Tender for the Supply of Research Services to establish MSY proxies for data-limited stocks (2017-18) to the Marine Institute, Rinville, Oranmore, Co. Galway. (Ref: ITT17-015)

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Contents

1 The Call

The overall aim of the project is to develop and test a range of assessment models and methods to establish MSY reference points (or proxy MSY reference points) across the spectrum of data-limited stocks. There is a requirement for the following research services over a 24 months period between May 2017 and April 2019:

Task 1: ***Stock prioritisation*** A number of example stocks have been identified (**Table 1**). The final list of stocks will be prioritised using criteria like: economic value of the stock; importance of the species to the ecosystem (key-stone species); sensitivity to the impacts of fishing; available data.

Task 2: ***Data collation*** To run in parallel with other tasks. The project relies on existing data sets, however these data need to be collated in a usable form. Most datasets are available from the Marine Institute, or are publicly available, but others may only exist in other European labs/agencies.

Task 3: ***Method and simulation framework development and implementation*** A number of data-limited methods exist. In order to compare the performance of these methods it would be useful to implement them all in the same framework, e.g. R. New methods may also be developed in the same framework.

Task 4: ***Method performance appraisal*** Develop a set of diagnostics that can be applied across range of models. Also assess the stability of the model, sensitivity to assumptions and bias in the advised catch.

Task 5: ***Reference point comparisons*** Once reference points have been identified, their performance should be evaluated through simple management strategy evaluations.

Task 6: ***Liaison with Marine Institute*** The service provider is expected to meet on a regular basis with Marine Institute staff involved in the project: Monthly update meetings at the Marine Institute premises in Oranmore Galway

Task 7: ***Linkage with other projects*** The service provider is required to link research output to the following projects:

- The International Council of the Exploration of the Sea (ICES) is in the process of developing methods to identify MSY proxy reference points for data-limited stocks (WKLIFE and WKPROXY series of workshops). The service provider is required to contribute to this process by proposing and testing new assessment models and methods of establishing reference points and will be expected to attend up to 4 one-week meetings at ICES headquarters in Copenhagen. However there are key differences with the ICES approach:
  This research contract will include stocks not currently assessed by ICES; this research contract will focus on the available data for each stock first and on the methods second; the ICES approach focuses on the methods first and then applies a limited number of methods to a large number of stocks.
- Marine Institute research and development on data poor stocks which includes the biology, stock dynamics and Management Strategy Evaluation

(MSE) for Pollock. It is expected that the service provider will collaborate closely with the team developing assessment methods for the pollock stock.

- Galway Mayo Institute of Technology GMIT had been awarded a Cullen fellowship for a PhD project on management strategy evaluation for monkfish. It is expected that the Cullen PhD and service provider will closely collaborate on tasks like data collation, assessment model implementation, simulation model development and management strategy evaluation.

2 Phase 1 Criteria

2.1 Proven Research Output of the Consortium

The consortium brings together individuals with highly complementary skills and a strong track record of relevant research, in the development of assessment models and advice frameworks for data rich and limited stocks. This experience spans academia, government and inter-governmental institutions, across the East Atlantic and beyond, e.g. International Whaling Commission and a range of Regional Fisheries Management Organoisations (RFMOs). Proven research output of relevance to the tender is listed below.

Dr Laurence Kell (Methodological Development)

Laurence Kell helped pioneer the MSE approach, developing the FLR framework for fisheries modelling (Kell et al., 2007) and applying it to support the development of multi-annual management plans under the Common Fisheries Policy (Kell et al., 2005a,b, 2006b). As well as working in Europe, through ICES and the STECF, he has been involved in a variety of management bodies, including the IWC (as head of the UK scientific delegation and as an alternate commissioner), ICCAT (where is he currently employed as the Population Dynamics Expert), and is the chair of the tuna RFMO MSE working group (Kell et al., 2015a).

At ICCAT his duties include the establishment of review mechanisms, the provision of guidance on assessment models and assumptions underpinning scientific advice. Has been heavily involved in the development of new assessment methods and approaches (Kell et al., 2016a), particularly related to simulation testing (Deroba et al., 2015), MSE (Kell et al., 2016b; Carruthers et al., 2016), Ecological Risk Assessment (Arrizabalaga et al., 2011) and the provision of robust management advice (Pons et al., 2017; Kell et al., 2015b). He has wide experience in developing scientific advice frameworks for both the main target and bycaught and endangered species (Frédou et al., 2016; Fortuna et al., 2014).

Throughout his career he has collaborated widely with a large number of scientists from a variety of disciplines and developed approaches to improve dialogue with stakeholders and decision makers (e.g. Glenn et al., 2012; Leach et al., 2014; Fromentin et al., 2014). He has also won and coordinated a variety of multi-disciplinary projects on fisheries management, software development, capacity building, participatory modelling, MSE and Risk Analysis (e.g. EFIMAS, COMMIT, UNCOVER PRONE and JAKFISH).

Prior to working at ICCAT, he built an interdisciplinary team of scientists at the Fisheries Laboratory (Cefas) in Lowestoft, where he helped develop the careers of junior scientists by supporting their research training, through PhDs and helping them take leadership of work packages in EU Projects. He regularly provides training to a wide variety of groups, on stock assessment modelling, MSE and the provision of management advice.

- Research output in the development of fish stock assessment methods:
    - Peer reviewed publications; numerous first and multi-authored papers on a range of topics, including stock assessment, risk and uncertainty, MSE, economics and stakeholder involvement

- Successful grant applications; prior to working at ICCAT won and coordinated a large number of research programmes nationally (UK), under FP7 and in support of the CFP. Now as the Population Dynamics Expert working at the ICCAT Secretariat has been involved in proposing awardng and supervising contracts under the GBYP[1] and AOTTP[2].

- PhD/Post Doc Supervision; While at Cefas initiated research training for junior staff, at ICCAT have a responsibility for guiding scientists and developing capacity, e.g. in stock assesment, MSE and risk assessment.

- Methods developed for and accepted by scientific fisheries advisory bodies pioneered the USE of MSE in support of the CFP and now developing HCR for North Atlantic Alacore and Atlantic bluefin tuna. To do this implemented a variety of assessment methods as R packages for stock assessment (e.g. **FLXSA**, **mpb**, **FLBR**, **ALKr**, **kobe**, **diags**).

- Stock assesments performed for North Atlantic Albacore and swordfish, Atlantic bigeye using **mpb** and Mediterranean swordfish using **FLXSA**. Data-poor methods also used for Atlantic bigeye and bluefin and Mediterranean albacore using **FLife**.

Dr Alexander Tidd (Post-Doc)

Alex Tidd is a fisheries scientist with 17 years of professional experience with a PhD on fleet dynamics from Imperial College London. He has over 10 years experience conducting high quality research within EU/UK/Asia-Pacific government/Worldbank funded projects. His research on fisheries fleet dynamics, human decision-making and fisheries management has led to 19 peer-reviewed journal publications and a book chapter, which have attracted 535 citations and an h-index of 11. He has also published many scientific advisory reports for annual tuna Regional Fisheries Management Organisation (tRFMO), UK government and EU project reports. He has led 2 proposals securing £60,000 and been co-investigator in 14 successful collaborative high profile research/policy proposals within the research field worth over £8.3 million.

His main role while at Cefas was as the fisheries fleet dynamics scientist within the systems modelling team, a multidisciplinary strategic team responsible for conducting research into sustainable marine resources. He gained extensive experience in data collection (from fish and fishery surveys), coordination (EU Data Collection Regulation DCR) and the analysis of large data sets, open source database development and management. During this time and while at Imperial College as part of his PhD thesis, he researched discrete choice models widely used in economics, and their applications and use within fisheries. He developed discrete choice models to understand and predict how fishers operate within a natural, economic and regulatory environment and how the changes in these environments affect fisher decisions. For example, changes in stock abundance (Tidd et al., 2011) or changes in fish prices may lead fishers to change the areas where they fish (Tidd et al., 2012).

Given this understanding, models of behaviour can be developed that can be used to determine the effectiveness of changes in management controls. Further as part of the large EU Framework 6 consortium project called (CAFÉ – CApacity, Fishing mortality, and Effort) he worked with Dutch and Danish colleagues on North Sea

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[1]http://www.iccat.int/GBYP/en/
[2]http://www.iccat.int/AOTTP/en/

flatfish management strategy evaluation (MSE) to show the benefits of incorporating fleet dynamics models within a process-based bio-economic operating model to determine how changes in capacity performed under different management scenarios. More recently, he developed a discrete choice model to demonstrate the decision making of fishers and how they interact spatially with other maritime sectors such as aggregates, maritime traffic and regulations and estimated how they responded to this environment (Tidd et al., 2015, 2017). He has also developed ecological process-based models in projects: EU Flatnose - Scientific advice concerning the impact of the gears used to catch plaice and sole, EU Necessity - Nephrops and Cetacean Species Selection Information and Technology (Catchpole et al., 2005) and published on the effects of introducing different fishing gears (tools used to capture marine resources) and the effects of no discarding within the North Sea flatfish and whitefish fishery.

In terms of pure economic analysis he modelled changes in productivity ('effort creep') in the western central Pacific ocean purse fleet using Data Envelopment Analysis (DEA)(Tidd et al., 2016). Using the same econometric techniques he investigated capacity utilisation, and evaluated the excess capacity in the fleet and the optimum numbers of vessels required in the fleet at full capacity. This is a unique piece of work for the region due to the dramatic advancements in new fishing technologies in the last 10 years and hopefully will be of real importance to Pacific Island nations when setting effort limitations within their sovereign waters.

- Research output in the development of fish stock assessment methods:

    - Peer reviewed publications: 19 peer reviewed publications and 1 book chapter in fleet dynamics, MSE, statistical ecology and stock assessment applications.

    - Successful grant applications: Led 2 proposals securing £60,000 (EU project and Cefas seedcorn) and Co-investigator in 14 successful collaborative high profile multi discipline research/policy (including stock assessment applications) proposals within the research field worth over £8.3 million.

    - Student supervision: Supervised a Masters student, Katherine Maltby from the university of Sheffield to completion (2012-2013) (Fleet dynamics, definition of fleets and fisheries and database development).

    - Methods developed for and accepted by scientific fisheries advisory bodies:

        * Defining UK fleets and fisheries for DCR to feed into many European fish stock assessments.

        * Development of novel approaches to estimate effort creep for the Parties to the Nauru Arrangement (PNA) to feed into regional bio-economic and assessment models.

Dr Cóilín Minto (Local Expert)

Cóilín is a senior researcher in quantitative ecology and biostatistics at the Marine and Freshwater Research Centre at the Galway-Mayo Institute of Technology (GMIT). His research focuses on the development and application of statistical methodologies to dynamics at individual, population and community levels. Cóilín studied both biology and statistics at undergraduate and graduate levels and received his PhD from Dalhousie University, Halifax, Nova Scotia. His statistical research interests

cover foundational and novel approaches, including: probability theory, likelihood and Bayesian hierarchical analysis, longitudinal analysis and dynamic time series analysis, particularly state space modelling. Implementation is facilitated by extensive programming experience in R, *BUGS, AD-Model Builder, TMB coupled with high-performance/parallel computing. Published articles include analyses of life history dynamics, community dynamics, conservation status and population recovery. Technical reports cover stock assessments (e.g., megrim IVa-VIa, boarfish, sardine and anchovy in the Adriatic), management strategy evaluation and power analysis of monitoring programmes. Current research includes: bioeconomic modelling; multivariate non-linear time series analysis; development of statistical methodologies for the assessment of data-poor populations; and the development of analytical techniques for monitoring abundance. Cóilín is a full member of the International Biometric Society and a founding developer of the RAM Legacy Stock Assessment Database.

- Research output in the development of fish stock assessment methods:

    - Thirty two peer reviewed publications in the areas of population dynamics, statistical ecology and stock assessment.

    - Partner in successful grant applications: Monkfish MSE (MI-GMIT Cullen fellowship) (2017-2020); Newport Research Cluster Project, Marine Research Programme (Unlocking the Archive project; MI-GMIT) (2017-2020); DGMARE Tender: Study on approaches to management for data-poor stocks in mixed fisheries (DRuMFISH) (GMIT partner in consortium) (2015-2017); Conservation International-FAO (Global Status of Data-Poor Stocks) (2012-present); Department of Agriculture, Food and and the Marine: Fisheries Knowledge for Optimal Sustainable Management (2017-2022).

    - PhD supervisor to: Mr. Luke Batts (Cullen fellow working on monkfish MSE); Mr. Paul Dolder (Mares Joint Doctoral Programme fellow working on fleet dynamics); Post-Doc co-supervisor to Dr Olga Lyashevska (EPA Strive: Ecosystem tipping points grant (PI D. Brophy, GMIT)).

    - Co-developed methods accepted by scientific fisheries advisory bodies: megrim IVa-VIa assessment (ICES); Northeast Atlantic boarfish assessment (ICES); Adriatic GSA 17-18 sardine and anchovy assessments (STECF).

2.2 Satisfactory Insurances

The tenderer GMIT declares that it has Public Liability insurance of not less than €2.6 million.

2.3 Financial Standing

The tenderer GMIT declares that it is in good standing with the Bank of Ireland.

3 Phase 2 Criteria

3.1 Experience

Dr Laurence Kell

Working as the Population Dynamics Expert of ICCAT requires initiating, supervising and supporting research services in support of the sustainable utilisation of Atlantic tuna and other species caught in tuna fisheries. This has required a wide range of activities including

- North Atlantic Albacore MSE, developed the framework to conduct MSE of an Management Procedure based on a biomass dynamic model. This required developing code for conditioning the Operating Model, implementing the Observation Error Model and the stock assessment as methods in R.
- Atlantic Blufin MSE
- Worldwide tuna MSE,
- Ecological Risk Assessment, developed methods in R to estimate productivity for bycaught species in South Atlantic and Indian Ocean longline fisheries
- Cross-validation, showed how hindcasting and model-free validation can be used to evaluate multiple measures of prediction skill.
- SISAM, Steering committee member.
- Data-poor, Editor of special issue in Fisheries Research.
- Bayesian Multiple Imputation] Submitted paper that showing how missing data, can be accounted for in stock assessments.
- Risk, development of methods to allow stakeholders and scientists to evaluate the impact of uncertainty.

Dr Alexander Tidd

Alex has over 17 years' experience in fisheries research/policy in a UK government research agency and 4-years postdoctoral research experience, also in a government research setting, in New Caledonia along with over 6 months within an academic setting at the university of Tasmania (UTAS). Alex's research is highly collaborative and often involves working in large interdisciplinary teams that consist of ecologists, economists, biologists, mathematicians, statisticians and oceanographers. During the past decade he has formed many international research collaborations including leadership of within large EU-funded consortium research projects that has helped him advance technically, independently and professionally by delivering high quality research in a range of activities.

- Over 10 years computing and programming skills (SQL, R, SAS). Relational databases (postgresql, Microsoft Access), data-analysis (statistical and mathematical).
- Scientific sampling and surveying. Led scientific research cruises (trawl surveys) using both bona fide research vessels and chartered commercial vessels in Celtic and Irish sea.

- Over 5 years experience analyzing data for data collection framework (DCF)/Data Collection Regulation within EU projects, Defra and NWWRAC (North Western Waters Regional Advisory Council). This involved defining metiers, fleets and fisheries formatting data for inclusion in multi-country databases.

- Dissemination of data via websites to give fishermen access to survey data. Also dissemination of data via project reports (EU, Worldbank), grey literature (WCPFC science committees) and peer-reviewed publications.

- Statistical, mathematical and econometric modeling to assess effort creep and technological advancement to feed into Western and Central Pacific stock assessments.

- Stock assessment applications for evaluating the implications of using different fishing gears (see Catchpole et al., 2006).

- Fleet dynamics with MSE (flatfish) for EU project café. In addition see Pilling et al. (2008).

Dr Cóilín Minto

- In collaboration with Dr Norman Graham (MI) developed one of the first Bayesian surplus production applied in an ICES setting (megrim IVa-VIa); while not fully data-poor, a fully age-structured assessment was not possible for this stock so an alternative method was developed and accepted as the basis for advice.

- FAO and Conservation International working group 2012-present: developing and testing catch-only data-poor methods for assessing status. Role included simulation experimental design, high performance computing application to simulation testing of methods, global application to FAO 'stocks' and co-authoring publications (????).

- Currently working on the 'Robin Hood' method as part of the DRuMFISH project. In particular the development of hierarchical models in TMB reflecting biological and fishery structure for application to the assessment of North Sea flatfish and all *Nephrops* functional units.

Character and Skills References

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3.2   Technical Capacity

Full CVs are provided in the appendix.
Clearly demonstrate that you have the professional capacity, technical experience and capability to fulfil the tender requirements as set out in Section 4 below.Responses under this section should also include details of education and professional qualifications of relevant staff and experience relevant to this contract.

Dr Laurence Kell

- BSc in Biological Sciences
- BA in Mathematics
- Phd in Population Dynamics
- Research Fellow University of Miami
- Leader of Systems modelling team Cefas
- Population Dynamics Expert ICCAT
- Founder of FLR
- ICCAT and IWC Commissioner
- Course Instructure, including ICES courses on MSE, and stock assessment and management fro DG Mare; numerous courses on stock assessment and modelling in R for ICCAT.
- Maintainer and developer of many FLR packages and other packages.

Dr Alexander Tidd

- Doctor of Philosophy (PhD) Imperial College, London (United Kingdom) Statistical modelling of fishing fleet behaviour and fleet dynamics.
- Bachelor of Science in Chemistry (BSc Hons)

Dr Cóilín Minto

- PhD in Population Ecology (Dalhousie University 2011) - Relevant credit courses: (Mathematics and Statistics Department) Probability Theory, Intermediate Statistical Theory, Regression Analysis, Time Series Analysis, Advanced Topics in Statistics and Probability: State-Space Analysis. (Biology Department) Biological Modelling, Foundations of Ecology, Fish Ageing, Communication skills.
- Certificate in project management (St. Mary's University, Halifax, Nova Scotia).
- Relevant programming proficiency in: R, TMB (C++), *BUGS, JAGS, SQL.
- Experienced git and embedded markdown user for scientific reproducibility.
- Lecturer in statistical ecology (GMIT 2012-present).
- FAO stock assessment course developer and trainer (2017).
- National courses in statistical programming delivered to: MI, EPA, BIM (2012-present).
- External reviewer of stock assessments (e.g., deepwater redfish for ICES 2016).
- RAM Legacy stock assessment database co-developer and co-coordinator for European stocks (2008-present).
- R package `lhmixr` developer (https://github.com/mintoc/lhmixr).

4 Proposed Project Plan

The principles of the European Union Common Fisheries Policy (CFP), which has driven the management of Europe's common fisheries resources since 1983, are to manage the activities of fishing fleets aims to ensure sustainable exploitation of the ocean's living resources, the provision of important food resources to humankind, and the profitability of an industry that is an important economic and social activity in many areas of Europe and elsewhere. The overall aim of the project is to support the CFP by developing and testing a range of assessment models and methods to establish MSY reference points (or proxy MSY reference points) across the spectrum of data-limited stocks.

Quantitative scientific advice is at the heart of fisheries management regulations, providing estimates of the likely current and future status of fish stocks through statistical population models, termed stock assessments, but also probabilistic comparisons of the expected effects of alternative management procedures. Management Strategy Evaluation (MSE) uses stochastic simulation to incorporate both the inherent variability of natural systems, and our limited ability to model their dynamics, into analyses of the expected effects of a given management intervention on the sustainability of both fish stocks and fleets.

Following the adoption of the precautionary approach (PA, Garcia, 1996) by many fisheries organisations, biological reference points have become central to management. Reference points are used as targets to maximise surplus production and limits to minimise the risk of depleting a resource to a level where productivity may be compromised. They must integrate biological processes such as growth, recruitment, mortality and connectivity into indices for productivity and spawning reproductive potential (Kell et al., 2015b) to provide limits and targets for exploitation. They are increasingly required for by-caught, threatened, endangered, and protected species where data and knowledge are limited, not just for the main commercial stocks, where analytical assessments are available (Sainsbury and Sumaila, 2003).

A main objective of reference points is to prevent overfishing, e.g. growth, recruitment, economic and target overfishing. Growth and recruitment overfishing are generally associated with limit reference points, while economic overfishing may be expressed in terms of either targets or limits. The difference between targets and limits is that indicators may fluctuate around targets but in general limits should not be crossed. Target overfishing occurs when a target is overshot, although variations around a target is not necessarily considered serious unless a consistent bias becomes apparent. In contrast even a single violation of a limit reference point may indicate the need for immediate action. Therefore to achieve MSY requires limit as well as target reference points.

4.1 Workplan

A variety of reference points and methods for deriving them are used for both data rich and poor stocks. In a data rich situtation reference points may be derived directly from a stock assessment model, e.g. in a biomass dynamic model where MSY is a function of the estimated parameters (r and K); ad-hoc approaches when using age methods such as Virtual Ppopulation Analysis, where assumptions about the stock recruitment relationship and future selection and biological parameters have to be made after fitting the assessment model; or in a state space formulation (Nielsen and Berg, 2014) which actually estimates a prediction mechanism and reference points.

In data poor situations a wide variety of statistical methods have been used or proposed to estimate stock status, productivity, fishing rates and reference points, for example using samples of length-composition (Kokkalis et al., 2015; Prince et al., 2015), age-composition (Thorson and Cope, 2015), fishery catch and fishing effort data (Roa-Ureta et al., 2015), abundance indices (Needle, 2015) or simple length-based reference points (Cope and Punt, 2009). Before being able to make management recommendations, a link between a trigger reference point and stock status has to be identified, e.g. so a harvest control rule (HCR) can be used to link removals to the current state of the resource (Restrepo and Powers, 1999). Cope and Punt (2009) proposed a way to do this for catch-based length indicators, using a decision tree and a risk assessment. This approach could be used for a range of indicators. However, (Cope and Punt, 2009) also noted that a full examination of such an approach requires a management strategy evaluation.

In an MSE setting reference points are tuned (i.e. chosen) to meet management objectives. Harvest strategies (i.e. HCRs) can either be model based or empirical Dowling et al. (2015), in the former a stock assessment is used to estimate stock status and reference points while in the later management is based on trends in the data directly. The Commission for the Conservation of Southern Bluefin Tuna (CCSBT) provides a model-free example of a MP (Hillary et al., 2015) that is based on year-to-year changes and trends in empirical indicators (i.e. CPUE and fisheries independent indices); reference levels are then tuned to meet management objectives using MSE, where tuning refers to adjusting the parameters of the MP to try and achieve the stated objectives represented by the OM. Model-based MPs, for example those based on a stock assessment model, may include the estimation of MSY-based reference points, but the values of F, F_{MSY}, B and B_{MSY} from the OM do not need to be equivalent to their proxies in the MP (e.g. if a stock assessment models used in the MP is structually different from that used to condition the OM).

WKLIFE was tasked with developing operational methods for setting proxy reference points for stocks where survey based assessments indicate trends (category 3) and for which reliable catch data are available (category 4). Methods so far examined include length-based indicators, spawning potential ratio (SPR), catch and cpue, and catch only based methods. These methods are now being implemented by the ICES study group WKPROXY, and along with others (Thorson et al., 2015; Carruthers et al., 2014), will be first evaluated using simulation, e.g. using crosstesting where a data rich stock assessment is used to generate data and then fitted to a data poor model and estimates of stock status compared. This approach requires a data rich assessment and that the stock assessment represents the stock dynamics. Alternatively life history theory and relationships can be used to simulate stocks and fisheries for a variety of hypotheses about their dynamics, i.e. using the FLife package (see Rosenberg et al., 2014). To ensure a management advice framework based on a stock assessment and

reference points (i.e. a control system) is robust requires showing that it still functions correctly in the presence of uncertainty or stressful environmental conditions (Radatz et al., 1990). This requires an Operating Model (OM, i.e. a simulation model that represents hypotheses about resource dynamics) conditioned on ecological processes that affect the behaviour of management systems, i.e the focus is on the future, not on fitting historical data as when conditioning an OM on a stock assessment. This is a less data, and more hypothesis-orientated approach (Kell et al., 2006a).

To conduct MSE requires six steps (Punt and Donovan, 2007); namely

Identification of management objectives and mapping these to performance measures to quantify how well they are achieved

Selection of hypotheses about system dynamics for building **O**perating **M**odels (i.e. Simulation Models)

Building the simulation models, i.e. conditioning them on data and knowledge, and rejecting and weighting different hypotheses.

Identifying alternative management strategies, (i.e.the combination of pre-defined data, stock assessment methods, reference points and HCRs.

Running the simulations using the HCRs as feedback control procedures; and

Agreeing the Management Strategies that best meet management objectives.

The MSE will be conducted using FLR[3] (Kell et al., 2007) a family of packages in R for conducting MSE and stock, following the tasks below. Task 1 will help identify stocks and management objectives; Task 2 will allow the OMs to be conditioned; Task 3 will allow the OM to be implemented and psuedo data simulated to evaluate the proposed stock assessment methods and reference points; Task 4 will screen the candidate stock assessment methods (both those considered by WKLIFE but others to ensure that methods are state-of-the-art); and Task 5 will conduct MSE. Task 6 will ensure that the project delivers tools that make a major contribution to the management of data poor stocks; and Task 7 will help in dissemination, and ensure that methods developed tested across a wide range of case studies.

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[3]http://www.flr-project.org/

4.2 Tasks

4.2.1 Task 1: Stock prioritisation (Alex)

A number of example stocks have been identified. The final list of stocks will be prioritised using criteria like: economic value of the stock; importance of the species to the ecosystem (key-stone species); sensitivity to the impacts of fishing; available data.

The final choice of stock will be made after the award of the contract based on their economic, social and ecological importance but also to reflect a contrasting range of life histories, fisheries and datasets. We will however focus on the following stocks:

- Sprat in the Celtic Sea and West of Scotland Sprat (Sub-area VI & Divisions VIIa-c and f-k)

- Grey gurnard VI & VII (excl. VIId)

- Ling IIIa, IVa, VI, VII, VIII, IX, XII, and XIV

- Rays, primarily in areas VIIa,f,g

- John dory in ICES Sub-area VII and Divisions VIIIa,b and d (Northeast Atlantic)

- In collaboration with Newport STO:

    - Saithe VII, VIII, IX, X
    - Pollock VII

- Turbot VIIe,f,j,h and sub area VIII and IXa

- Brill VII (or suitably defined)

A meta-database will be created identifying the data sources and relevant publications for the potential stocks of interest but also for related stocks and species. A reason for considering related stocks and species is because it is possible to compare the performance of data poor and data rich methods using cross-testing. In a cross-test data and population estimates from a data rich assessment are used to simulate data poor datasets which can then be used to test data poor assessment methods, allowing candidate methods to be identified. While a Robin Hood approach can be used to take information from data rich stock to inform assessments of information poor species, i.e. taking from the rich to help the poor. Since similarities in taxonomy, life-history or ecology allows the information from 'data-rich' stocks to be utilised as 'prior distributions' or penalty functions for the data poor species. Hierarchical Bayesian methods allow poor-data species to borrow strength from species with good-quality data. Jiao et al. (2011) for example used hierarchical Bayesian state-space surplus production models and showed estimates were considerably more robust than those of the non-hierarchical models.

Once the meta-database has been prepared (end of month 1) then a list of study stocks will be agreed, following which a database will be designed and an attempt to aquire the data made, following which the final list will be agreed (end of month 2).

4.2.2 Task 2: Data collation (Alex)

Data collation (to run in parallel with other tasks) The project relies on existing data sets, however these data need to be collated in a usable form. Most datasets are available from the Marine Institute, or are publicly available, but others may only exist in other European labs/agencies.

Datasets will include, stock assesment datasets (ICES, NAFO, STECF[4], ...), fisheries, life history parameters (Fishbase[5], fishnets[6]), surveys (MI), commercial sampling sets (MI), and economic data (e.g. BIM).

Life history data will also be compiled since many studies have shown the relationships between life history traits for processes such as growth, maturity and natural mortality. Life history has also been used to develop priors in stock assesments for difficult to estimate parameters. e.g. the population growth rate (r) in data poor assessments. Life history parameters can also be used to develop an Operating Model.

The meta-database will be extended with code to read the data into a common format, e.g. data frames and other objects in R and FLR to model stocks, populations and fisheries. It is important to ensure that data are easily available and that any processing steps are well documented and standardised this is true for both the basic data and the results from the MSE (e.g. datasharing[7]). s.

4.2.3 Task 3: Framework Development (Laurie)

Method and simulation framework development and implementation A number of data-limited methods exist. In order to compare the performance of these methods it would be useful to implement them all in the same framework, e.g. R. New methods may also be developed in the same framework.

All methods will be implemented in R and be compatible with The Fishery Library in R (**FLR**) (Kell et al., 2007), a project that has for the last ten years been building an extensible toolset of statistical and simulation methods for quantitative fisheries science, with the overarching objective of enabling fisheries scientists to carry out analyses of management procedures in a simplified and robust manner through the MSE approach.

FLR has become widely used in many of scientific bodies providing fisheries management advice, both in Europe and elsewhere. The evaluation of the effects of elements of the revised CFP, the analysis of the proposed fisheries management plans for the North Sea, or the comparison of management strategies for Atlantic tuna stocks, among others, have used the **FLR** tools to advice managers of the possible courses of action to favour the sustainable use of many marine fish stocks.

The **FLR** toolset is currently composed of a variety of packages, covering the various steps in the fisheries advice and simulation workflow. They include a large number of S4 classes, and more recently Reference Classes, to model the data structures that represent each of the elements in the fisheries system. Class inheritance and method overloading are essential tools that have allowed the **FLR** packages to interact, complement and enrich each other, while still limiting the number of functions an user needs to be aware of. Methods also exist that make use of R's parallelization facilities and of compiled code to deal with complex computations.

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[4]https://stecf.jrc.ec.europa.eu/dd/medbs/ram
[5]http://www.fishbase.org/search.php
[6]https://github.com/fishnets/fishnets
[7]https://github.com/AdrianHordyk/datasharing

Using **FLR** means that advantage can be taken of existing methods, and that dissemination and support is easier and will be maintained after the life of the project. Under the project development will be on mainly on four packages **FLife**, **mpb**, **hcr** and **oem**. In addition new methods will be added to other **FLR** packages as appropriate.

FLife is a package for modelling life history relationships, e.g. for developing priors, estimating quantities such a Z from length data, deriving reference points and indicators and for creating OMs.

mpb is a package for modelling biomass dynamic based management procedures, it has also been used to assess a variety of stocks, e.g. Atlantic bigeye and North Atlantic albacore and swordfish. It also forms the basis of the North Atlantic albacore MP evealuted using MSE.

hcr will be a new package that will include a variety of emprirical HCRs, e.g. those used by CCSBT, proposed by ICES and from a review of the literature (e.g. Pomarede et al., 2010).

oem will be a new package that implements a variety of observation error models, that will be used to simulate a variety of datasets from OMs that will be used by the data poor methods.

In addition Dr Kell is the developer of two packages that are used to provide a common set of diagnostics across stock assessment methods (**diags**) and to summarise stock status relative to reference points and for summarising the results from MSE (**kobe**)

There are a variety of R packages, that already implement a variety of data poor methods, e.g. https://github.com/quang-huynh/MLZ, https://github.com/AdrianHordyk/LBSPR https://github.com/cran/DLMtool, wherevever possible these packages will be used and we will collaborate with their developers.

4.2.4 Task 4: Method Performance Appraisal (Laurie)

Method performance appraisal Develop set of diagnostics that can be applied across range of models. Also assess the stability of the model, sensitivity to assumptions and bias in the advised catch.

A range of summary statistics will be required to illustrate trade-offs between multiple potentially conflicting objectives. Although there are many potential summary statistics so that decision makers can choose between tangible options on the basis of actual projections rather than abstract concepts and performance statistics, however, should ideally be few, informative and based axes such as 'stock status', 'safety', 'stability' and 'yield'. It is also necessary to distinguish between techincal summary statistics (i.e. those required to evaluate model fits and performance) and those required to evaluate management objectives.

Results will be presented using an interactive app, based on shiny, that can be used to evaluate the performance of the models.

4.2.5 Task 5: Reference Point Comparisons (Alex, Cóilín)

Reference point comparisons (across candidate methods) Once reference points have been identified, their performance should be evaluated through simple management strategy evaluations. A set of appropriate stock assessment models will be fit to the available data (Task 1 and 2). Methods used will reflect the available data on a stock-by-stock basis (Task 2) and also methods available or developed in

Tasks 3 and 4. Performance diagnostics (e.g., residual inspection, retrospective patterns) will be run for each assessment model fit.

We will provide a review of reference points and indicators, based on a variety of assumptions, e.g. MSY based on biomass dynamic stock assessment models, and indicators such as L_{opt}, L_{50} and L_{mega} for length-based methods. Then compare these using simulation, e.g. cross-testing and simulations based on FLife. This will allow the power of the methods to detect whether a stock has achieved its targets and avoid its limits. Based on this screening process a set of candidate reference points and assessment methods will be proposed for MSE.

MSE will include a Value-of-infomation analysis, where the benefits of collecting better data and new infomation will be evaluated.

4.2.6   Task 6: Liaison with Marine Institute (Cóilín, Alex, Laurie)

The service provider is expected to meet on a regular basis with Marine Institute staff involved in the project: Monthly update meetings at the Marine Institute premises in Oranmore Galway

The proposal is ambitious but achievable. However there needs to be good communication between the consortum and the Marine Instiutute to ensure the project keeps focused and delivers. Therefore we will arrange monthly face-to-face meetings, make all code, data and results available on the cloud and in a suitable repository (e.g. github) and provide a web based interface for model results.

Wider project 6-monthly progress reports and meetings at the Marine Institute will ensure the over-arching goals of the project are achieved.

4.2.7   Task 7: Linkage with other Projects (Cóilín)

- Monkfish
  This project will develop in close collaboration with the Cullen Fellowship of Mr Luke Batts, co-supervised by Dr Hans Gerritsen (MI) and Dr Cóilín Minto (GMIT). Active collaboration will occur with Tasks 3–5, as these are similarly proposed in the Cullen Fellowship where they are applied specifically to *Lophius budegassa* and *Lophius piscatorius* stocks in ICES areas VII-VIII.

- Pollock
  Active collaboration exists between GMIT and the Newport Research Cluster (e.g., *Unlocking the Archive* project). Further collaboration and linkages will be built around data-poor assessment of pollock (liasing with the dedicated Scientific and Technical Officer working on pollock at the Furnace research facility). Both visits to Newport and group attendance at the monthly meetings will facilitate collaboration and crossover.

- DRuMFISH project
  The project will also link with the DGMARE project: "Study on approaches to management for data-poor stocks in mixed fisheries (DRuMFISH)" to which GMIT is a partner in the consortium. Methodological development from DRuMFISH (e.g., hierarchical methods) will be directly relevant to the present proposal.

- CPV codes 71354500-9 Marine survey services 73112000-0 Marine research services 90712300-4 Marine conservation strategy planning 98360000-4 Marine

services 77700000-7 Services incidental to fishing 73000000-2 Research and development services and related consultancy services 73110000-6 Research services 73200000-4 Research and development consultancy services 73210000-7 Research consultancy services.

- There are also other projects worldwide that can be link to e.g. the global group on stock assessment methods and the tRFMO MSE WG.

4.3   Project Management and Milestones

To achieve the goals of the project requires good communication between the consortum and the Marine Instiutute. Therefore we will arrange monthly face-to-face meetings and 6 monthly meetings throughout the lifetime of the project. In addition all code will be available via a repository such as github, databases will be accesible via the cloud and we provide a web based interface (such as a shiny app) for model results.

The 6 monthly meetings, i.e. kick-off, 6th month, 12th month and the final meeting will provide the milestones. Outputs will include working papers for the two ICES groups WGCSE, and WKPROXY. These will document the methods and also present case study applications which will be agreed at the 6 monthly meetings and developed on the cloud. To help with this a wiki will be used.

4.3.1 Task Summary

A full break down of tasks is given below. Each task is assigned to a lead who will take responsibility for delivery, however, the task overlap and members of the consortium will be involved across the range of tasks as required, see figure 1.

Task 1 Stocks (Alex)

- Identify managment objectives and current reference points.
- Create a meta-database, that will identify data sources and allow case studies to be choosen.
- The meta-database should include related species and stocks, as well as those listed below, to allow OMs to be conditioned, cross-testing to be conducted and priors to be developed.

Task 2 Data (Alex)

- Design a DB to hold the data refered to in the meta-database
- Develop R/SQL scripts to access and read the data
- Develop tools to summarise, check the data and conduct meta-analyses.
- Summarise the error structure of the data series to allow a variety of OEM to be implemented
- Develop tools to help in conditioning OMs

Task 3 Framework (Laurie)

- Review appropriate assessment methods, used by ICES and Regional Fisheries Management Organisations
- Identify code and R packages
- Implement methods as required in R using S4 classes and methods and packages such as TMB, Stan, Bugs.
- Develop OMs based on life history and/or data rich stocks
- Develop OEMs for the range of data (e.g. CPUE, catch, length, size composition) used in the data poor assessments.

Task 4 Methods (Laurie)

- Compare methods to determine data and infomation needs, e.g. using simulation without feedback control to conduct power analyses where the probabilities of achiveing targets and avoiding limits is evaluated.

Task 5 Reference Points (Alex)

- Fit and compare appropriate stock assessments that reflect the available data (Task 2) and methods developed (Tasks 3 and 4)
- Run MSE using the OM, OEM and MPs based on Task 4.
- Conduct a Value-of-Infomation analysis, i.e. what are the benefits of reducing CVs or collecting alternative data series

Task 6 Liason (Cóilín)

- Monthly meetings to monitor progress and get feedback .
- Six monthly meetings to review progress and agree next stage of work.
- Attendance at ICES WGs to provide advice and obtain feedback.

Task 7 Other Projects (Cóilín)

Active collaboration will be developed and maintained with the following on-going projects

- Pollock assessment and MSE at Newport

- Cullen fellowship on Monkfish MSE

- DRuMFISH project on data-poor stock assessment in mixed fisheries

4.4 Outputs

The expected outputs are a a collection of existing and new assessment models for data-limited stocks, all implemented in the same framework (e.g. R) with a set of diagnostic tools that can be applied to all models.

Methods will be implemented as R packages and/or methods; this will include full documentation, online help vignettes and tests. As well as conducting cross-testing to validate models a full set of diagnostic tools will be provided, inlcuding checks for convergence using methods such as likelihood profiling; identification of violation of assumptions by checking residuals to fits using the **diags** package; and use methods such as the jack knife or bootstrap to identify problems with the data and model specifications; and conduct hindcasting to evaluate prediction ability (Kell et al., 2016a).

A set of proposed reference points for a range of stocks with associated management strategy evaluations to contribute to sustainable management of these stocks.

We will review the reference points currently used in the management of stocks under the CFP and estimated by ICES, in addition we will review reference points used elsewhere by other management bodies and RFMOs. Then compare datapoor and traditional target and limit reference points using crosstesting, in consultation with the Marine Institute and ICES WGs we will come up with a set of candidate reference points, classified by data reqirements, and evaluate these using MSE.

Working documents describing the methods and findings to relevant ICES groups (e.g WGCSE; WKPROXY).

Dr Kell will attend the Methods related WGs to develop the novel approaches, while Dr Alexander Tidd will attend stock assessment WGs to present applications. All papers will be coauthored with Galway-Mayo Institute of Technology and Marine Institute staff.

Publication(s) in peer-reviewed journals on new methods/tools/evaluations.

There are a variety of manuscripts that the project will produce, i.e. on new methods, applications, and a potential review of the relative value-of-information to the value-of-Control.

4.5 Deliverables

Data Case study data

> **Meta-database** identifying data sources for candidate stocks, this will be updated through the life of the project and be made available via the web as a living document.

> **Stock database** to hold the data required to condition the OMs and to parameterise the OEM, with tools for analysis and summary.

> **Summary database** For performance statistics from the MSE.

R Packages These will form part of the **FLR** family of packages

> **FLCore** will be updated to include data poor methods as appropriate; in particular the following packages

>> **kobe** Package with methods for summary statistics

>> **diags** Package for stock assessment diagnostics

FLife Package for simulation basd on life histories, e.g. for conditioning OMs

mpb Package for management procedures based on biomass based methods

hcr Package for emprirical MPs

oem Observation error models.

Dissemination ICES WGs Attendance at WGCSE and WKPROXY

Web based tools Shiny app to summaries results

Manuscripts A folio of papers will be agreed at the 1st 6 montly meeting, this will include at least 1 paper each on

Paper 1 Methods

Paper 2 Applications and

Paper 3 Review, e.g. of the relative value-of-infomation and control.

5   Phase 3 Criteria

5.1   Cost

The contract is for 18 months and the proposed budget is:

Post Doc A 16 month post-doc on an Irish University Association researcher scale level 2, point 1 would cost €46,401 times 16/12 €62,135. The role of the post-doc would be data preparation, method development and implementation, liaison with the Marine Institute and co-reporting/co-authoring.

Principle Investigator €50,000 to support methodological development. Although this is low it is probaly adequate since a lot of the work would take advantage of synergies with **FLR**.

Local Expert One month plus 18 days (day per month) = €13,455. for Galway expert on method development, implementation and responsibility for reporting/co-authoring.

Travel Travel 4x1 week ICES meetings + monthly meetings $\sim$ €10,000

Galway-Mayo Institute €85,590 + overheads at 30% = €11,1267 **PI Contract** €50,000
Total €161,267

6 Tables

Table 1: Preliminary list of stocks

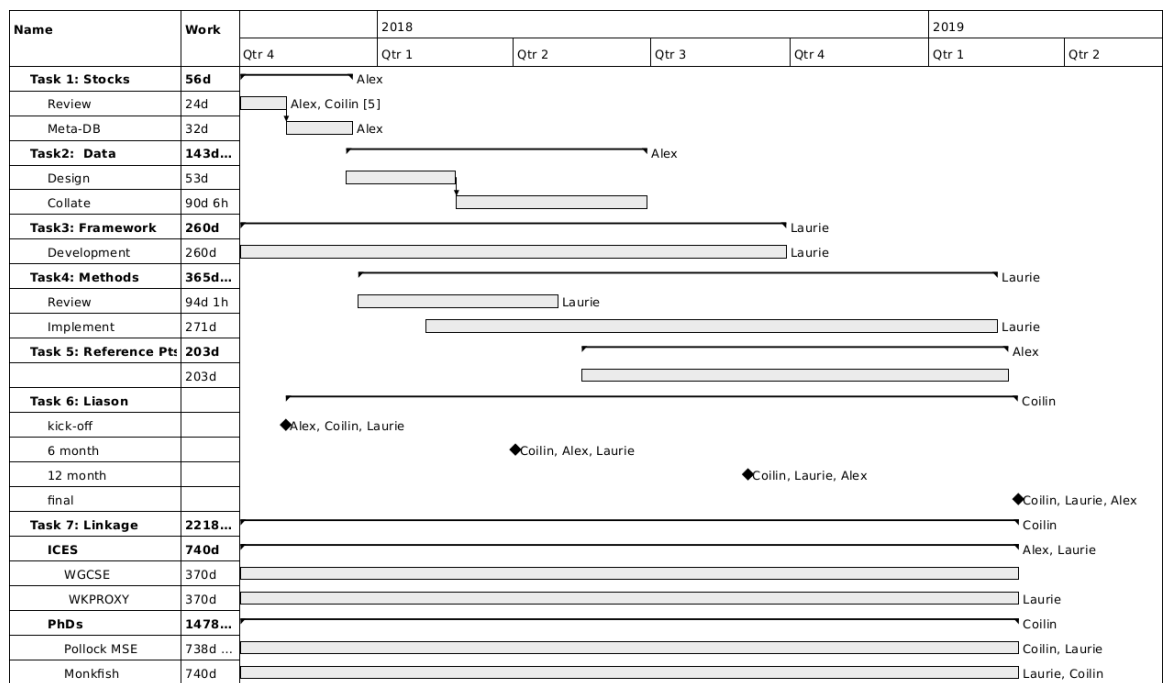| Species	TAC	Commercial Catch	Data	Comments
Sprat	No	Targeted species for small fleet	Poor; mainly landings weights	Key-stone prey fish
Gurnards	No	Nearly 100% discarded	Reasonable discard and survey data. No age data	Key-stone prey – widely distributed and abundant
Saithe Pollock Ling	Yes	Mixed fishery	Some port sampling, observer and survey data. Very limited age data	Key-stone predator
Rays Skates	Yes	Targeted and mixed fishery	Some port sampling, observer and survey data. No age data	Sensitive species – slow reproduction
John Dory	No	Mixed fishery but can be targeted to an extent	Some port sampling, observer and survey data. No age data	Sensitive species – valuable non-TAC species (not protected by fisheries management)
Turbot Brill	No	Mixed fishery but can be targeted to an extent	Some port sampling, observer and survey data. Very limited age data	Sensitive species – valuable non-TAC species (not protected by fisheries management)

Name	Work	2018					2019	
		Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2
Task 1: Stocks	**56d**	Alex						
Review	24d	Alex, Coilin [5]						
Meta-DB	32d	Alex						
Task2: Data	**143d…**		Alex					
Design	53d							
Collate	90d 6h							
Task3: Framework	**260d**					Laurie		
Development	260d					Laurie		
Task4: Methods	**365d…**						Laurie	
Review	94d 1h			Laurie				
Implement	271d						Laurie	
Task 5: Reference Pts	**203d**						Alex	
	203d							
Task 6: Liason							Coilin	
kick-off		◆Alex, Coilin, Laurie						
6 month				◆Coilin, Alex, Laurie				
12 month					◆Coilin, Laurie, Alex			
final								◆Coilin, Laurie, Alex
Task 7: Linkage	**2218…**						Coilin	
ICES	**740d**						Alex, Laurie	
WGCSE	370d							
WKPROXY	370d						Laurie	
PhDs	**1478…**						Coilin	
Pollock MSE	738d …						Coilin, Laurie	
Monkfish	740d						Laurie, Coilin	

Figure 1: Proposed Project timeline.

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7 Appendices

GMIT tax clearance certificate

Revenue
Cáin agus Custaim na hÉireann
Irish Tax and Customs

Tax Clearance Certificate Issued

We confirm that your tax affairs are in order, and you have been issued with a tax clearance certificate.

In order to confirm to a third party that you have a tax clearance certificate, you will need to provide them with your PPSN/tax reference number and the tax clearance access number below.

Applicant Name: **Galway-mayo Institute Of Technology**

Applicant PPSN/Tax Reference Number: **4751726A**

Access Number: **699583**

Please note that in order to retain your tax clearance certificate you need to continue to keep your tax affairs in order. Revenue will review your tax affairs periodically and will rescind your tax clearance certificate if your tax affairs are not in order at any stage.

Applicant CVs

Alex Tidd - CV

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Fisheries Scientist - Bio-economic modelling
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Applied fisheries research modelling the fleet dynamics of the purse seine fishery. Evaluating fishing efficiency, investment dynamics, fisher tactics and strategies. Writing reports and papers for peer-review journals.

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Fisheries Scientist - Higher Scientific Officer
Centre for the Environment, Fisheries & Aquaculture Science (Cefas), Lowestoft (United Kingdom)

Applied fisheries research. Work undertaken including research on bio-economic modelling, fisheries management, and the efficacy of capacity and effort measures and spatio-temporal closures. Involved in the collection and quality assurance of fishery-data, including from scientific trawl surveys. Publications in peer-reviewed journals. Active in range of EU-funded scientific projects (Efimas, Necessity, Flatnose, Cafe, Aframe, Vectors).

10 Jan 2000–14 Aug 2005

Information Scientist - Scientific Officer
Centre for the Environment, Fisheries & Aquaculture Science (Cefas), Lowestoft (United Kingdom)

Research and development position working on many European Union funded contracts and providing support for Defra. Data analysis. Database construction. Biological oceanography, spatial-temporal modelling.

EDUCATION

30 Oct 2008–1 Jul 2013

Doctor of Philosophy (PhD)   PhD

Imperial College, London (United Kingdom)

Statistical modelling of fishing fleet behaviour and fleet dynamics.

Sep 1993–May 1995

Bachelor of Science in Chemistry (BSc Hons)   Degree

Manchester Metropolitan University, Manchester (United Kingdom)

Biochemistry, Organic Chemistry, Inorganic Chemistry, Physical Chemistry and Mathematics.

Publications

Tidd, A.N., Watson, R.A., Rousseau, Y., Parker, R., Tyedmers, P. Analysis of global fleet capacity indicators. (in prep).

Tidd, A.N., and Kell., L.T., Investment dynamics of tropical tuna purse seine fleets. (in prep).

Janßen, H., Bartelings, H., Bastardie, F., Eero, M., Girardin, R., Hamon, K., Hinrichsen, H., Marchal., P., Nielsen, R., Le Pape, O., Schulze, T., Simons., S., Teal, L.R., **Tidd, A.N.,** Vermard, Y. (2017). Integration of fisheries in marine spatial planning:Quo vadis? Estuarine, Coastal and Shelf Science, 10.1016/j.ecss.2017.01.003.

Tidd, A.N., Brouwer, S., Pilling, G.M. (2017). Shooting fish in a barrel? Assessing fisher-driven changes in catchability within tropical tuna purse seine fleets. Fish Fish. 2017; 00:1–13. doi:10.1111/faf.12207.

Girardin, R., Hamon, K., Pinnegar, J., Poos, J.J., Thebaud, O., **Tidd, A.N.,** Vermard, Y., Marchal, P. (2016). Thirty years of fleet dynamics modelling using discrete-choice models: what did we learn? Fish Fish. doi:10.1111/faf.12194 .

Tidd, A.N., Reid, C., Pilling G.M., Harley, S.J. (2016). Estimating productivity, technical and efficiency change in the Western Pacific Purse seine fleets. ICES Journal of Marine Science doi: 10.1093/icesjms/fsv262.

Girardin, R., Vermard, Y., Thébaud, O., **Tidd, A.N.** and Marchal, P. (2015). Predicting fisher response to competition for space and resources in a mixed demersal fishery. Ocean & Coastal Management 106, 124-135.

Tidd, A.N., Vermard, Y., Marchal, P., Pinnegar, J., Blanchard, J.L., and Milner-Gulland, E.J. (2015). Fishing for space: fine-scale multi-sector maritime activities influence fisher location choice. Plos One 10, 1-14.

Marchal, P., Desprez, M., Vermard, Y., **Tidd, A.N.** (2014). How do demersal fishing fleets interact with aggregate extraction in a congested sea?. Estuarine, Coastal and Shelf Science, 149, 168-177.

Martinez, I., Ellis, J.R., Scott, B.,**Tidd, A.N.** (2013). The fish and fisheries of Jones Bank and the wider Celtic Sea. Progress In Oceanography, 117, 89-105.

Tidd, A.N. (2013). Effective fishing effort trip indicators and their use for efficient spatial management in mixed demersal fisheries. Fisheries Management and Ecology, 20, 377-389.

Tidd, A. N., Hutton, T., Kell, L. T., and Blanchard, J. L (2012). Dynamic prediction of effort re-allocation in mixed fisheries. Fisheries Research 125–126, 243–253

Tidd, A.N., Hutton, T., Kell, L.T., Padda, G. (2011). Exit and entry of fishing vessels: an evaluation of factors affecting investment decisions in the North Sea English beam trawl fleet. ICES Journal of Marine Science 68, 961–971.

Iriondo A., García D., Santurtún M., Castro J., Quincoces I., Lehuta S., Mahévas S., Marchal P., **Tidd A.N.,** Ulrich C. (2012). Managing Mixed Fisheries in the European Western Waters: application of Fcube methodology. Fisheries Research, 134–136, 6–16.

Mahévas, S., Vermard, Y., Hutton, T., Iriondo, A., Jadaud, A., Maravelias, C. D., Punzón, A., Sacchi, J., **Tidd, A.N.,** Tsitsika, E., Marchal, P., Goascoz, N., Mortreux, S., and Roos, D. (2011). An investigation of human vs. technology-induced variation in catchability for a selection of European fishing fleets. ICES Journal of Marine Science, 68, 2252– 2263.

Hutton, T., A, Mardle, S, **Tidd, A.N.** (2008). Advances in Fisheries Science (Book Chapter) The decline of the fishing fleets along the English and Welsh Coastline. 50 years on from Beverton and Holt. Blackwell Publishing, Eds: A. Payne, J. Cotter, and T. Potter, pages 26–48.

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Pilling, G.M., Kell, L.T., Hutton, T., Bromley, P.J., **Tidd, A.N.,** and Bolle, L.J. (2008). Can economic and biological management objectives be achieved by the use of MSY-based reference points? A North Sea plaice (*Pleuronectes platessa*) and sole *(Solea solea)* case study. ICES Journal of Marine Science, 65, 1069–1080.

Catchpole, T.L., **Tidd, AN.**, Kell, L.T., Revill, A.R., Dunlin, G. (2007). The potential for new Nephrops trawl designs to positively effect North Sea stocks of cod, haddock and whiting. Fisheries Research, 86, 262– 267.

Pilling, G.M., Millner, R.S., Easey, M.W.,Maxwell, D., **Tidd, A.N.** (2007). Phenology and North Sea cod (Gadus morhua): has climate change affected otolith annulus formation and cod growth? Journal of Fish Biology, 70, 584–599.

Trenkel, V.M., Pinnegar, J.K., Dawson, W.A., Du Buit, M.H., **Tidd, A.N.** (2005). Spatial and temporal structure of predator-prey relationships in the Celtic Sea. Marine Ecology Progress Series, 299, 257– 268.

Blanchard, J.L., Dulvy N.K., Ellis, J.E., Jennings S., Pinnegar, J.K., **Tidd, A.N.,** Kell, L.T. (2005). Do climate and fishing influence size-based indicators of Celtic Sea fish community structure? ICES Journal of Marine Science. 62, 405– 411.

Pinnegar, J.K., Trenkel, V.M., **Tidd, A.N.,** Dawson, W.A. and Du Buit, M.H. (2003). Does diet in Celtic Sea fishes reflect prey availability? Journal of Fish Biology, 63, 197– 212.

Policy Reports

Tidd, A.N., Pilling G.M., Hampton, J. (2016). Examining indicators of effort creep in the WCPO purse seine fishery. WCPFC-SC12-2016/MI-WP-08.

Tidd, A.N., Pilling G.M.,(2016). Preliminary capacity utilization analysis of the WCPO purse seine fleet using Data Envelopment Analysis (DEA). WCPFC-SC12-2016/MI-IP-03.

Tidd, A.N., Tremblay-Boyer, L. (2016). Exploratory analysis linking bigeye concentrations with vessel attributes. WCPFC-SC12-2016/MI-IP-07.

Scott, R., **Tidd, A.N.,** Davies, N., Pilling G.M., and Harley, S.J. (2015). Implementation of alternative CPUE/abundance dynamics for purse seine fisheries within MULTIFAN-CL with application to effort-based projections for skipjack tuna. WCPFC-SC11-2015/MI-WP-02.

Tidd, A.N., Pilling G.M., and Harley, S.J. (2015). Examining productivity changes within the tropical WCPO purse seine fishery. WCPFC-SC11-2015/MI-WP-06.

Rice, J., Tremblay-Boyer, L., Scott, R., Hare, S., **Tidd, A.N.** (2015). Analysis of stock status and related indicators for key shark species of the Western Central Pacific Fisheries Commission Rev 1 (29 July 2015). WCPFC-SC11-2015/EB-WP-04-Rev 1.

Tidd, A.N. (2014). Investment dynamics of the Western and Central Pacific Ocean US purse seine fleet. WCPFC-SC10-2014/MI-IP-05.

Kell, L.T., Palma C., **Tidd, A.N.** (2009). Standardisation of North Atlantic Albacore, Thunnus alalunga, CPUE. SCRS/09/101.

Ulrich C., Andersen, B.S., Castro J., Jacobsen R.J., Maravelias C., Nielsen J.R., Reeves, S., Santurtun M., **Tidd A.N**., Wilson D. (2009). Potentials and challenges in fleet- and métier-based approaches for fisheries management in the CFP. ICES CM2009/R06

Tidd, AN., Warnes, S. (2007). Species distributions from Celtic Sea groundfish surveys 1992 – 2003. Cefas Technical Report.

Trenkel, V.M., Pinnegar, J.K., **Tidd A.N.** (2004) Can multispecies models be expected to provide better assessments for Celtic Sea groundfish stocks? ICES CM 2004/ FF: 05.

Research Grants

2014 'Discardless' – Strategies for the gradual elimination of discards in European fisheries.. EU HORIZON2020 Large Consortium project worth. €5,000,000 in total and £60,000 granted to Cefas. Principal Investigator.

2014 Stick, Gamble or Twist, the fishers dilemma. Seedcorn independent research project

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Cefas. £12,000 Principal Investigator.

Research Projects

2014 – 2016 'Scicofish' - Scientific support for the management of oceanic fisheries in the Pacific Islands region. Funded by EU and Worldbank. Project Researcher.

2013 – 2014 Sea Angling - a survey of recreational sea angling activity and economic value in England (MF1221). UK Department for Environment Food and Rural Affairs. £406,977. Project Researcher.

2011– 2013 Vectors of Change in Oceans and Seas Marine Life, Impact on Economic Sectors (VECTORS). European Commission Framework 7 Large Consortium worth €12,400,000. Cefas Co-Investigator.

2008 – 2010 Scientific advice concerning the impact of the gears used to catch plaice and sole (FLATNOSE). European Commission Tender Lot 3. Cefas Project Managed, Co-Investigator and Work-Package Leader. €1,000,000

2006 – 2007 Fisheries Interactions (MF0322) UK Department for Environment Food and Rural Affairs. £1,012,823. Project Researcher

2007 – 2009 A framework for fleet and area based fisheries management (AFRAME). European Commission Framework 6 Consortium worth €1,300,000. Project Researcher.

2006 – 2007 Creation of Multi-Annual Management Plans for Commitment (COMMIT). European Commission Framework 6 Consortium worth €1,400,000. Project Researcher.

2006 – 2009 Capacity, F and Effort (CAFÉ). European Commission Framework 6 Large Consortium worth €1,500,000. Project Researcher/Project Managed.

2006 – 2008 Operational Evaluation Tools for Fisheries Management Options (EFIMAS). European Commission Framework 6 Large Consortium worth €4,500,000. Project Researcher.

2003 – 2007 Nephrops and Cetacean Species Selection Information and Technology (NECESSITY). European Commission Framework 6 Large Consortium worth €4,200,000. Project Researcher.

2002 – 2005 Technological developments and tactical adaptations of important EU fleets (TECTAC). European Commission Framework 5 Large Consortium worth €1,800,000. Project Researcher.

2002 – 2005 Integrated approach to the biological basis of age estimation in commercially important fish species (IBACS). European Commission Framework 5 Large Consortium worth €999,000. Project Researcher.

2001 – 2003 Ongoing development of structurally detailed, statistically testable fishery models. (DST2). European Commission Framework 5 Large Consortium worth €3,000,000. Project Researcher.

2000 – 2003 Allowing fishermen access to survey data (MF0803). UK Department for Environment Food and Rural Affairs. £103,134. Project Researcher.

Invited Activities

2016 - Invited to teach and give a practical on effort creep for the SPC advanced Stock Assessment workshop.

On-going reviews in peer review journals.

2015 - Invited expert to work with Forum Fisheries Agency on the development of a regional bio-economic model (Honiara).

2014-2016 Provided reviews for the Western Central Pacific Fishery Council annual science committees.

2008–June SGRST-08-02: Harvest Control Rules Expert Group (Scientific Technical Economic Council for Fisheries).
Invited participant in expert group to provide suggestions for changes to the EU commission rules, in order to improve long-term yields, reduce costs, and to improve the stability of

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fishing operations and markets.

2008 – September (Rapporteur) ICES Conference of Marine Science Halifax Canada. Main theme session on Capacity F and Effort.

Awards	Paper of the year for best early career scientist within Cefas 2011-2012. 2 x Paper of the month in 2011 and 2012 within Cefas.
Postgraduate student supervision	Katherine Maltby. MBiolSci project on "Fisher behaviour and socio-ecological models". Supervised by Julia Blanchard & Alex Tidd, based at The University of Sheffield with placement at Cefas. Sept 2012 – June 2013.
Field work	Fisheries assessment Surveys: 2001/2002/2003/2004 (August -September). North Sea Groundfish Survey -Participant. 2005/2006/2007 (July). Eastern Channel beam trawl survey - Participant/2nd Scientist in Charge (2007). 2006/2007/2008/2009/2011/2012/2013 (November). Western Groundfish survey. Scientist in Charge/2nd Scientist (alternative years). 2005/2006/2007 (March). EU Data collection Regulation (DCR). (Scientist in Charge 2006/2007).
Organisational / managerial skills	Project planning. Managing scientific projects. Staff management on scientific research surveys. Work well with people and in teams. Enjoy organising teams, data etc.
Job-related skills	Applied fisheries research (fleet dynamics, trawl surveys, marine biology), data analysis and statistics (including quality assurance of data and data-visualisation), scientific writing (peer-reviewed papers, as well as technical reports. Specialist skills in bio-economic modelling (Random Utility Models, Data Envelopment Analysis).
Digital competence	R, SAS (Use of ODBC and SQL in both packages). Databases: Access and some use of Postgresql. Dreamweaver web development tools. ECOPATH and ECOSIM training course at ICES in 2013. PCA, Cluster analysis etc., and GLMs and economic valuation through discrete choice modelling framework. Data Envelopment Analysis for analysis of efficiency and performance.
Other skills and competences	PADI open water diver. Otolith micro-chemistry. Teacher of English to Speakers of Other Languages. (TESOL). Sea survival skills. ENG1 certificate. Manual Handling. Fire-fighting, First Aid, Water Safety. Full EU driving licence.

Cóilín Minto
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Dublin Road, Galway City
Ireland

Education

- **Ransom Myers' Laboratory Dalhousie University**   Halifax, NS, Canada
  Ph.D.   2011
    - Thesis: *Ecological Inference from Variable Recruitment Data*.
      Nominated for the Dalhousie University Doctoral Thesis Award in the Natural and
      Medical Sciences and Engineering.
    - Relevant courses:
      (Mathematics and Statistics Department) Probability Theory, Intermediate Statistical
      Theory, Regression Analysis, Time Series Analysis, Advanced Topics in Statistics and
      Probability: State-Space Analysis.
      (Biology Department) Biological Modelling, Speciation, Foundations of Ecology, Fish
      Ageing, Communication skills.

- **Trinity College**   Dublin, Ireland
  B.A. Zoology (Fisheries focus)   1999-2003
    - Thesis: *Fecundity and reproductive capability of orange roughy (Hoplostethus
      atlanticus) on the Porcupine Bank, Northeast Atlantic*.
    - Graduated with a First-Class Honors (Gold Medalist in Natural Science).
    - Relevant courses: Data analysis, Ecology, Fisheries Biology, Marine Biology,
      Vertebrate/Invertebrate ecology, Evolution, Behavioral Ecology.

Professional Experience

- **GMIT Irish Survey of Student Engagement analyst**
  Visualisation and interpretation of high dimensional survey data assisting institutional
  response to student feedback.
- **International Council for the Exploration of the Sea, Copenhagen, Denmark.**
  External reviewer of assessments for deepwater redfish and megrim, 2016.
- **National Center for Ecological Analysis and Synthesis, Santa Barbara, CA.**
  Working group participant, Nov. 2014-present
    - Measuring the status of fisheries and factors leading to success.
- **RAM Legacy Stock Assessment Database (ramlegacy.org): European Co-ordinator**
- **European Union Scientific, Technical and Economic Committee for Fisheries (STECF)**
  EWG 13 16: Landing Obligation in EU Fisheries; Expert Working Group 13 01: Technical
  Measures; Expert Working Group 15 01: Technical Measures III
    - Invited External Expert.
- **FAO and Conservation International**

Working group participant, lead analyst June 2012 – present.
- Exploitation and productivity status of fishery ecosystems.
- Applying data-limited stock status models and developing management guidance for unassessed fish stocks.

- **Galway-Mayo Institute of Technology, Galway, Ireland.**
Senior Researcher in Quantitative Ecology and Biostatistics, May 2010 – present.
  - Developing advanced biostatistical capacity in Irish/European fisheries research.
- **Dalhousie University, Halifax, NS, Canada.**
Ram Legacy Stock Assessment Database Developer, Aug. 2007 – May 2010.
  - Co-developer of a global fisheries stock assessment database.
- **National Center for Ecological Analysis and Synthesis, Santa Barbara, CA.**
Working group participant, Nov. 2007-May 2009
  - Finding common ground in marine conservation and management.
- **Department of Fisheries and Oceans Canada, Dartmouth, N.S.**
External reviewer Nov. 2007
  - External reviewer: state-space models for Recovery Potential Assessments for cusk.
- **ICES Working Groups**
WGSAM 2007, WKFLAT 2012, WGWIDE 2013, WKCELT 2014.
  - Scientific delegate to the ICES Working Groups.
- **Ransom Myers' Laboratory, Dalhousie University, N.S., Canada.**
Ph.D. student Sep. 2004 - April. 2010.
- **Ransom Myers' Laboratory, Dalhousie University, N.S., Canada.**
Visiting Scientist Jul. 2004 - Sep. 2004
  - Development of Structural Equation Modeling (SEM) frameworks for species interactions.
- **Irish Sea Fisheries Board (Bord Iascaigh Mhara), Dun Laoghaire, Ireland.**
Research Assistant Nov. 2003 - Jun. 2004
  - Analyzing and communicating data on Irish deep-sea fisheries. Responsibilities included: fostering collaboration with the Irish National Seabed Survey, presentation to the national steering group on orange roughy.
- **Irish Sea Fisheries Board (Bord Iascaigh Mhara), Dun Laoghaire, Ireland.**
Onboard Fisheries Biologist: May 2002 - Sept. 2002/May 2003-Sept. 2003
  - Onboard deepwater and mid-water fisheries biologist. Completed a cumulative of 110 days at sea where the responsibilities included: the collection of all onboard data on commercial vessels fishing deepwater and midwater areas of the continental slope in the Northeast Atlantic; identification and quantitative sampling of the catch.

Research Skills

- **Quantitative Biological Sampling:** Sampling design; Data management.
- **Statistical Programming Languages**: R/S-Plus, Matlab, SAS, AD-Model Builder, TMB, WinBUGS, JAGS.
- **Mathematical software**: Maple, Axiom, Matlab, GNU Octave.
- **Relational Database Management Systems**: MySQL, PostgreSQL.

- **Scripting Languages**: BASH, Perl.
- **Markup Languages**: LaTeX, HTML.
- **Operating Systems**: Linux (Debian), UNIX, Mac OS X, Windows.
- **High-performance computing:** Message Passing Interface for parallel computing.
- **Miscellaneous**: Project management (St. Mary's Professional and Executive Development Program certificate, Halifax, NS, Sept. 2007).

Teaching/Training Experience

- Developed and taught two postgraduate level (2 x 5 European Credit Transfer System credits) courses for international students (EMBC+: embcplus.org) in *Statistical Ecology* and *Harvesting*: Autumn terms 2013-2016.
- Tailored Introduction to R courses x 2 to EPA, Ireland, November 2016.
- Courses in reproducible analysis to Environ 2015, 2016.
- Two day *Introduction to R* course to GMIT, September 2013.
- Tailored course in fisheries statistics to the Irish Marine Institute, June 2012.
- PhD supervisor: Paul Dolder 2015-present; Master's thesis supervisor: Timo Staeudle 2016. Honors thesis supervisor: Mark Whelan 2012-2013; Advisory Committees: Sarah Davie (Ph.D., GMIT 2013); Melanie Zölck (Ph.D. GMIT 2013).
- Teaching Assistant, Analysis of Biological Data, Dalhousie University, Winter 2006.
- Guest lecturer, Biological Modeling, Dalhousie University, Fall 2005.
- Teaching Assistant, Fish Ecology and Evolution, Dalhousie University, Fall 2005.

Peer Reviewing Experience

Reviewer on behalf of:
Animal Conservation; *Canadian Journal of Fisheries and Aquatic Sciences*; *Ecological Applications*; *Ecological Modelling*; *Fish and Fisheries*; *Global Ecology and Biogeography*; *ICES Journal of Marine Science*; *Journal of Fish Biology*; *Journal of the Marine Biological Association of the United Kingdom*; *Environmental Conservation*; *Marine Ecology Progress Series*; *Nature Climate Change*; *Nature*; *PLOS ONE*; *Proceedings of the Royal Society of London B*; *Proceedings of the National Academy of Sciences*; *Science*; *Vie et Milieu*.

Recent Presentations

- MyFish symposium, Athens, Greece, October (2015). Invited session keynote: *Challenges in tracking stock productivity and relaying to ground control*.
- National University of Ireland, Galway (NUIG), Ireland (2014). School of Mathematics, Statistics and Applied Mathematics statistics reading group seminar: *Exploration of statistical modelling of fishing fleet dynamics*.
- Johan Hjort Symposium, Bergen, Norway (2014). Invited session keynote: Can we and should we reunite stock assessment and recruitment science?
- World Conference on Stock Assessment Methods, Boston, USA (2013). *Exploring data-limited methods to assess global fisheries: conceptual framework, applications and limitations*. Presented by Kristin Kleisner.

- Joint Research Council of the European Union, Ispra, Italy (2013). *Time-varying parameters in fish stock-recruitment relationships.*
- National University of Ireland, Galway (NUIG), Ireland (2012). School of Mathematics, Statistics and Applied Mathematics statistics reading group seminar: *An EM algorithm for including immature individuals in sex-specific growth models.*
- International Biometric Society - British and Irish Region, NUIG, Galway, Ireland (2011). Invited seminar: *Time-varying parameters in the study of fish population dynamics.*
- American Fisheries Society Annual Meeting, Seattle, Washington, USA (2011). Oral presentation: *Multivariate autoregressive processes for estimating the covariance of time-varying pre-recruit productivity.*
- Centre for Environment, Fisheries & Aquaculture Science (CEFAS), Lowestoft, UK (2011). Invited seminar: *Insights into fish population dynamics and fisheries impacts from the Ransom Myers Legacy Database.*
- National University of Ireland, Galway (NUIG), Ireland (2011). School of Mathematics, Statistics and Applied Mathematics statistics reading group seminar: *State space estimation of fish stock abundance.*
- Galway-Mayo Institute of Technology (GMIT), Ireland (2010). Departmental seminar: *A random walk through the history of fisheries science.*
- Harvest Fisheries Seminar Series, Department of Fisheries and Oceans, Dartmouth, N.S. (2008). Oral presentation: *Survival variability and population density: a meta-analytical approach.*

Publications

<u>Primary literature</u>

Bell, R.J., Collie, J.S., Branch, T.A., Fogarty, M.J., **Minto, C.** and Ricard, D. (*in review*). Are fisheries resizing the food web? *ICES journal of Marine Science.*

Minto, C., Hinde, J. and Coelho, R. (*in press*). Including unsexed individuals in sex-specific growth models. *Canadian Journal of Fisheries and Aquatic Sciences.* DOI: 10.1139/cjfas-2016-0450.

Rosenberg, A.A, Kleisner, K.M, Afflerbach, J., Anderson, S.C., Dickey-Collas, M., Cooper, A.B., Fogarty, M.J., Fulton, E.A., Gutiérrez, N.L., Hyde, K.J.W., Jardim, E., Jensen, O.P., Kristiansen, T., Longo, C., Minte-Vera, C.V., **Minto, C.**, Mosqueira, I., Osio, G.O., Ovando, D., Selig, E.R., Thorson, J.T., Walsh, J.C. and Ye, Y. (*in press*). Applying a new ensemble approach to estimating stock status of marine fisheries around the world. *Conservation Letters.*

Anderson, S.C., Cooper, A.B., Jensen, O.P., **Minto, C.**, Thorson, J.T., Walsh, J.C., Afflerbach, J., Dickey-Collas, M.C., Kleisner, K.M., Longo, C., Osio, G.C., Ovando, D., Rosenberg, A.A., Selig, E.R. (*in press*). Improving estimates of population status and trajectory with superensemble models. *Fish and Fisheries.*

Browne, D., **Minto, C.**, Cosgrove, R., Burke, B., McDonald, D., Officer, R. and Keatinge, M. (*in press*). A general catch comparison method for multi-gear trials: application to a quad-rig trawling fishery for Nephrops. ICES Journal of Marine Science.

Rindorf, A., Dichmont, C.M., Thorson, J.T., Charles, A., Worsøe Clausen, L., Degnbol, P., Garcia, D., Hintzen, N.T., Kempf, A., Levin, P., Mace, P., Maravelias, C., **Minto, C.**, Mumford, Pascoe, S., Prellezo, R., Punt, A.E., Reid, D.G., Röckmann, C., Stephenson, R.L., Thebaud, O., Tserpes, G. and Voss, R. (*in press*). Including ecological, economic, social and institutional considerations when setting targets and limits for multispecies fisheries. *ICES Journal of Marine Science*.

Fogarty, M.J., Rosenberg, A.A., Cooper, A.B., Dickey-Collas, M., Fulton, E.A., Gutiérrez, N.L., Hyde, K.J.W, Kleisner, K.M., Kristiansen, T., Longo, C., Minte-Vera, C.V., **Minto, C.**, Mosqueira, I., Osio, G.C., Ovando, D., Selig, E.R., Thorson, J.T. and Ye, Y. (2016). Fishery production potential of large marine ecosystems: A prototype analysis. *Environmental Development*, 17(1), 211–219.

Zölck, M., Mohn, C., **Minto, C.**, McGrath, D., Brophy, D. (2015). Bio-physical model provides insight into dispersal of plaice (*Pleuronectes platessa* L.) from putative spawning grounds to nursery areas on the west coast of Ireland. *Journal of Sea Research*, 99, 61-73.

Thorson, J. T. and **Minto, C.** (2015). Mixed effects: a unifying framework for statistical modelling in fisheries biology. ICES Journal of Marine Science, 72 (5): h.

Davie, S., **Minto, C.**, Officer, R. and Lordan, C. (2015). Defining value per unit effort in mixed métier fisheries. Fisheries Research, 165, 1–10.

Davie, S., **Minto, C.**, Officer, R., Lordan, C., and Jackson, E. (2015). Modelling fuel consumption of fishing vessels for predictive use. *ICES Journal of Marine Science*, 72: 708-719.

Britten, G., Dowd, M., **Minto, C.** Ferretti, F., Boero, F. and Lotze, H. (2014). Predator decline leads to decreased stability in a coastal fish community. *Ecology Letters*, 17: 1518-1525.

Minto, C., Mills Flemming, J., Britten, G.L. and Worm, B. (2014). Productivity dynamics of Atlantic cod. *Canadian Journal of Fisheries and Aquatic Sciences*, 71: 203–216.

Cosgrove, R., Sheridan, M., **Minto, C.** and Officer, R. (2014). Application of finite mixture models to catch rate standardization better represents fleet behaviour and improves precision. *Fisheries Research*, 153: 83–88.

Rosenberg, A.A., Fogarty, M.J., Cooper, A.B., Dickey-Collas, M., Fulton, E.A., Gutiérrez, N.L., Hyde, K.J.W., Kleisner, K.M., Kristiansen, T., Longo, C., Minte-Vera, C., **Minto, C.**, Mosqueira, I., Osio, G.C., Ovando, D., Selig, E.R., Thorson, J.T. & Ye, Y. (2014). Developing new approaches to global stock status assessment and fishery production potential of the seas. *FAO Fisheries and Aquaculture Circular* No. 1086. Rome, FAO. 175 pp.

Thresher, R., Morrongiello, J., Sloyan, B.M. Golub, K.K., Shephard, S., **Minto, C.**, Nolan, C., Cerna, F., Cid, L. (2014). Parallel decadal variability of inferred water temperatures for Northern and Southern Hemisphere Intermediate Water Masses. *Geophysical Research Letters*, 41: 1232-1237.

Shephard, S., **Minto, C.**, Zölck, M., Jennings, S., Brophy, D., and Reid, D. (2014). Scavenging on trawled seabeds can modify trophic size structure of bottom-dwelling fish. *ICES Journal of Marine Science*, 71: 398-405.

Thorson, J.T., **Minto, C.**, Minte-Vera, C.V., Kleisner, K. and Longo, C. (2013). A new role for effort dynamics in the theory of harvested populations and data-poor stock assessment. *Canadian Journal of Fisheries and Aquatic Sciences*, 70: 1829-1844.

Ribeiro Santos, A., **Minto, C**., Connolly, P. and Rogan, E. (2013). Oocyte dynamics and reproductive strategy of *Aphanopus carbo* in the NE Atlantic - implications for fisheries management. *Fisheries Research*, 143: 161-173.

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Grants and Awards

Department of Agriculture, Food and and the Marine grant	
(2xWP lead, PI D. Reid, Marine Institute)	2016
Session keynote speaker Myfish Symposium, Athens, Greece	2015
EPA Strive: Ecosystem tipping points grant (WP lead, PI D. Brophy, GMIT)	
2015-2018	
Mares Joint Doctoral Programme on Marine Ecosystem Health and Conservation	2015-2018
Data-poor assessment LOT Tender MARE/2014/44	2015-2017
Conservation International contract	2015
BIM Implications of Alternative Technical Measures on the Economic Performance of the Irish Fishing Fleet	2014-2017
Session keynote speaker Hjort Symposium, Bergen, Norway	2014
National Parks & Wildlife Service Ireland contract	2014
FAO/Conservation International contract	2013
DAMARA LOT tender	2013-2015
Marine Institute GEPETO project tender	2013-2014
FAO/Conservation International contract	2012-2013

Ecological Society of America Sustainability Science Award (shared)	2011
Faculty of Graduate Studies Scholarship, Dalhousie University, Halifax, N.S.	2007-2009
Faculty of Graduate Studies Scholarship (honorary), Dalhousie University, Halifax, N.S.	2004
Supporting Measures for Sea Fisheries Development Programme Grant	2004
Gold Medal Award in Natural Science, Trinity College, Dublin.	2003
British Ecological Society Scholarship, Cambridge, UK.	2003
Maureen de Burgh Memorial Prize in Marine Biology, Trinity College, Dublin.	2002
J.B. Gatenby Prize in Zoology (shared), Trinity College, Dublin.	2002

References

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Resume

Laurence Kell has been involved in pioneering the MSE approach and was among the rst to use MSE to develop management advice in Europe under the Common Fisheries Policy. He also has extensive experience of large pelagic sheries management.

Education

PhD: *The impact of an alien piscivore the zander (Stizostedion lucioperca (L.)) on a freshwater sh community*.

BA Mathematics

BSC Biological Sciences

Experience

May 2009 – present	**Population Dynamics Expert** International Commission for the Conservation of Atlantic Tunas, C/Corazon de Maria, 8 Madrid, Spain Participates across a range of research areas, e.g. stock assessment, risk assessment, MSE and communication with stakeholders, ensuring that ICCAT is credible and internationally recognised, open to innovation, independent and adaptable.
December 1987-May 2009	Team Leader Cefas **Lowestoft** Pake eld Road Lowestoft, Su olk NR33 0HT, UK Lead an inter-disciplinary team of scientists that work on a range of national and European projects.

April 1999 - July 2000   International Research Fellow

Rosenstiel School of Marine and Atmospheric Science

University of Miami

Rickenbacker Causeway

Miami, Florida 22149, USA

Conducted MSE for tuna stocks

Involvement in Research Projects and Management

- Coordinator of MATACS, MATES, FEMS, COMMIT, and JAKFISH EU projects.
- Founder of the FLR Initiative
- Population Dynamics Expert at ICCAT (2009 to present)
- IWC Head of UK Scienti c Delegation and Alternate Commissioner (2000 to 2007).

Publications

Over 200 journal and RFMO papers

Polina Levontin, Paul Baranowski, Adrian W Leach, Alexandria Bailey, John D Mumford, Antoni Quetglas, Laurence T Kell: *On the role of visualisation in sheries management*. Marine Policy 01/2017; 78., DOI:10.1016/j.marpol.2017.01.018

Laurence T. Kell, Ai Kimoto, Toshihide Kitakado: *Evaluation of the prediction skill of stock assessment using hindcasting*. Fisheries Research 11/2016; 183:119-127., DOI:10.1016/j. shres.2016.05.017

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L T Kell, H Arrizabalaga, P De Bruyn, G Merino, I Mosqueira, R Sharma, J-M Ortiz de Urbina: *The Implicit North Atlantic Albacore Management Procedure.*.

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L T Kell, J-M Fromentin, R Hillary: *A Comparison of Model Based and Model Free Harvest Control Rules Using Management Strategy Evalution For North Atlantic Blue n Tuna*.

H Arrizabalaga, J_M Fromentin, L T Kell, L A Kerr, Secor D.H.: *Population and Stock Hypotheses for North Atlantic Blue n Tuna*.

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L Kell, Gorka Merino, Paul De Bruyn, JM Ortiz Urbina, Haritz Arrizabalaga, H Murua, J Santiago: *An example of a management procedure based on a biomass dynamic stock assessment model*.

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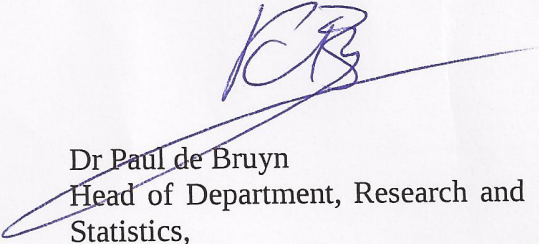28002 Madrid,
SPAIN
17 April 2017

To whom it may concern

Dr Kell has worked as the Population Dynamics Expert (PDE) at the International Commission for the Conservation of Atlantic Tunas, an inter-governmental fishery organization responsible for the conservation of tunas and tuna-like species in the Atlantic Ocean, since 2009. Science underpins the management decisions made by ICCAT and the PDE plays an important role in ensuring the quality of the advice provided by the scientific working groups of ICCAT. Dr Kell's duties include the establishment of review mechanisms, the provision of guidance to Working Groups on assessment models, including the establishment of rules and guidelines on their appropriate use, and the fostering of consistency in the approaches and assumptions underpinning the scientific advice provided to the Commission.

Dr Kell participates actively in the scientific work of ICCAT across a wide range of areas including the maintenance and dissemination of appropriate and approved software, participating in multi-disciplinary teams and committees to develop quality control procedures, reviewing fishery data collection proposals, working on improvement of the data management systems and the limitation of the quality of data and their variability. He also has been been responsible for the selection of consultants as part of ICCAT special programmes, drafting terms of reference, participating in the supervision of their work, and reviewing deliverables.

 As part of his duties Dr Kell works across a diverse range of research areas, including stock assessment, ecological risk assessment, management strategy evaluation and communication with stakeholders. He has been a leader of the work on the North Atlantic albacore MSE. Importantly he has also maintained a strong peer review record, actively working with ICCAT scientists and others, (e.g. from the other tuna Regional Fisheries Management Organisation and ICES). This has ensured that the work of ICCAT is credible and internationally recognised, open to innovation, independent and adaptable

Dr Kell is a highly experienced member of the secretariat, his support provided to the scientific work of the SCRS is invaluable. Particularly to junior scientists and those from developing countries. He regularly conducts training course in modeling and R. In particular Dr Kell continues to provide useful tools to the SCRS to improve their scientific evaluations and facilitate the provision of management advice. He has a willingness and openness to collaborate to achieve multiple objectives while also conducting a wide range of scientific work. Dr Kell also has an extremely pleasant disposition and is easy to work with.

Dr Paul de Bruyn
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Professor J D Mumford
Professor of Natural Resource Management

20 April 2017

Dr Laurie Kell

I am very pleased to write in support of the application by Laurie Kell. I have worked with Dr Kell for more than ten years in a series of projects with funding from the European Commission and from the International Commission for the Conservation of Atlantic Tunas (ICCAT), dealing with issues of uncertainty and modelling in stock assessment for a range of fish stocks. We continue to work together to develop novel methods for identifying and incorporating uncertainty in practical fisheries management.

Laurie Kell has been an international leader in the development and implementation of the Management Strategy Evaluation approach in fisheries. He has published extensively on quantification methods applicable to fisheries management and has maintained a continuous stream of funded research grants at national, European and international levels. He has demonstrated skills in project management, research team leadership and, most importantly, in research output delivery in published papers, technical reports and presentations in both scientific meetings and to Commission delegates. He has been highly effective in delivering technically complex and scientifically rigorous quantitative approaches to uncertainty in fisheries management that have been practical enough to be put into practice, particularly in the successful management of tunas. These methods are particularly applicable to fish stocks in which data is sparse. They are also very relevant to decisions on prioritisation for the collection of additional data.

Laurie Kell has worked in national and international research institutions. He has developed close relationships with universities and has provided valuable external supervision to PhD students, particularly in my own Faculty at Imperial College London.

Laurie Kell is well known for his exceptionally quick and directed thinking in technical meetings. He is highly respected as a leader in such discussions, with a very clear and forthright focus on achieving practical results, while sticking firmly to a robust quantitative presentation and interpretation of relevant evidence. He is always a convincing and energetic presence.

Yours sincerely,

Prof John Mumford

Dr Alex Tidd has an established and burgeoning track record in the field of fisheries science. His research experience includes stock assessment as well as development of original interdisciplinary methods that draw on a combination of economics, ecology and systems modeling.

He is very experienced in working in large interdisciplinary European Commission projects. He has experience in using a wide range of quantitative modeling tools including tools in R to carry our management strategy evaluation, bioeconomic models and analyses, population dynamics and the analysis individual fishing vessel data. This work includes sensitivity anlayse and testing of assumptions.

Alex's current work with global fisheries databases requires modeling fisheries for data-poor situations. This work also involves combing large and disparate datasets demonstrating his ability to synthesis data and then use these data to develop quantitative models. I have absolute confidence in his capabilities to carry out the work describe in this tender as well as producing high quality research outputs.

Sincerely,

Julia Blanchard,

Associate Professor in Ecology & Fisheries
Institute for Marine and Antarctic Studies
University of Tasmania
Hobart, Australia