

CURRICULUM VITAE

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Summary

Employment

2006– Independent statistical consultant, trading as *J. Heffernan Consulting*.
2000–2006 Lecturer in Environmental Statistics, Dept of Mathematics & Statistics, Lancaster University.
1998–2000 Research Associate, Dept of Mathematics & Statistics, Lancaster University.

Post School Education

1995–1998 Ph.D. Statistics (Lancaster University).
1992–1995 B.Sc. (Hons) Mathematics & Statistics, with French minor (Lancaster University) First Class.
Awarded prize for best Mathematics and Statistics degree.

Professional Experience

Statistical consulting

Course on Applied Bayesian Statistics for Environmental Modelling, Centre for Ecology and Hydrology (2015) This built on the Introductory course of the same name (below). The material in this more advanced course was based on a set of completed CEH research projects; participants worked through the full detail of each applied problem using R and BUGS software, with demonstration of troubleshooting and convergence diagnosis in these environments. The course also emphasised prior elicitation and consequences of prior assumptions, visualising model structure by using Graphical Models, and techniques for combining data from different sources, which are of particular relevance in the ecological setting.

Course on Introductory Bayesian Statistics for Environmental Modelling, Centre for Ecology and Hydrology (2014). This course covers the philosophy underpinning Bayes' approach, and the probability theory behind Bayes' Theorem as well as describing the practical expertise required to estimate highly structured stochastic models by using Markov chain Monte Carlo methods. Material was presented as mixture of lectures and supporting hands-on workshops so that participants were able to implement for themselves all of the concepts introduced in the lectures.

Course on Extreme Value Modelling for Offshore Sea States (2014)

This training course was written for a consortium of met-ocean analysts and offshore wind engineers, using their own data examples. The course gave an introduction to Statistical Extreme Value Theory and associated methods, together with computer tutorials in the use of the software to provide hands-on experience of extreme values analysis. Discussion focussed on specific applications in the offshore setting and the statistical challenges that arise in this area, in particular how to respond to the practical limitations met when dealing with very small data sets.

Course on Introductory Statistics for Oceanographers, National Oceanographic Centre, (2014)

This bespoke statistics course targeted at NOC staff and students had a set of active NOC research projects at its core. The material introduced the language of hypothesis testing and Analysis of Variance as a route into linear modelling and model selection. Emphasis was on understanding – and checking – the assumptions underpinning each analysis and the resulting conclusions. Each statistical methods lecture had a twin computer lab, where the R computing package was used to put the ideas into practice. The course emphasised the choice of statistical methods for given research problems, the use of R for analysis and the understanding and interpretation of results.

Statistical modelling for the prediction of occurrence of lead pipes, Welsh Water (2013)

This work required the prediction of incidence of lead pipes at Welsh Water domestic customer properties. Logistic regression models were successful at predicting the rate of lead pipe incidence, using routinely collected service data integrated with Postcode data. We relied on validation datasets to assess the predictive ability of our models, since goodness-of-fit diagnostics for such regression models are notoriously poor. The final models were used to link to GIS to target properties with characteristics indicating higher risk of lead pipe incidence.

Statistical support and advice, JBA Risk Management (2012 – 2015)

JBA Risk Management is a supplier of natural hazard modelling to the insurance and re-insurance industries. I have provided statistical input to their modelling of multivariate extremes within the process of spatial risk mapping. This has included the delivery of custom written in-house training in extreme value methods applied to their environmental hazard datasets.

Multivariate Extremes R package development, AstraZeneca (2010–2012)

This work builds on the joint publications Southworth & Heffernan (2012) which offer the novel application of statistical extreme value methods to clinical safety data. I have collaborated with statisticians at AstraZeneca to develop an R package `texmex`, implementing threshold based univariate extreme value methods, and the conditional multivariate extreme value method of Heffernan and Tawn (2004). My contribution has included the development of a suite of unit tests for the package, reproducing previously published results.

Multivariate Extreme Value Analyses for Offshore Sea States, Fugro Geos (2009–2014)

These projects involved the updating of off-shore sea state criteria. The aim was to describe the conditional distributions of one or more variables given values of a further variable which were higher than levels seen in available data records. Making proper allowance for the dependence that arises between variables at high levels is important for making informed decisions about realistic loadings on structures.

Course on Extreme Value Modelling for Clinical Safety Data, AstraZeneca (2011)

This training course provides support for the Extreme Values R package `texmex` developed for AstraZeneca (above). The course gives an introduction to the theory and methods underpinning this R package, together with computer tutorials in the use of the software to provide hands-on experience of safety data analysis using the package. The audience for the course has been statisticians within AstraZeneca, with core application examples taken from AstraZeneca's own data library.

Course on Mixed Models for Analysing Experimental Data, Centre for Ecology and Hydrology (2011–2014) Following the success of the 2010 Introduction to Statistics course developed for CEH (below), this course has been developed using current CEH research to illustrate in much greater depth the use of statistical Mixed Models for analysing the type of data frequently arising in CEH projects. Like the Introductory course, all of the methods introduced in this course were fully illustrated in R workshops so that participants gain a working knowledge of the statistical practices described.

Course on Introductory Statistics for Ecologists, Centre for Ecology and Hydrology, (2010–2013)

I wrote this introductory statistics course for CEH staff and students. The course material was closely woven round a set of example research questions, with associated data sets, chosen from active CEH projects. Each lecture on statistical methods was accompanied by a workshop in which the participants used the R computing package to try the methods for themselves. To date, the course has been given a total of six times.

Statistical support, Department of Medicine, Lancaster University (2009)

Providing statistical support within the CHICAS (Combining Health Information, Computation and Statistics) group of the Department of Medicine, I was involved in a number of medical statistics projects. These were mostly exploratory projects which would go on to form the basis of larger studies. This work required the quick assimilation of project aims and data structures, data analysis and finally the reporting of results to the medics running the projects.

Exploratory work developing bat and bird classifier for radar data, Central Science Laboratory (2009)

This work involved the novel application of marine radar used to detect flying animals, specifically bats and birds. Little is known about the flight and foraging behaviour of bats, and the goal of the project was to develop an automatic classifier of the flying objects as bats or birds. The main challenge of the project was the validation of the classification tool since no training/test data were available. Close collaboration with ecologists and ornithologists as well as technical radar personnel was critical to the success of the work.

Statistical Analysis of Selenium content of Scottish soil and food products, Central Science Laboratory (2009)

This work involved a number of statistical analyses of data describing levels of Selenium in soil and food samples taken from farms around Scotland. The goal was to establish whether there was evidence of farms with nominally high and low Selenium levels (predicted from their underlying geology) having commensurately high and low levels in soil and food samples recovered from the sites. The resulting study report is to be used by the Food Standards Authority to make recommendations regarding the production of high Selenium products in Scotland.

Extreme Values Statistics for Met-ocean Applications, OceanMetriX (2008)

I have been involved in a number of projects concerning novel application of Extreme Value Statistics to a variety of met-ocean problems. The problems have presented challenges such as accommodating process non-stationarity, or temporal clustering of extreme events, in the estimation of long-run probabilities of rare events. In all projects, deadlines were short (typically days rather than weeks) and the emphasis was on providing practical working solutions within the available time.

Statistics for Defra Scientists, Central Science Laboratory (CSL) (2008)

I collaborated with statisticians from CSL and CEFAS to develop a course on Statistical Literacy for DEFRA scientists responsible for commissioning scientific research. This intensive course gives an overview of what statistics has to offer scientific research. It offers a description of the breadth and depth of the subject of statistics, rather than how to do it. I was responsible for collation and writing of course material.

Extreme Values Statistics for offshore dynamics, Orcina Ltd (2008)

Orcina is a software house serving the offshore engineering industry. Orcina's main product is a software package for the design and analysis of marine systems. I have contributed to a project to extend the software's functionality to offer Extreme Value analysis of the dynamic model data which is output by the software.

Extreme Values Statistics for Flood Investigation, Freehills (2008)

I have been involved in the investigation of a major flood by the legal representatives of an Australian mining company whose property was severely affected by the flood. I have contributed as part of an interdisciplinary team offering technical expertise to assess the extreme nature of the flood. An important part of this work has been the communication of technical ideas, and their impact, to non-mathematicians.

Advice on nutrient surveys for UK coastal waters, Centre for Environment, Fisheries & Aquaculture Science (CEFAS) (2006)

I developed a data simulation tool to emulate the behaviour of nutrients at monitoring locations, for the purpose of advising survey design for subsequent sampling of the nutrients. The tool combined ideas from different areas of statistics, including nonparametric smoothing, time series, geostatistics and extreme value modelling. Initial work carried out in one week required the design and implementation of the tool, and submission of a detailed report. Follow-up work has involved running the simulation tool in a variety of scenarios, and coordinating the multi-disciplinary team to write up the findings in a paper which subsequently appeared in *Environmetrics*, 2009.

Modelling trophic relationships, CEFAS (2006)

This project, collaborating with marine biologists, examined a novel approach to assessing evidence for over-fishing which aggregated fish by *trophic level*, an objective measure broadly representing location on the food chain. My role as statistician was to summarise populations by trophic level, and to look for temporal instabilities in relationships between this and other measures of fish activity. Since this was a new way of investigating fish populations, much of the challenge lay in establishing the problem itself, before a solution was proposed. Initial work carried out in one week resulted in implementation and documentation of new methodologies for describing trophic relationships, the report running to some 82 pages. Follow-up work pursued some of the initial findings in more detail.

Expert witness, High-Court Investigation into sinking of bulk carrier MV Derbyshire (2000)

I became involved in the Re-opened Formal Investigation with Prof Jonathan Tawn mid-way through the hearing, when concern was raised about results of previous Extreme Values statistical analyses. We were asked to repeat the statistical analysis, explain the anomalous results and analyse the problem using best statistical practice. We had to provide a detailed report, to be broadly accessible by a non-statistical readership. The initial time-scale for completion of the analysis and report, and Court appearance, was two weeks.

I was responsible for the data handling, R code development, statistical analysis and report writing part of the work. Working to such a tight deadline and in such a high-profile setting meant that automated code testing and data validating routines were imperative as we could not afford to make mistakes.

Bulk carrier safety, Dept of the Environment, Transport and the Regions (DETR) (2000–2001)

Following the High-Court investigation, Prof Tawn and I were invited to form the statistical arm of a team carrying out a large designed experiment using wave tank data to make recommendations about bulk carrier safety.

Two key aspects of our Court work which had enabled such a rapid response were the use of the highly flexible Generalised Pareto tail model, (rather than the less flexible models often favoured in engineering settings) and the choice of the likelihood inferential framework (allowing straightforward error estimation and covariate

modelling). These features continued to prove invaluable, the same single flexible approach accommodating investigation of a huge range of scenarios involving different ships and their operating and weather conditions. My role was similar to that which I had assumed for the Court work. The volume of work was much greater here and the time-scale less pressured, so I developed an automatic report writing tool, eliminating any risk of transcription errors. This automation was vital, as our submitted reports ultimately ran to 624 pages.

Environmental Statistics Lecturer

Research

As a member of the top 5* research rated Lancaster University Department of Mathematics and Statistics, my principal activity was research. The pinnacle of my achievement to date is the collaboration with Jonathan Tawn on multivariate extreme value statistics. This work was recognised as being truly ground breaking by its publication as a discussion paper in JRSS Series B (Heffernan and Tawn, 2004). The paper attracted much attention and led, among other things, to my sabbatical trip to Cornell University in 2004 to work with Applied Probabilist Sidney Resnick, a leading figure in the field of Extreme Value Theory.

My list of publications, all but two of which have joint authorship, shows my enjoyment of working as part of a team of researchers. My versatility led to my being involved in a broad spectrum of Extreme Values research from the heavily theoretical (*e.g.* Heffernan & Resnick 2005 and 2007, Heffernan, *et al.*, 2007) to the very applied (*e.g.* Butler *et al.* 2007, Heffernan & Tawn 2001).

Teaching

Although this represented a smaller part of my obligations, I enjoyed lecturing and took teaching very seriously. I liked the challenges of developing new courses and of lecturing to a range of audiences with different backgrounds.

I was responsible for the complete re-writing and delivering of the Department's first-year undergraduate Statistics course, attended by over 100 students. This was a task of considerable importance, since the course was often the students' first contact with Statistics and its success would be critical to their decision whether to carry on with the subject.

I was a member of the Lancaster Environment Centre, a cross-faculty group of departments with environmental teaching and research interests. During my involvement in this group, I helped to set up a multi-disciplinary course in Environmental Risk Assessment, with contributions from nine different subject areas from Law to Environmental Toxicology to Statistics.

Skills and Achievements

Internationally recognised expertise in Extreme Value Statistics

My theoretical expertise is best reflected by my publications in top flight statistics journals, most notably the 2004 Royal Statistical Society discussion paper (Heffernan and Tawn), and by my extended collaboration with Sidney Resnick, one of the field's founding figures (Heffernan and Resnick 2005 and 2007). This work in the area of Multivariate Extreme Value Theory proposed and then built on a paradigm shift in the approach to the statistical modelling of rare events in high dimensions. My experience in the application of Extreme Value Methods led to my being appointed to the team of expert witnesses aiding the High-Court Investigation in 2000, into the loss of the MV Derbyshire, detailed above.

An indication of my international reputation is given by my appearance as invited speaker at numerous prestigious conferences, including the meeting on Extreme Value Theory and Risk Assessment in Climate Sciences, Laboratoire des Sciences du Climat et de l'Environnement (Aussios, France 2013), Extremes: Statistical Modelling and Applications, Workshop in honour of Prof. Sidney Resnick (Technische Universitat Munchen, 2012) Interface Conference, jointly organized by NISS and SAMSI (Durham, North Carolina 2008), the Environmetrics Conference (Chicago 2006), the European Meeting of Statisticians (Prague 2002) and Extremes in Theory and Practice (Leuven, Belgium 2001). I have also used my fluency in the French language to give statistics seminars in French, as an invited seminar speaker at the Institut National des Sciences Appliquées, Toulouse and the Annual Meeting of the French Statistical Association, Nantes both in 2001, and the University Joseph Fourier, Grenoble I, in 2002.

Extensive experience in Applied Statistics

My Ph.D specialised in Spatial Statistics, especially point processes and geostatistics. As postdoctoral Research Associate, I changed area to focus on statistical Extreme Value Theory and its applications. I also have specialist knowledge of many and various other areas of the subject through my lecturing at all levels and from supervision of Ph.D and student projects.

Close involvement in broad range of applications

I feel strongly that it is of paramount importance for the statistician to have detailed understanding of all aspects of the applied problem before any serious application of statistics can be attempted; it is therefore essential to invest time in getting to know the science behind the numbers. My commitment to contributing to the science can be seen (below) from the broad range of applied journals in which I have published articles. Applied areas include epidemiology, oceanography, atmospheric science, naval architecture, microbiology and environmental monitoring.

Excellent communicator and team player

My collaboration with specialists from applied subject areas has been characterised by the strong belief that a principal duty of the statistician is to communicate effectively, both verbally and on the page. This is a vital prerequisite for the statistician fully to understand the problem, and the non-statistician the solution.

In the Derbyshire Investigation and follow-up work commissioned by the then DETR, I was part of a large multi-disciplinary and multi-national team. In this as in subsequent consulting work, I took on the role of arbiter and interpreter, enabling joint understanding by all the disciplines.

Ability to work effectively to tight deadlines

All consulting work has reflected the need of the customer to achieve results in a short space of time. The Derbyshire expert witness work was carried out in its entirety while the case was before the court, and therefore under extreme time pressure. More recent independent contracts have often been achieved in a single week's work from project start to submission of final report.

A key skill that underpins this ability is my high level of fluency in the R statistical computing language. In addition to the large range of off-the-shelf statistical packages offered by this language, R facilitates the rapid development of bespoke computing routines for tailor-made statistical analysis.

Professional Activities

1995– Fellow of Royal Statistical Society (RSS)

I am an active Fellow of this, the UK's only professional and learned society devoted to the interests of statisticians. My involvement includes participation at Society conferences (both as invited and contributed speaker), contributions to Society newsletters and magazines, and active membership of Society committees (see below).

2004–2006 Member of RSS Research Section Committee

This committee is responsible for overseeing the selection of discussion papers for the Society's flagship Series B journal. Responsibilities include the screening of potential papers at the forefront of advances in statistical methodology. My membership is indicative of my status as a respected statistical researcher with a thorough familiarity of current statistical methodological research.

2000–2005 Member of the RSS Environmental Statistics Section Committee

The Committee's objectives include acting as a national focus for statisticians involved in environmental work. It organises regular meetings and courses on a wide variety of topics of interest to statisticians and other environmental scientists. It also provides a cadre of experts on whom the Society can call for professional advice.

Publications

Theses:

Ph.D. thesis (Lancaster University, 1998). "Joint modelling of Point Process and Geostatistical measurement data", supervised by Prof. Peter Diggle, examined by Prof. Sylvia Richardson.

Papers/Articles:

1. Eastoe, E.F., Heffernan, J.E. and Tawn, J.A. (2014) Nonparametric estimation of the spectral measure, and associated dependence measures, for multivariate extreme values using a limiting conditional representation. *Extremes*, Volume 17, Issue 1, pp 25–43.
2. Harry Southworth and Janet E. Heffernan (2013). `texmex`: Statistical modelling of extreme values. R package version 2.1.

3. Southworth, H. and Heffernan, J.E. (2012) Multivariate extreme value modelling of laboratory safety data from clinical studies. *Pharmaceut. Statist.*, doi: 10.1002/pst.1531.
4. Southworth, H. and Heffernan, J.E. (2012) Extreme value modelling of laboratory safety data from clinical studies. *Pharmaceut. Statist.*, doi: 10.1002/pst.1510.
5. Heffernan, J.E., Barry, J., Devlin, M. and Fryer, R. (2009) A simulation tool for designing nutrient monitoring programmes for eutrophication assessments. *Environmetrics*, **21** (1), 3–20. Published Online: 3 Apr 2009
6. Heffernan, J.E. and Resnick, S.I. (2007) Limit laws for random vectors with an extreme component *Ann. Appl. Probab.*, **17**, No. 2, 537–571.
7. Butler, A., Heffernan, J.E., Tawn, J.A., Flather, R.A., Horsburgh, K.J., (2007) Extreme value analysis of decadal variations in storm surge elevations. *Journ. Marine Systems* **67**, 189–200.
8. Butler, A., Heffernan, J.E., Tawn, J.A. and Flather, R.A. (2007) Trend estimation in extremes of North Sea surges. *J. Roy. Statist. Soc. C (Applied Statistics)* **56**, Part 4, 395–414.
9. Heffernan, J.E., Tawn, J.A. and Zhang, Z. (2007) Asymptotically (In)dependent Multivariate Maxima of Moving Maxima Processes. *Extremes* **10**, 1-2, 57–82.
10. Eastoe, E.F., Halsall, C.J., Heffernan, J.E. and Hung, H. (2006). A statistical comparison of survival and replacement analyses for the use of censored data in a contaminant air database: A case study from the Canadian Arctic. *Atm. Env.* **40**, 6528 – 6540.
11. Heffernan, J.E. and Resnick, S.I. (2005). Hidden Regular Variation and the Rank Transform. *Adv. Appl. Probab.* **37** (2), 393–414.
12. Butler, A., Heffernan, J.E., Flather, R.A. and Tawn, J.A. (2004). Spatial estimation of extremal trends in North Sea surge elevations. In *Flood Risk Assessment: the Proceedings of the IMA Conference on Flood Risk Assessment*, 117–126, IMA, Southend.
13. Heffernan, J.E. and Tawn, J.A., (2004). A conditional approach for Multivariate Extreme Values (with discussion), *J. Roy. Statist. Soc. B* **66**, Part 3, 497–546.
14. Heffernan, J.E. and Tawn, J.A., (2004). Extreme values in the dock. *Significance* **1** Issue 1, 13–17.
15. Heffernan, J.E. and Tawn, J.A., (2003). An extreme value analysis for the Investigation into the sinking of the M.V. Derbyshire. *Appl. Stats.* **52**, Part 3, 337–354.
16. Heffernan, J.E. and Tawn, J.A., (2001). Extreme value analysis of a large designed experiment: a case study in bulk carrier safety. *Extremes* **4**, 359-378.
17. Tawn, J.A. and Heffernan, J.E. (2001). Summary of statistical analysis of the seakeeping model tests, 41–54, of Proceedings of the Royal Institution of Naval Architects conference *Design & Operation of Bulk Carriers – Post M.V. Derbyshire*. London.
18. Heffernan, J.E. (2000) A directory of coefficients of tail dependence, *Extremes* **3**, 279-290.
19. Coles, S.G., Heffernan, J.E. and Tawn, J.A. (1999) Dependence measures for extreme value analyses, *Extremes* **2**, 339-365.
20. Currie, J.E. (1999). On the analysis of spatial point process data with inaccurately observed covariate information. *Statistics for the environment 4: Pollution assessment and Control* Eds. V. Barnett, A. Stein and K. Feridun Turkman. John Wiley & Sons Ltd.
21. Stanley, K.N., Wallace, J.S., Currie, J.E., Diggle, P.J. and Jones, K. (1998). The seasonal variation of thermophilic *Campylobacters* in beef cattle, dairy cattle and calves. *Journ. Appl. Microbiol.* **85**, 472-80.
22. Stanley, K.N., Wallace, J.S., Currie, J.E., Diggle, P.J., Jones, K. (1998). Seasonal variation of thermophilic *Campylobacters* in lambs at slaughter. *Journ. Appl. Microbiol.* **84**, 1111-1116.
23. Wallace, J.S., Stanley, K.N., Currie, J.E., Diggle, P.J. and Jones, K. (1997). Seasonality of Thermophilic *Campylobacter* populations in chickens. *Journ. Appl. Bacteriol.* **82**, 219-224.
24. Hurley, M.A., Currie, J.E., Gough, J. and Butterwick, C. (1996). A Framework for the Analysis of Harmonised Monitoring Scheme Data for England and Wales. *Environmetrics*, **7**, 379-390.

Invited Courses

Session on *Extreme Value Theory* contributing to NERC/EPSRC Environmental Maths and Statistics Programme training course on Statistical Methods for Environmental Evaluation for UK postgraduate and post-doctoral Environmental Scientists (March 2004).

One week course on *Extreme Value Theory*, Lancaster University with Prof. Jonathan Tawn. Part of Royal Statistical Society/EPSRC Graduate Training Programme for UK postgraduate Probability and Statistics students (July 2003).

Session on *Modelling Extremes* contributing to series of Royal Statistical Society Environmental Statistics Study Group meetings on Environmental Impact Assessment (November 2001).