Institution: Bangor University, 10007857		
Unit of Assessment: UoA 7 - Earth Systems and Environmental Sciences		
Title of case study: Governments and assessment bodies adopt an innovative quantitative method to assess the sustainability of mobile bottom fishing gears.		
Period when the underpinning research was undertaken: 2000 - 2019		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	**Role(s) (e.g. job title):**	**Period(s) employed by submitting HEI:**
1) Professor Jan Geert Hiddink 2) Professor Michel J. Kaiser 3) Dr Marija Sciberras 4) Dr Gwladys Lambert 5) Miss Kathryn Hughes 6) Dr Claire Szostek	1) Professor in Marine Biology 2) Professor in Marine Biology 3) Postdoctoral Research Officer 4) PhD student and Postdoctoral Fisheries Scientist 5) Research Officer (Global Fisheries) 6) PhD student and Shellfish Centre Science Officer	1) September 2002 - present 2) August 1998 - July 2018 and Honorary Professor August 2018 - July 2021 3) December 2013 - August 2017 4) September 2008 - May 2015 5) June 2013 - October 2015 6) September 2011 - present
Period when the claimed impact occurred: 2016 – 31 July 2020		
Is this case study continued from a case study submitted in 2014? N		

1. Summary of the impact

Mobile bottom-fishing provides 35% of global catches worth over GBP27,000,000,000, but it can cause serious ecological damage. Bangor research has provided quantitative evidence-based tools to assess the ecosystem effects of bottom-fishing at regional and global scales. The tools have been: a) the primary tool recommended for use by the Marine Stewardship Council (MSC) to ensure biodiverse and resilient seabeds for their certified fisheries; b) endorsed by the International Council for the Exploration of Seas (ICES) for use in the EU Marine Strategy Framework Directive to achieve key policy requirements; c) used by Welsh Government to underpin a consultation and decision on scallop dredging in a marine protected area.

2. Underpinning research

Bottom fishing provides 35% of global fish and invertebrate catches by volume worth GBP27,000,000,000 with a trawl footprint ranging from <10% of seabed area in Australian and New Zealand waters, the Aleutian Islands, East Bering Sea, South Chile, and Gulf of Alaska to >50% in some European seas. Despite its crucial role in food security, bottom-fishing is also the most widespread source of physical disturbance to the world's seabed and thus the major human impact on shelf-sea ecosystems **[3.1, 3.a, 3.b]**. Mobile bottom fishing on seabed (benthic) habitats, which includes bottom trawling and scallop dredging, can cause serious ecological damage directly by removal and indirectly by collateral damage, thereby reducing the biodiversity, biomass and biota abundance of these ecosystems. Practitioners from the seafood industry and fisheries management agencies plus consumer choice certification schemes identified the need for a quantitative risk assessment method to underpin the evaluation of these ecosystem impacts **[3.2]**.

Professor Jan Hiddink, Professor Michel Kaiser and their Bangor University research team (Dr Marija Sciberras, Dr Gwladys Lambert, Miss Kathryn Hughes and Dr Claire Szostek) developed a rigorous approach to assess bottom fishing impacts on seabed habitats in fisheries globally for use by fisheries managers, policy makers and conservationists, including in those fisheries where little data may be available. Bangor initiated and led this research in collaboration with a network of global experts including academics, governmental research institutes and the UN Food and Agriculture Organization. Bangor research showed that the Relative Benthic Status (RBS) of fished habitats can be predicted by three parameters within a simple ecological model: 1) impact rate (depletion per trawl/dredge pass as the fraction of biota killed or removed), 2) recovery rate and 3) the intensity of fishing **[3.3, 3.a, 3.b]**. Unlike qualitative or categorical risk assessments, including those based on subjective expert opinion, Bangor's RBS method provides a quantitative estimate of seabed status relative to an unimpacted baseline **[3.3, 3.a, 3.b]**. Hiddink and his team developed widely applicable methods to estimate the first two parameters in their model using data from a global compilation of all available data from studies of bottom fishing impacts on seabed macroinvertebrates (114 studies, 25 of which were performed by Bangor) **[3.4, 3.5, 3.a, 3.b, 3.c]**. The research showed that Bangor's first input parameter (impact rate) can easily be obtained by knowing the penetration depth of the fishing gear into the seabed **[3.4]**, and that the second input parameter (biota recovery rate) can be predicted from the biota's longevity **[3.6, 3.a, 3.b, 3.c, 3.d]**. The sensitivity of habitats to bottom fishing is, therefore, predicted to be higher in habitats harbouring higher proportions of long-lived organisms. Bangor mapped the intensity of bottom fishing on the world's continental shelves, the third parameter, and provided a method to estimate trawling footprints for regions where high-resolution data are not available by using the correlation between the footprint and total trawling effort **[3.1, 3.a, 3.b]**.

Bangor's underpinning research provides the tools to estimate bottom fishing impacts worldwide **[3.3]**, which is essential for fishing industry, conservation, management, and certification bodies to guide the choice of management measures needed to meet sustainability objectives. Significantly, because of these estimated globally applicable parameter values, Bangor's model can be applied to data-poor fisheries, including places where detailed data on fishing effort distribution **[3.1]**, characteristics of seabed habitats, or the abundance of seabed fauna are not available (e.g. much of the southern hemisphere).

Bangor's globally applicable model does not preclude the need for detailed studies in areas with specific policy needs. For example, scallop dredging uses one of the most environmentally damaging mobile bottom gears but being a major fishery in Wales it contributes GBP74,000,000 per year in UK landings. Research by Bangor University has shown that damage varies widely with environmental conditions; it can be severe, but is fairly modest in the Cardigan Bay area, probably because of a high level of natural disturbance by waves **[3.7, 3.e]** resulting in benthic communities of more resilient, short-lived species **[3.6, 3.a, 3.b, 3.c, 3.d].**

Bangor's research on the benthic impacts of mobile bottom trawls and scallop dredges supports assessment against sustainability criteria and evaluation of alternative management strategies (e.g. closed areas, gear modifications). It allows the setting of management targets that account for natural variation in resilience set by the environmental context, which can be used in decisions on where to allow fishing while minimising ecological impacts.

3. References to the research

Research Outputs

3.1 Amoroso, R., **Hiddink, J. G., Hughes, K. M.** and **Kaiser, M. J.,** et al. (2018) Bottom trawl-fishing footprints on the world's continental shelves. *Proceedings of the National Academy of Sciences,* **115**(43) E10275–E10282. DOI (Peer-reviewed journal article) Submitted to REF2021 (REF identifier UoA7_15)

3.2 **Kaiser, M. J., Hiddink, J. G.** and **Hughes, K. M.,** et al. (2016) Prioritization of knowledge needs to achieve best practices for bottom trawling in relation to seabed habitats. *Fish and Fisheries*, **17**(3), 637–663. DOI (Peer-reviewed journal article)

3.3 Pitcher, C. R., **Hiddink, J. G., Kaiser, M. J.** and **Hughes, K. M.,** et al. (2017) Estimating the sustainability of towed fishing-gear impacts on seabed habitats: a simple quantitative risk assessment method applicable to data-limited fisheries. *Methods in Ecology and Evolution*, **8**(4), 472-480. DOI (Peer-reviewed journal article)

3.4 **Hiddink, J. G., Sciberras, M., Szostek, C. L., Hughes, K. M.** and **Kaiser, M. J.,** et al. (2017) Global analysis of depletion and recovery of seabed biota following bottom trawling disturbance.

Proceedings of the National Academy of Sciences, **114** (31), 8301–8306. DOI (Peer-reviewed journal article) Submitted to REF2021 (REF identifier UoA7_53)

3.5 **Sciberras, M.**, **Hiddink, J. G., Szostek, C.L.**, **Hughes, K. M.** and **Kaiser, M. J.,** et al. (2018) Response of benthic fauna to experimental bottom fishing: a global meta-analysis. *Fish and Fisheries*, **19**(4), 698-715. DOI (Peer-reviewed journal article)

3.6 **Hiddink, J.G., Sciberras, M.** and **Kaiser, M.J.,** et al. (2019) Assessing bottom-trawling impacts based on the longevity of benthic invertebrates. *Journal of Applied Ecology*, **56**(5), 1075-1084. DOI (Peer-reviewed journal article)

3.7 **Lambert, G., Hiddink, J. G.** and **Kaiser, M. J.,** et al. (2017) Defining thresholds of sustainable impact on benthic communities in relation to fishing disturbance. *Scientific Reports*, **7**, 5440. DOI (Peer-reviewed journal article) Submitted to REF2021 (REF identifier UoA7_24)

Grants

3.a **Kaiser, M.** (2013 - 2015) *Trawling Best Practices*. University of Washington, GBP137,269 (Bangor University: R28P02, R28P03, R28P05, R28P06)

3.b **Hiddink, J. G.** (2012 - 2017) *BENTHIS: Benthic ecosystem fisheries impact study*. EU FP7 grant: BENTHIS EU-FP7 312088, GBP264,351 (Bangor University: R28E02)

3.c **Hiddink, J. G.** (2014 - 2019) *Integrating Macroecology and Modelling to Elucidate Regulation of Services from Ecosystems* (IMMERSE). NERC directed programme: NE/L003201/1, GBP710,744 (Bangor University: R28R18)

3.d **Hiddink, J. G.** (2013 - 2018) *Biogeochemistry, macronutrient and carbon cycling in the benthic layer*. NERC directed programme: NE/K001639/1, GBP114,347 (Bangor University: R28R15)

3.e **Kaiser, M.** (2012 - 2014) *Sustainable use of fisheries resources in Welsh waters*. European Fishery Fund, GBP1,499,965 (Bangor University: R28W02)

3.f **Hiddink, J. G.** (2017 - 2020) *Marine Stewardship Council habitat risk assessment*. Marine Stewardship Council (MSC) Open Competitive Process: C002988, GBP153,000 (Bangor University: R28C09)

4. Details of the impact

Bangor University research has directly influenced the sustainable management of the global GBP27,000,000,000 bottom fishing industry, by: a) informing the evidence-based policy requirements of Welsh Government (WG) and the EU (**policy impact**), while b) enabling a sustainable fishing industry by informing evidence-based management plans (WG, EU) and Marine Stewardship Council (MSC) certification for consumers (**economic impact**), and c) ensuring a biodiverse and resilient seabed (WG, EU and MSC, **environmental impact**), by providing science end-users with quantitative evidence-based tools to assess the ecosystem effects of bottom fishing.

The **Marine Stewardship Council** (MSC) is the largest independent non-profit organization that sets international standards for sustainable fishing, certifying 17% of global catches. Bangor science critically guided the scoring of the impact of bottom fishing on habitats (Principle 2.4.1) in 19 MSC accreditations, totalling 1,871,000t of landings per year, representing 9.8% of global bottom fishing landings volume **[5.1]**. The way the science was translated into scores, however, did allow a great deal of subjective interpretation. Hence, MSC identified in its Standard Review that an evidence-based standardised tool was required to determine the impact of bottom fishing on habitats, because objective assessments were hampered by the paucity of quantitative understanding of impact and recovery. The MSC standard has been under intense scrutiny, from UK Parliament and NGOs like Greenpeace, who believe that bottom fishing is an inherently destructive fishing method and cannot be considered sustainable. To avoid undermining the credibility of their certifications, MSC **commissioned Bangor** to develop a tool that translates the research-evidence base presented in Section 2 for use by fisheries-certification bodies worldwide to assess habitat impacts of bottom fishing of individual fisheries **[3.f]**. An **interactive web-based tool** that translates Bangor's methods to estimate bottom fishing impacts into a suggested score for the 'Habitats outcome' was delivered to the MSC in October 2019. This tool has already revolutionised the way the MSC assesses Principle 2.4.1. The Senior Fisheries Standards Manager at MSC stated that "*the impact of Bangor's research translating into this tool is significant … to ensure a highly evidence-based and credible tool for labelling in relation to certifying sustainable fisheries and permitting the consumer to make sustainable choices*" **[5.2]**. MSC certifies about 17% of global fisheries, with approximately 35% of global fisheries catches by weight coming from bottom trawls **[5.3]**. Therefore, the tool is available to **approximately 5.95% of global fisheries** to assess their seabed impacts (estimated value of approximately GBP4,700,000,000 per year). Bangor's research has directly benefited the MSC by increasing the credibility of the standard with the public, and therefore avoids a loss of market share for the ecolabel and its certified high-standard fisheries - as well as guiding consumers to make informed choices benefitting the environment, fishers and suppliers.

Achieving 'Seafloor Integrity' in the EU **Marine Strategy Framework Directive** (Descriptor 6, MSFD) requires methods to assess the effect of bottom fishing activity on seafloor ecosystems at a European scale, but quantitative evidence-based methods were not available when the MSFD was put into EU law. The Directorate-General for Environment (EU-DGENV) requested the International Council for the Exploration of the Sea (ICES) provide advice on how to quantitatively assess bottom-fishing impacts. ICES offers advice based on the best available science that is characterised by quality assurance, developed in a transparent, unbiased, and independent process, and relies on high quality science to underpin their advice. **ICES advised** the EU to use **the bottom fishing assessment method developed by Bangor** in 2016, 2017 and 2019 ("*population dynamic approach*" in the advice documents) **[5.4, 5.5, 5.6]**. Bangor's science therefore benefitted ICES by underpinning their provision of evidence-based approaches to assessing 'Seafloor Integrity' **[5.7]**.

As well as impacts at global scales, the science has underpinned changes in policy at the Welsh national level. King scallops are the third most valuable wild-caught seafood in Wales, at GBP1,400,000 for 800t, with Cardigan Bay providing most (66%) of the landings. **Welsh Government** has been under pressure, from both conservationists and fishers, over the correct trade-off between environmental benefits and economic costs of areas closed to scallop dredging in Cardigan Bay. In response to this pressure, WG consulted on opening an area previously closed to scallop dredging. WG arguments for opening the area were underpinned solely by evidence generated by Bangor research putting disturbance from scallop dredging into the context of natural disturbance levels due to waves and tides **[5.8]**. The consultation generated significant media attention and over 5500 responses were received. In October 2016, the Cabinet Secretary for Environment and Rural Affairs concluded that it was appropriate to proceed with the **preparation of new legislation** to introduce a flexible permit scheme within Cardigan Bay, explicitly citing Bangor's research as underpinning this decision **[5.9]**. Bangor's research therefore benefitted WG by allowing it to make evidence-based decisions that will increase the value of Welsh fisheries whilst not compromising the environment.

5. Sources to corroborate the impact

5.1 **Marine Stewardship Council** (**MSC) accreditation reports** that cite Bangor trawling impact research papers to underpin the scoring of the effects of bottom fishing on the 'Habitats outcome PI 2.4.1' (inurl:msc.org "Hiddink"), link is to Google search (inurl:msc.org "Hiddink").
https://www.google.co.uk/search?q=inurl:msc.org+%22hiddink%22
5.2 **Testimonial from Fisheries Assessment Manager, Marine Stewardship Council** (both a participant and reporter in the impact process) highlighting the importance of the trawl impact tool for MSC assessments.
5.3 **Watson, R. A. and Tidd, A. (2018)** Mapping nearly a century and a half of global marine fishing: 1895-2015. *Marine Policy*, **93**, 171-177. The research reports MSC certified 17% of fisheries, 35% from bottom trawls, leading to assertion that 5.95% of global catches are MSC certified. The research reports global catches are approximately 80,000,000t, MSC certified bottom trawl catches = 4,760,000t. If average price for fish is 1GBP/kg it equates to GBP4,700,000,000.
https://www.sciencedirect.com/science/article/abs/pii/S0308597X18300605?via%3Dihub
5.4 **Advice to EU DGENV (Directorate-General for Environment) (2016)** on approaches for the assessment of D6 in EU Marine Strategy Framework Directive (MSFD) using the Population Dynamic approach (developed and parameterised by Bangor) with FP7-project BENTHIS **[3.b]** cited on p3 in: ICES (2016) EU request for guidance on how pressure maps of fishing intensity contribute to an assessment of the state of seabed habitats. *ICES Special Request Advice 2016 Book 1*, ICES, Copenhagen, 5pp.

http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2016/Special_Requests/EU_guidance_on_how_pressure_maps_of_fishing_intensity_contribute_to_an_assessment_of_the_state_of_seabed.pdf

5.5 **Advice to EU DGENV (2017)** recommending basing D6 assessment in MSFD on the Population Dynamic approach (PD2 method, developed and parameterised by Bangor citing **[3.3, 3.4, 3.6]** in: ICES (2017) EU request on indicators of the pressure and impact of bottom-contacting fishing gear on the seabed, and of trade-offs in the catch and the value of landings. *ICES Special Request Advice 2017*, 13, ICES, Copenhagen, 27pp.
http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2017/Special_requests/eu.2017.13.pdf

5.6 **Advice to EU DGENV (2019)** recommending the Population Dynamic approach (now called "Population Dynamic Model" developed and parameterised by Bangor citing **[3.3, 3.5, 3.6]**) in seafloor assessment processes, in: ICES (2019) EU request to advise on a seafloor assessment process for physical loss (D6C1, D6C4) and physical disturbance (D6C2) on benthic habitats. *ICES Advice 2019*, sr.2019.25. https://doi.org/10.17895/ices.advice.5742

5.7 **Testimonial from the Chair of Science of ICES from 2017 to 2020** and member of the MSC Technical Advisory Board (both a participant and reporter in the impact process) highlighting the importance of the trawl impact tool for MSC assessments, and the importance of Bangor trawl impact research for ICES advice to the EU.

5.8 **Welsh Government Minister for Natural Resources consultation (2015 to 2016)** entitled 'Proposed new management measures for the scallop fishery in Cardigan Bay'. Welsh Government arguments for opening the area were underpinned solely by evidence generated by Bangor research (as stated under heading 'Consultation description').
https://gov.wales/proposed-new-management-measures-scallop-fishery-cardigan-bay

5.9 **Welsh Government: New Management Measures for scallop fishing in Cardigan Bay (2016)** press release from Cabinet Secretary for the Environment and Rural Affairs, detailing Bangor collaborative research offering opportunity to implement an ecosystem-based approach to management of the fishery within the Cardigan Bay Special Area of Conservation.
https://gov.wales/new-management-measures-scallop-fishing-cardigan-bay