (years 2008–2012).[a] This has reflected an increase in live department profits by a similar percentage increase and the live animal handling department now employs an additional two members of staff in response to increased production.[a]

Young's Seafood Ltd.

Young's Seafood Ltd has a 55% share of the UK *Nephrops* market and is the leading brand for frozen fish, which includes a breaded scampi range. The raw *Nephrops* tail product – predominantly sourced from the company's Stornoway fishery – is highly susceptible to post-mortem spoilage, and wastage levels in the company were high owing to poor handling practices. In an attempt to reduce wastage and improve product quality, the University of Glasgow Langoustine Lab demonstrated that deterioration of *Nephrops* meat depends on initial storage

temperature. In 2006, the researchers recommended a 'handling window' to Young's in which the raw product must be sorted, tailed and iced within less than 4 hours of capture. Prior to this recommendation, many of the boats in the Young's fishing fleet did not even carry ice and the product was only iced at port or within the processing facility. Data obtained from Young's confirm the successful implementation of the 'handling window' showing that the mean on-board storage temperature has reduced from 5.6°C in 2006 to a steady 2.5°C in 2012.[b] A spokesman from the company states:

> *"Professor Neil's work clearly established the benefit of icing the freshly caught product as soon as possible after landing which saw an improvement in the quality of the product being landed. This brought with it several benefits. One, the fishermen had less product rejected for poor quality therefore providing a more stable income for their efforts and secondly there was a gain in processing yields as the product had deteriorated less prior to processing and so there was less wastage through rejects and quality of the meat being produced improved as it remained firmer."*

Improving sustainability

In 2009, Young's Stornoway fisheries successfully attained the Marine Stewardship Council (MSC) certification of sustainable good practice.[c] The MSC is a world-recognised, international body that aims to improve practices of the seafood industry and promote sustainable fishing of existing stocks. This was the UK's first award for a trawl fishery and the University of Glasgow's input was instrumental in its successful recognition. Assessment, certification and annual surveillance audits on the Stornoway Nephrops fishery have since been conducted by the independent assessors Moody Marine Ltd.; the University of Glasgow studies are cited throughout the annual reports clearly demonstrating their influence on the maintenance of the MSC certification. The 'YoungsTrace' self-assessment system was implemented across the Stornoway fleet in 2010 contributing to the maintenance of the certification.[d] The MSC certification had a positive impact on Young's ability to expand their customer-base.

> *"Attaining the MSC certification allowed Young's to attract business from other UK markets for scampi and European markets for langoustine for MSC designated products." and "there is no doubt that certain European customers would not have purchased product from us without the MSC certification [it] was of primary importance to them"…*General manager, Young's Seafood[b]

5. Sources to corroborate the impact

a. Statement from Scotprime Seafoods Ltd. (available on request)
b. Statement from General Manager, Young's Seafood Ltd. (available on request)
c. Public announcement of MSC accreditation gained by the Young's Seafood Ltd Stornoway *Nephrops* Fishery, 2009
d. Assessment, certification and annual Surveillance audits on Stornoway *Nephrops* Fishery by the independent assessors (Moody Marine Ltd.) which cite the University of Glasgow/UMBSM research throughout:
   - Public Certification Report on Stornoway *Nephrops* Fishery, 2009
   - Annual Surveillance Report 1, June 2010
   - Annual Surveillance Report 2, June 2011
   - Annual Surveillance Report 3, March 2012

Institution: University of Glasgow

Unit of Assessment: Unit 5, Biological Sciences

Title of case study: Introducing a new strategic framework for assessing the impact of marine renewable energy developments on seabirds

1. Summary of the impact

There is a potential conflict between the expansion of marine renewable energy developments, such as offshore wind farms, and seabird conservation. An Environmental Impact Assessment (EIA) must be carried out before planning permission can be granted for such projects. Working with environmental consultancies and key statutory bodies, Professor Furness at the University of Glasgow developed a clear, systematic and widely accepted framework for assessing the impact of wind, wave and tidal projects on seabird populations. This framework has expedited the project development process and lessened potential risks to seabirds, meeting conservation requirements while benefiting all those involved in renewable energy projects by reducing the risk of misjudgements in the impact assessment process.

2. Underpinning research

Research led by Professor Robert Furness (Professor of Seabird and Fishing Interactions, 1978–2011; Senior Research Fellow, 2011–present) at the University of Glasgow has focused on the ecology and conservation of seabirds in Scotland, particularly regarding population dynamics and distribution, and the effect of man-made factors on these populations. A key development in this regard was research to develop quantitative means to assess such conflicts.

Developing expertise in the impact of marine renewables on seabirds

Between 2002 and 2008, Furness chaired an international panel of experts in marine ecology (IAPEME), advising the Danish Government on monitoring the impacts of demonstration offshore marine wind farms. As a result of this work Furness recognised the need to develop appropriate expertise in the UK and worked with Professor Dan Haydon (Professor of Population Ecology and Epidemiology, 2004–present), with funding from Scottish Natural Heritage (SNH), to develop methods to assess the impacts of UK-based wind farms on seabird breeding success.

Between 2007 and 2009, the Glasgow team led by Furness evaluated the barrier-effect that marine wind farms present to natural migratory patterns of seabirds, for which there was no previous methodology.[1] The work was done in collaboration with Professor Anthony Fox and Dr Mark Desholm (Aarhus University, Denmark) who provided surveillance radar data on migrating seabirds collected from the Danish Nysted offshore wind farm before and after construction. The distance flown by birds to avoid the wind farm was calculated from these data and the energy cost of this (based on bird mass and dimensions) determined using software-based movement modelling. The Glasgow team generated migration scenarios for the common eider, to model the cost of their response to Nysted, and the effect of a larger (or multiple) wind farms. This showed that while the energy consumed avoiding a single wind farm (of 72 turbines) proved minimal; the cumulative impact of avoiding multiple wind farms along a migration route could increase energy consumption and potentially impact a population.[1]

Developing a framework to assess impacts of marine renewables on seabirds

In research undertaken in 2011, Furness devised a framework for quantifying the vulnerability of Scottish seabirds to offshore wind farms, tidal turbines and wave energy devices.[2,3] This followed the approach of an earlier framework, developed between 1998 and 2000 by Furness in collaboration with Dr Mark Tasker (Programme Leader, Joint Nature Conservation Committee) which had been developed to quantitatively assess the effect of reduced sandeel stock biomass on the breeding success of different seabird species.[4] This involved generating a 'vulnerability index' (described in more detail below) to score seabird species on various ecological and environmental parameters, providing a means to rank seabird vulnerabilities with respect to a given impact. The research identified regions where seabird breeding success was threatened by reduced food supplies due to industrial fishing.[1] It was also one of the first times such a vulnerability scale had been applied to identify the key locations where conflicts arise between man-made factors,

providing a useful and accepted approach for identifying such impacts on seabirds.

Whilst the original framework assessed impacts on breeding success, the new framework focussed more on impacts that affect adult survival. Seabirds are typically long-lived and produce few offspring, thus factors that affect adult birds have a significant impact on population dynamics. The new framework considered factors affecting the conservation status of the bird species, such as conservation importance under the 2009 European Commission Birds Directive, the percentage of the biogeographic population located in Scotland, adult survival rate and UK threat status. A further set of parameters were then used to represent behaviours that affect the vulnerability of seabird populations to the marine renewable development. These parameters varied depending upon the particular type of development being assessed, but for example with offshore wind farms these took account of flight height, flight manoeuvrability, amount of time spent in flight, and nocturnal flying habits. Each parameter was then scored using a five-point scale, from very high vulnerability (5), through to no vulnerability (0). The numerical scores were summed to yield a vulnerability score, and used to rank seabird populations at greatest risk, either with respect to collision with wind farm turbines or displacement/disturbance by them. These indicated that herring gulls, black-backed gulls and northern gannets were most at risk of collision and divers such as the black-throated diver, and common scoters were most at risk of displacement.[2]

Scoring parameters required information drawn from an extensive review of the scientific literature, and was refined in response to feedback from other expert seabird ecologists. Furness's own research with international colleagues helped contribute to this, including work to determine the foraging ranges, migration routes and wintering areas of adult seabirds, including northern gannets and great skuas (both of which are designated 'conservation priority' under the 2009 Birds Directive).[5]

The approach to vulnerability indices for tidal and wave energy devices followed a similar methodology, but substituted parameters on seabird behaviours pertinent to these devices, e.g. drowning risk, diving depth, foraging locations of bird species. These indicated that birds such as black guillemot, razorbill and shag were most vulnerable to tidal turbines, whereas divers, razorbills and common scoters were vulnerable to wave energy.[3] The research showed that despite the large number of different seabird populations occupying Scottish waters, only a relative few need be considered as part of EIA. It identified the key species to assess for each renewable type, showing that tidal array generators represented the lowest hazard to seabirds, but also showed that changes in migration behaviour observed in recent years are more likely attributable to changes in fish stocks and fisheries than marine renewables developments.[5]

3. References to the research

1. Masden E. A., Haydon D. T., Fox A. D., Furness R. W., Bullman R., Desholm M. (2009) Barriers to movement: Impacts of wind farms on migrating birds. *ICES J Mar Sci* 66: 746–753.
2. Furness, R.W., Wade, H., Masden, E.A. 2013. Assessing vulnerability of marine bird populations to offshore wind farms. *J Environ Manage* 119: 56–66. doi:10.1016/j.jenvman.2013.01.025.
3. Furness, R.W., Wade, H., Robbins, A.M.C., Masden, E.A. 2012. Assessing the sensitivity of seabird populations to adverse effects from tidal stream turbines and wave energy devices. *ICES J Mar Sci,* 69: 1466–1479. doi:10.1093/icesjms/fss131.
4. Furness, R.W. and Tasker, M.L. 2000. Seabird-fishery interactions: quantifying the sensitivity of seabirds to reductions in sandeel abundance and identification of key areas for sensitive seabirds in the North Sea. *Mar Ecol Prog Ser* 202: 253–264. doi:10.3354/meps202253.
5. Kubetzki, U., Garthe, S., Fifield, D., Mendel, B. and Furness, R.W. 2009. Individual migratory schedules and wintering areas of northern gannets. *Mar Ecol Prog Ser,* 391: 257–265. doi:10.3354/meps08254.

4. Details of the impact

The UK has pledged to derive 15% of its energy from renewable sources by 2020. Key to

achieving this target is the development of offshore marine renewable energy devices in Scottish waters. Scotland holds one quarter of Europe's potential offshore wind resources, and the power density achievable in Scottish waters has resulted in the world's largest concentration of wave and tidal energy devices currently under development and testing. A potential conflict therefore exists between offshore renewable energy developments (such as wind farms, tidal and wave energy) and seabird conservation. Before such developments can be approved, Environmental Impact Assessments (EIA) must be carried out to assess the potential impact on wildlife and the environment. These assessments require that those seabird species most at risk from such developments are identified.

Research by Furness described above has helped to strengthen the work of environmental consultancies specialising in the assessment of the impact of renewables on birds. It has also produced a robust methodology to assist developers and provide guidance to statutory bodies, mitigating conflicts between marine development and conservation.

Environmental consultancy

In August 2011, Furness was recruited as a consultant to the environmental consultancy MacArthur Green Ltd.[1] in recognition of his expertise in seabird ecology and conservation. Furness's expertise has considerably strengthened the work of this consultancy, particularly in industry guidance work that required a specialist in seabird conservation. This has resulted in several significant commissions with industry-wide impact, some of which are described in subsequent sections.

> "*MacArthur Green was involved in Marine and Offshore projects before Bob started however I was keen to expand this part of the company and Bob's skills and experience fitted our need perfectly. Bob has brought considerable value to MacArthur Green through his already well established reputation for excellence in his field. This has led to us growing our work in marine ornithology considerably*." – Director, MacArthur Green Ltd.[a]

Developing guidance on Ornithological Environmental Impact Assessments

In 2012, Prof Furness, through his consultancy role with MacArthur Green Ltd, was commissioned to review the sensitivity of seabirds in Scottish waters to offshore windfarms (by statutory regulator Marine Scotland)[b] and to tidal turbine and wave energy devices (by statutory advisor Scottish Natural Heritage).[c] Marine Scotland is responsible for marine licensing and enforcement in the Scottish coastal region on behalf of the Scottish Government. Scottish Natural Heritage (SNH) is one of several statutory advisors to Marine Scotland, and is responsible for providing advice to developers on the scope of EIAs, and for reviewing EIAs as part of the planning consent process.

Furness's reports, the research within which was published,[2,3] identified criteria for quantifying the vulnerability of Scottish seabirds based on ecological and behavioural data, and also draw upon earlier University of Glasgow research described above.[1,4,5] The two reports identified which few seabirds could be adversely affected by these developments, and which (all but a few) did not need to be considered by ornithological surveys.

> "*The report on tidal and wave energy devices was useful because it was commissioned by the regulators themselves, undertaken by a respected ornithologist and had a very definitive set of recommendations with regards potential impacts of wave energy converters. Such research undertaken by developers would not necessarily inform a consensus approach at the strategic level. The peer reviewed nature of both the underpinning vulnerability indices, and the final publication based on the report has added significant credibility to the guidance*." – Project (EIA) Manager, Pelamis Wave Energy Ltd.[d] (one of the leading technology prospects for Scottish renewables)

As these reports had been commissioned and endorsed at the statutory level by Marine Scotland and SNH, the guidance provides consistent advice at the highest level across the industry. This benefits stakeholders at all levels including landowners, the Crown Estate (who lease the seabed), renewable power developers (and the environmental consultants they commission), conservation

groups such as the RSPB, and other statutory advisory bodies such as the Joint National Conservancy Council (JNCC).

Application of the research reports

SNH has used the research reports to assist the applications review process (consenting) by identifying those species most susceptible to impact, and to guide the advice they provide in statutory responses to Marine Scotland. It also uses them to challenge statements in EIAs where a given bird species has been incorrectly described as invulnerable, and to shape advice on monitoring bird-related impacts to existing or planned research proposals. The influence of this research[2,3] is evident in the fact that it has been cited in 15 applications (for offshore wind, wave or tidal developments in Scotland) since first reported in 2012, representing over half of the marine renewable schemes on which SNH have been consulted.[e]

> "*[T]hese are the best guides we have to potential sensitivity [of seabirds to renewables], and so both we and the developers will continue to use them to guide the ornithological content and focus of the EIA process*." – Policy & Advice Manager (Marine Renewables), SNH.[f]

Establishing a framework for Cumulative Impact Assessments

In addition to EIAs undertaken for single development sites, cumulative impact assessments (CIAs) are necessary to look at the cumulative impacts of all developments in a given region on vulnerable seabird species. This will become increasingly important as the number of developments increase, and there had been a lack of standardised methodologies for assessing CIAs, particularly with regard to seabirds.

In 2012, Furness contributed to a report by Wetlands Trust (Consulting) Ltd., commissioned by the Crown Estate, to perform a population viability analysis of northern gannets in the UK, with the aim of assessing the cumulative impacts of existing and consented wind farms. This also drew on University of Glasgow research to identify strengths and weaknesses to different approaches for monitoring bird populations movements.[1,5] The report was prepared on behalf of a wider stakeholder consortium, the Strategic Ornithological Support Services (SOSS), which represents the marine planning regulators (Marine Scotland), advisors (SNH, JNCC), land-owner (The Crown Estate) and renewables developers.[f] It therefore provides guidance at the highest strategic level.

In 2013, Furness and MacArthur Green Ltd. developed a methodological framework for the CIA for the Pentland Firth and Orkney Waters wave and tidal projects.[g] This built upon Furness's framework for assessing the vulnerabilities to seabirds of such projects in EIAs.[3] The report was commissioned by The Crown Estate on behalf of a project steering group comprising the same stakeholders involved in SOSS, and was intended to accelerate and de-risk the development of renewables at a strategic level.[g]

5. Sources to corroborate the impact

a. Statement provided by Director, MacArthur Green Ltd., Glasgow; available on request.
b. Furness, R. & Wade, H. (2012) Vulnerability of Scottish seabirds to offshore wind turbines. Commissioned by Marine Scotland.
c. MacArthur Green Ltd. (Furness, R.) & Wade, H. (2012) Vulnerability of Scottish seabird populations to tidal turbines and wave energy devices. Commissioned by Scottish Natural Heritage.
d. Statement provided by Project development manager, Pelamis Wave Energy, Edinburgh; available on request.
e. Wildfowl & Wetlands Trust (Consulting) Ltd. (2012) Gannet Population Viability Analysis: Demographic data, population model and outputs. Commissioned by The Crown Estate on behalf of the Strategic Ornithological Support Services (SOSS) steering group.
f. Statement provided by Policy & Advice Manager – Marine Renewables, Scottish Natural Heritage; available on request.
g. MacArthur Green (2013). Ornithological Cumulative Impact Assessment Framework: Pentland Firth and Orkney Waters Wave and Tidal Projects. Report commissioned by The Crown Estate. David MacArthur, Professor Bob Furness, Dr Mark Trinder & Kirsty MacArthur