

# KEYNES FUND END OF AWARD REPORT

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**Project title and Round: Lighthouses in Economics Redivivus.**

**Report Due Date: 31<sup>st</sup> May 2021 Report received: 29<sup>th</sup> March 2021 Report approved:**

**Part 1: Summary of work and results for the Fund's webpage**

**Images are attached at the end.**

The objective of this project was to produce the empirical foundations for a new analysis of the debates around the public vs. private provision of coastal lighting. All previous studies relied on only a handful of case studies to reach very general conclusions on the role of government in the provision of public goods, but new historical data on English and Welsh lighthouses has recently been created by Dunn, Alvarez and Shaw-Taylor (2020 and 2021) and now on French lighthouses by Litvine, Dunn and Shaw-Taylor (2021) both with the support of the Keynes Fund. It is frequently assumed that nationalisation in 1836 led to a better service and lower taxes paid by ship owners (in light dues) but no one has been able to test the hypothesis. In order to offer a more rigorous and empirical conclusion to this debate it was necessary to create comparable geo-historical datasets that will make the analysis of network efficiency and the comparison of public vs. private provision possible. This what this project did.

Coastal lighting has become a test case in the public goods literature. Using historical examples, Coase (1974) famously challenged the popular idea that lighthouses were non-excludable and non-rivalrous goods that only the state could provide. For J.S. Mill (1848), Sidgwick (1883), Pigou (1920) and Samuelson (1964), sea lighting could never be left to the market due to a peculiar free-rider problem: passing ships could not be forced to pay for the service when sailing miles out at sea. Government intervention was required to enforce user fees. Coase, however, claimed that *all* lighthouses in England were private and profit-making before their partial nationalisation in 1836 and operated without major government interventions, which we now know to be mistaken.

Following Coase (1974) much of the focus has been on the performance of private lighthouse providers and comparisons with what became the largest provider, Trinity House (e.g., Taylor 2001, Bertrand 2006). Van Zandt (1993) argued that private actors could provide public goods but only because the state ensured tolls were paid in port, making light provision a public-private system. Bertrand (2006) showed that all early systems in Europe combined private and public provision, and that Coase's argument relied on an oversimplification of historical reality. Candela and Geloso (2017, 2018) added that including lightships into the broader lighthouse market implies not market failure, but government failure to allow private lighting services to flourish.

Coase's arguments have generated a wide-ranging debate, extending to many countries, including the US (Mixon and Shaw Bridges 2018), Hong Kong (Lai 2008), Sweden (Lindberg 2013). Callais and Geloso (2020) recently added to the debate, with the finding that political considerations played a strong role in selecting where lighthouses would be built in the USA. Saito's (2019) study of Japanese sea lighting shows private individuals in local harbours provided lights before nationalization in the 19<sup>th</sup> century. The consensus is that before the mid-19<sup>th</sup> century, private provision was normal (with state support).

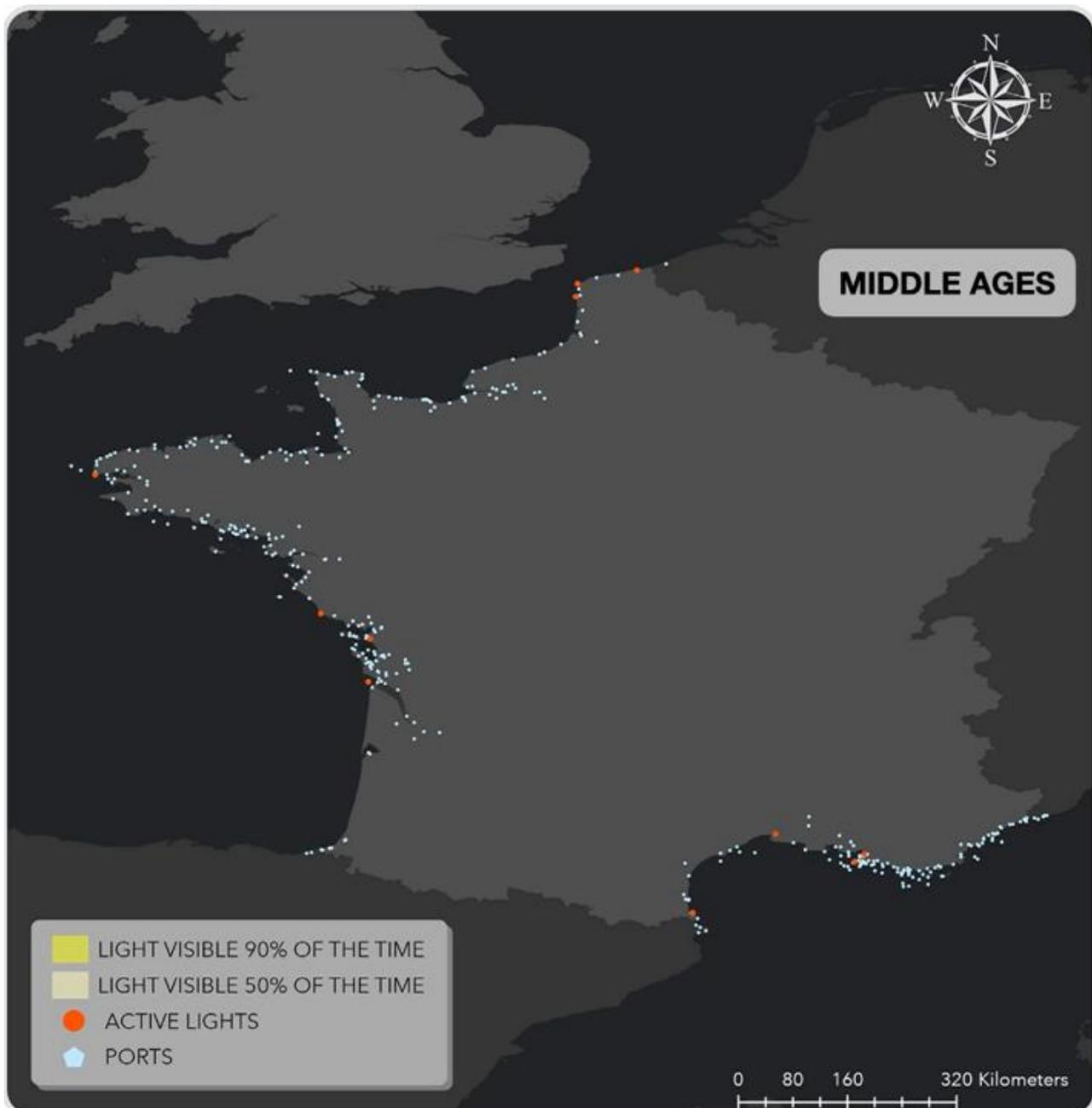
Yet, despite this extensive literature on the efficiency of lighthouse provision, no one has yet has not done any rigorous cost-benefit analysis of the different models of provision looking at the entire networks (pre- vs. post-nationalisation, England and Wales' very early development vs. Scotland's and Ireland's later lighthouse building, and Britain's largely free-market driven model vs. France's publicly funded model). In order to offer a more exhaustive and conclusive assessment of market failure in the provision of coastal lighting provision we created a series of new data:

- i. to provide a cost-benefit analysis of the efficiency of the lighting network in England and Wales [datasets 1 to 4 below]
- ii. to compare the efficiency of the spatial distribution of lights in the French (centralised and planned) vs. the British (market-driven) systems by measuring them against an optimal extension/location model. [datasets 2 to 4 below]
- iii. to estimate the induced productivity gains for the shipping industry based on extended dark-hour navigation, reduced frequency of wrecks/accidents along the coast [datasets 6 to 8 below]
- iv. to measure the comparative benefits to society of state vs. private provision of lighting by comparing the cost borne by shippers vs. the cost borne by the taxpayer and the resulting effects on safety at sea. [datasets 1 and 6 below]

*For this project we created:*

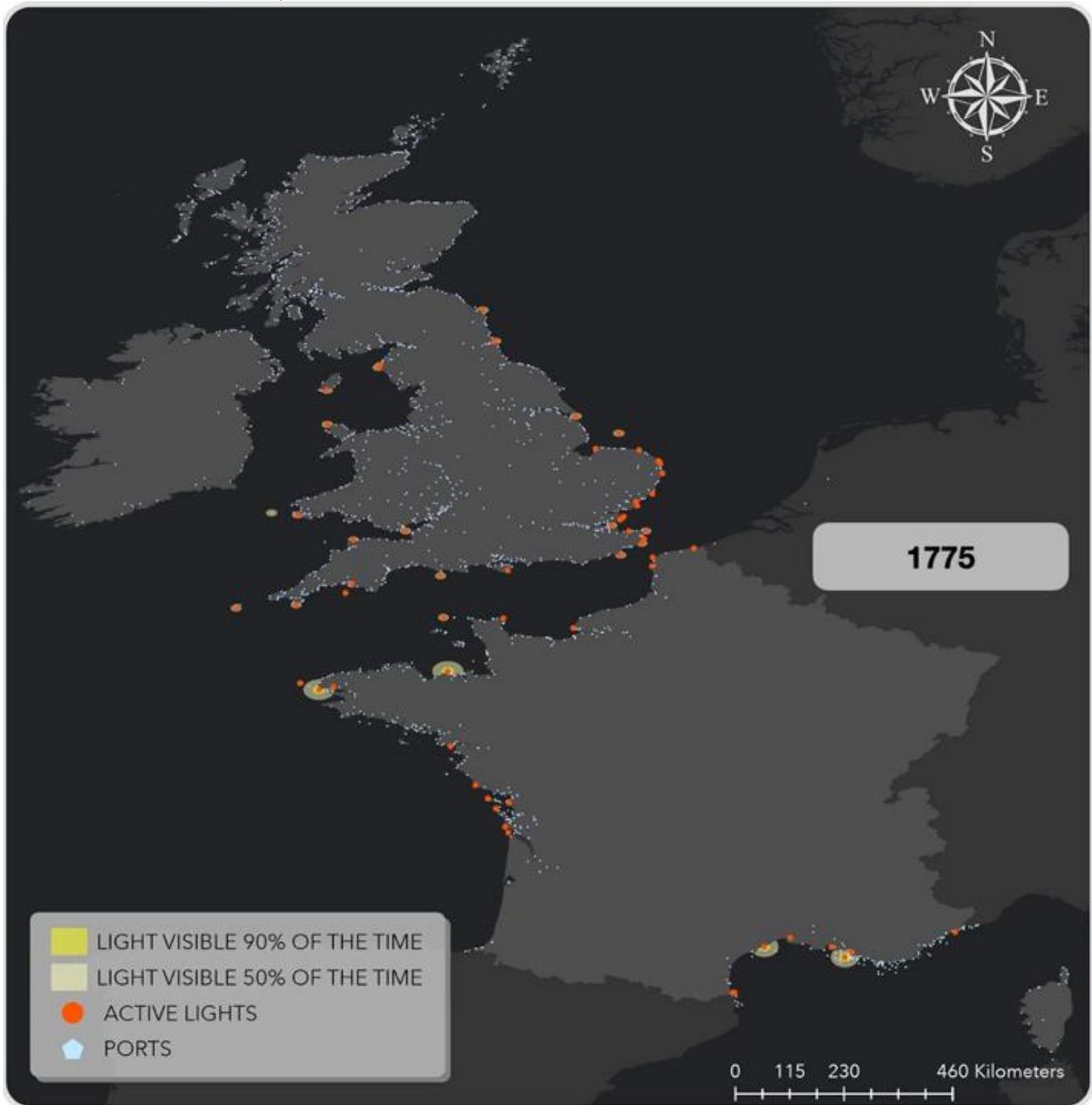
1. New data on gross light dues revenues by owner in England and Wales for 1680-1911
2. A new geospatial dataset for all French lights (1775-1929) containing over 800 lighthouse observations covering the full French coastline, containing georeferencing points and visibility range.

**ANIMATION 1 [French coastal lighting](#) (click on link to see the animations)**



3. A new geospatial dataset for all Scottish lights (1911) containing 436 lighthouse observations covering the full Scottish coastline, containing georeferencing points and visibility range.

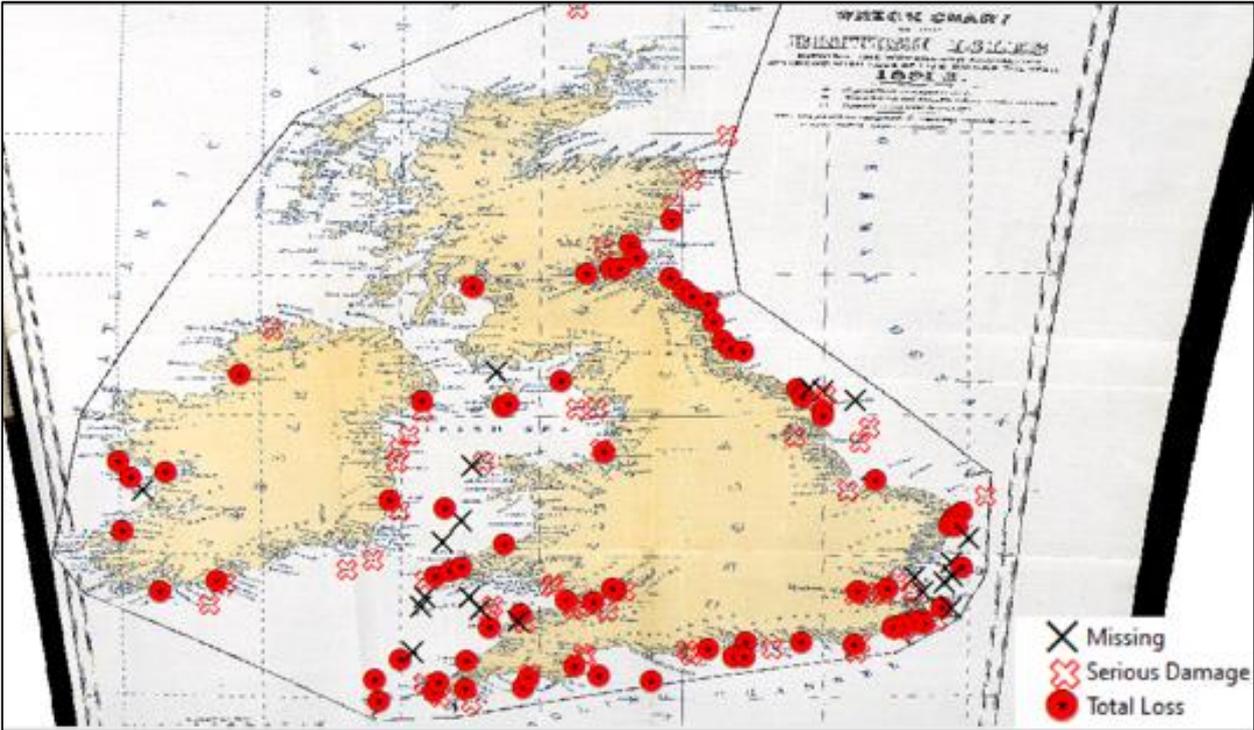
**ANIMATION 2: [combined networks for England and Wales, Scotland and France](#) (click on link to see the animation)**



4. A new dataset documenting 7,455 journey times (i.e., departure day from port A to arrival day at port B) between 130 port-pairs England and Wales 1651-1683; for 1830-1845, 2,591 comparable journey times between 1,815 port-pairs England and Wales. We had originally expected to produce only 3,100 journey times but were able to produce twice this amount by developing a new, more efficient, methodology to extract this information.

5. A new dataset geolocating all documented wrecks and accidents between 1854-1911 around the British Isles, 60,000 observations.

**IMAGE 3 Georeferencing of wrecks – illustration of the extraction of wreck points from British admiralty chart.**



**IMAGE 4 Wrecks dataset (georeferenced wreck sites, SHOM & Hydrographic Office)**

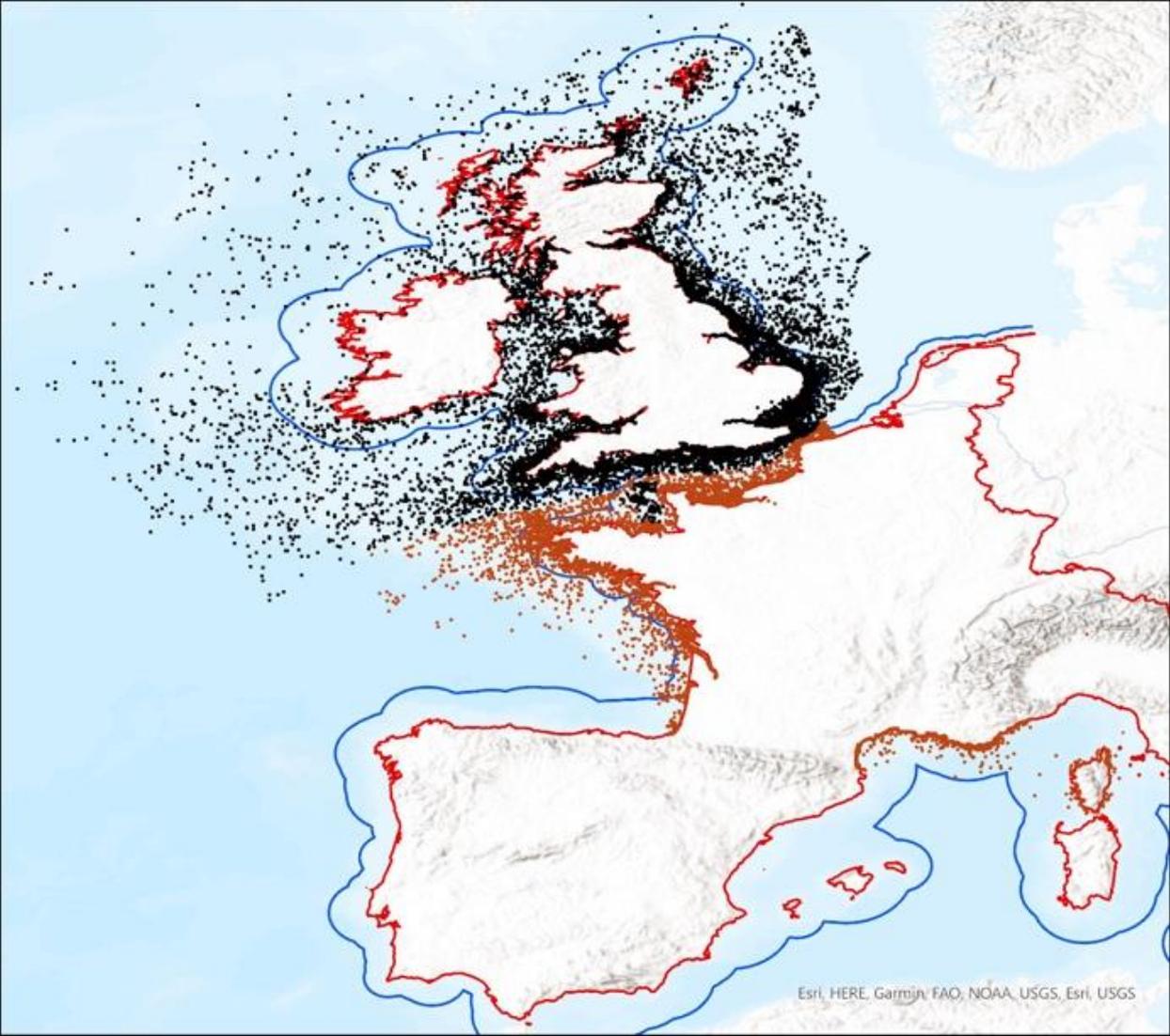
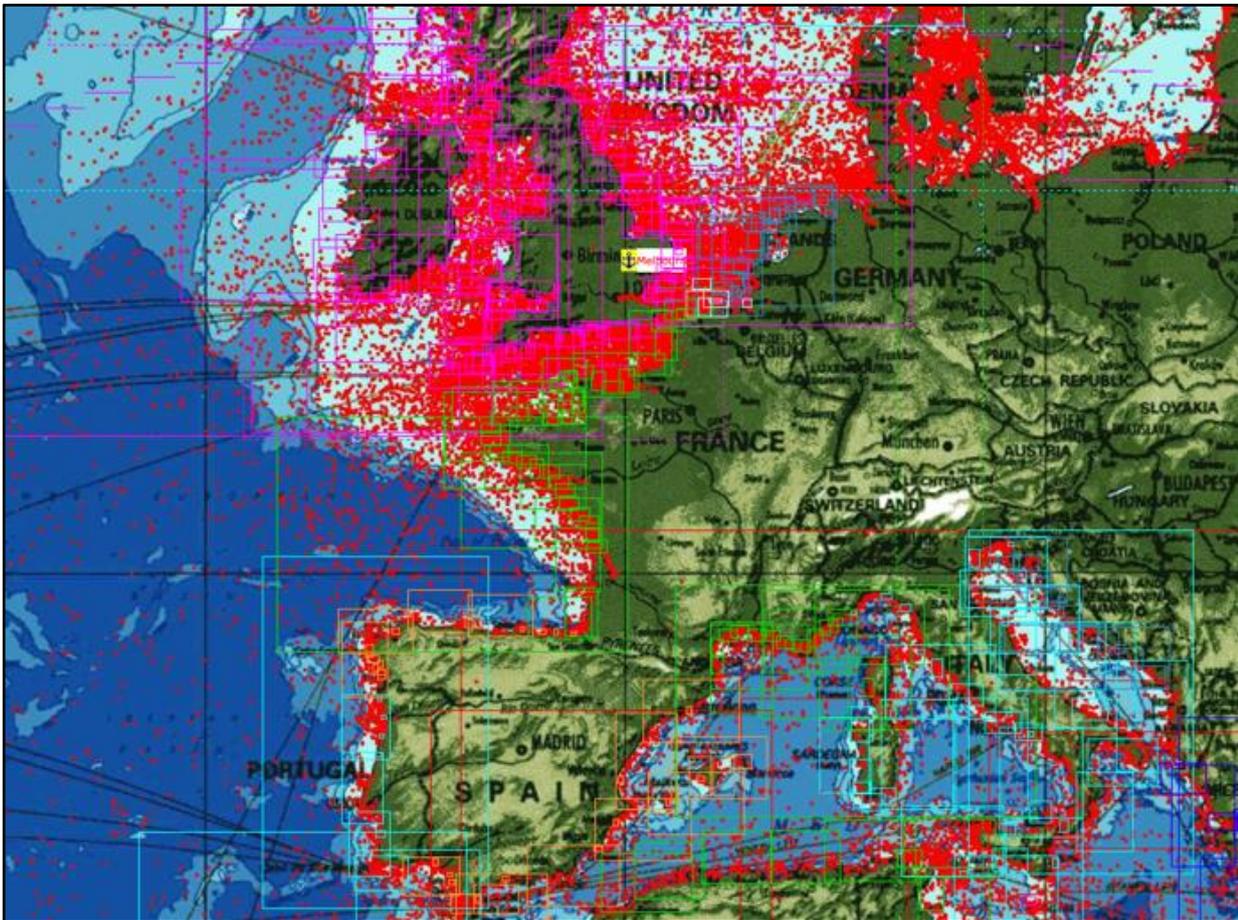


IMAGE 5 aggregated data for all European hydrographic agencies from Wrecksites.EU)



6. A new dataset documenting moon phases for any night since 1500.
7. A new experimental methodology to create real-world coastal routing models by using both available light provision and environmental variables. We have collaborated with the [EU Copernicus programme](#) (EU environmental data collection agency) and the [SHOM](#) (the French National Hydrographic Service) to establish our methodology for the new routing engine and access the most detailed modelling of wind, waves, currents, and visibility data. This is work in progress, but will make a significant difference, when completed, to the analysis of the contribution of light provision to safety at sea, and productivity of the shipping industry. The first stage of this work involved creating a new code to produce real-life visibility (improving on simplified geometric visibility we used before) based on a combined Digital Elevation Model (DEM) and bathymetric model of European coastal areas.

**IMAGE 6 Real-life visibility potential.**

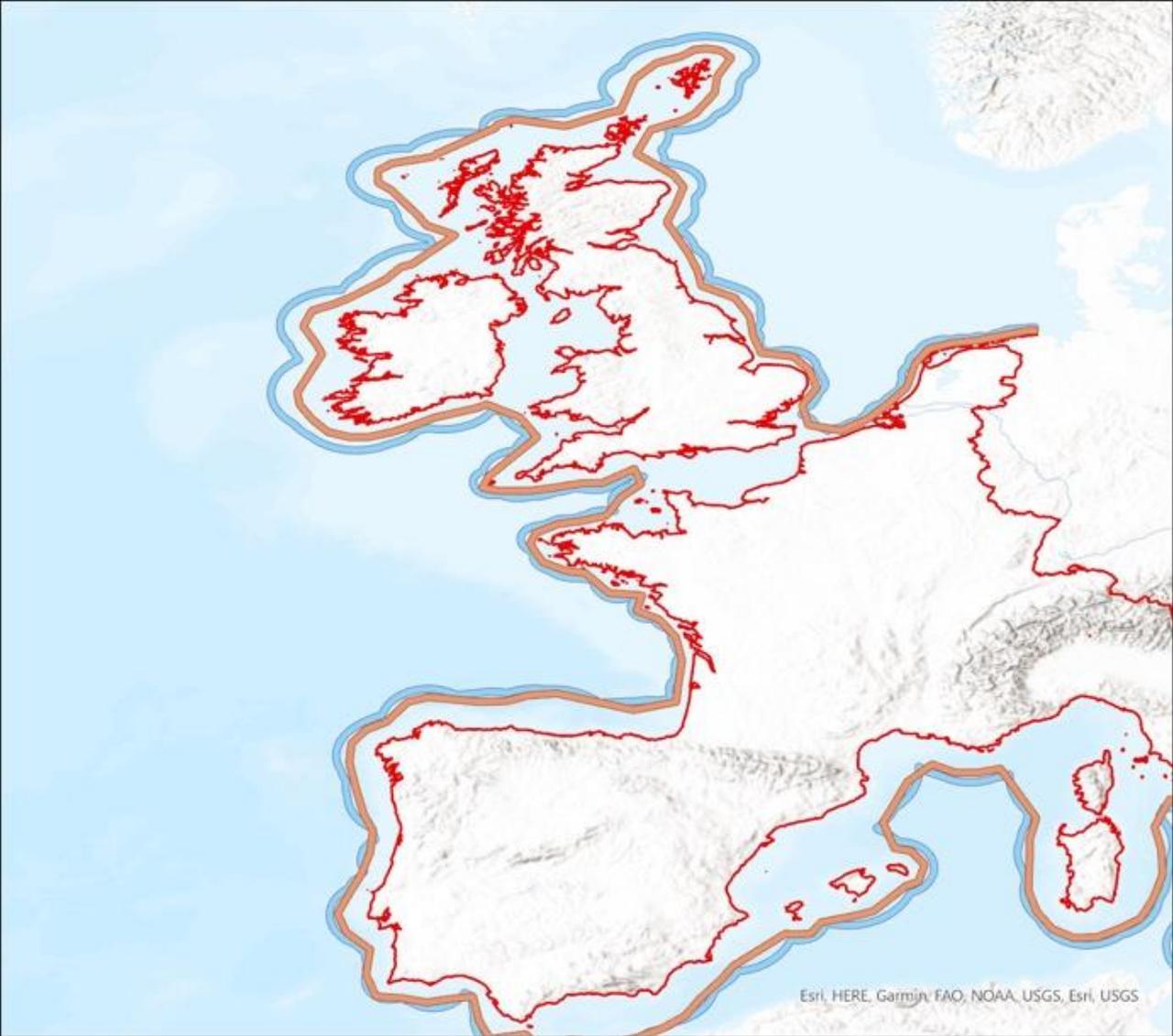
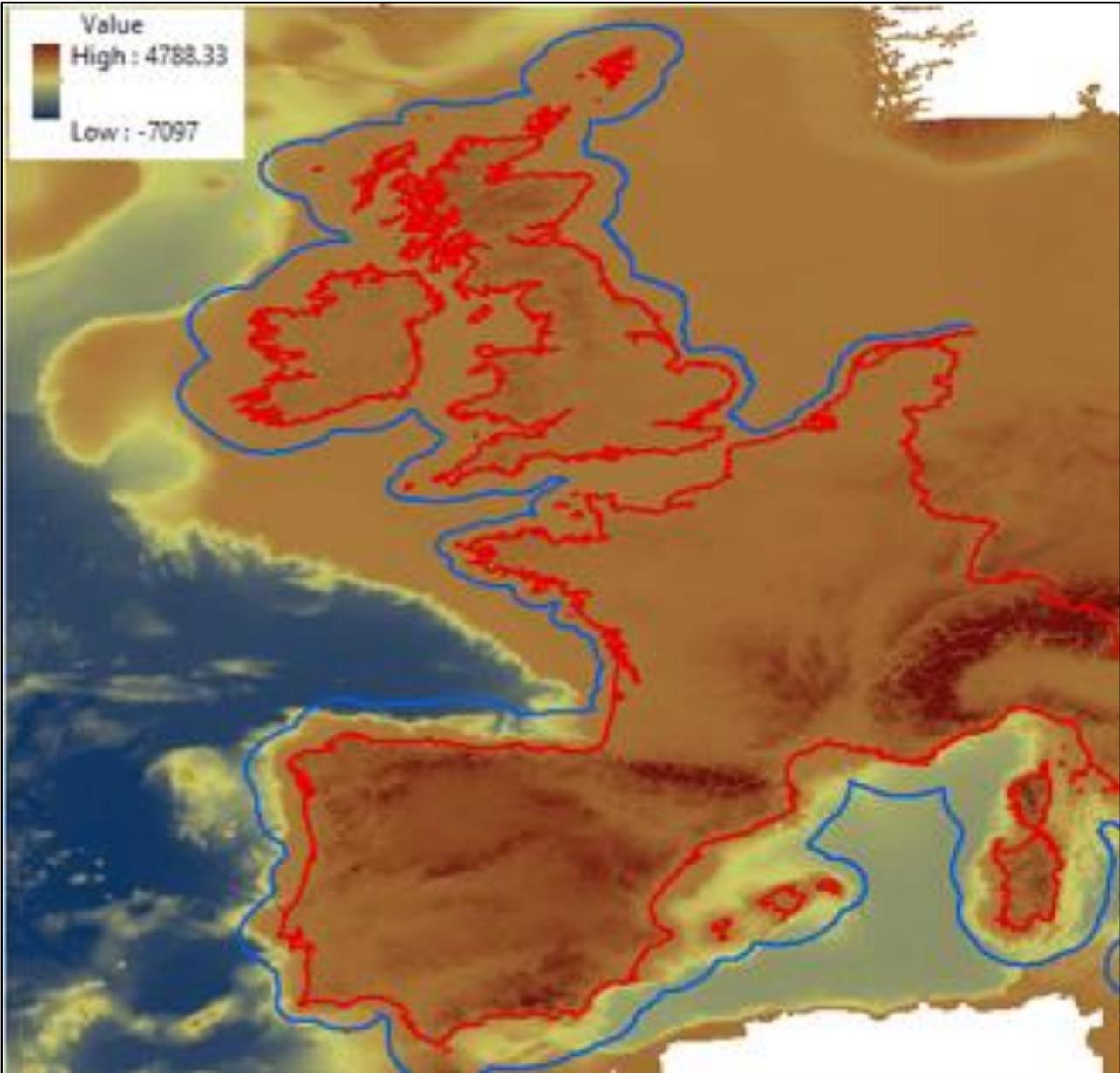
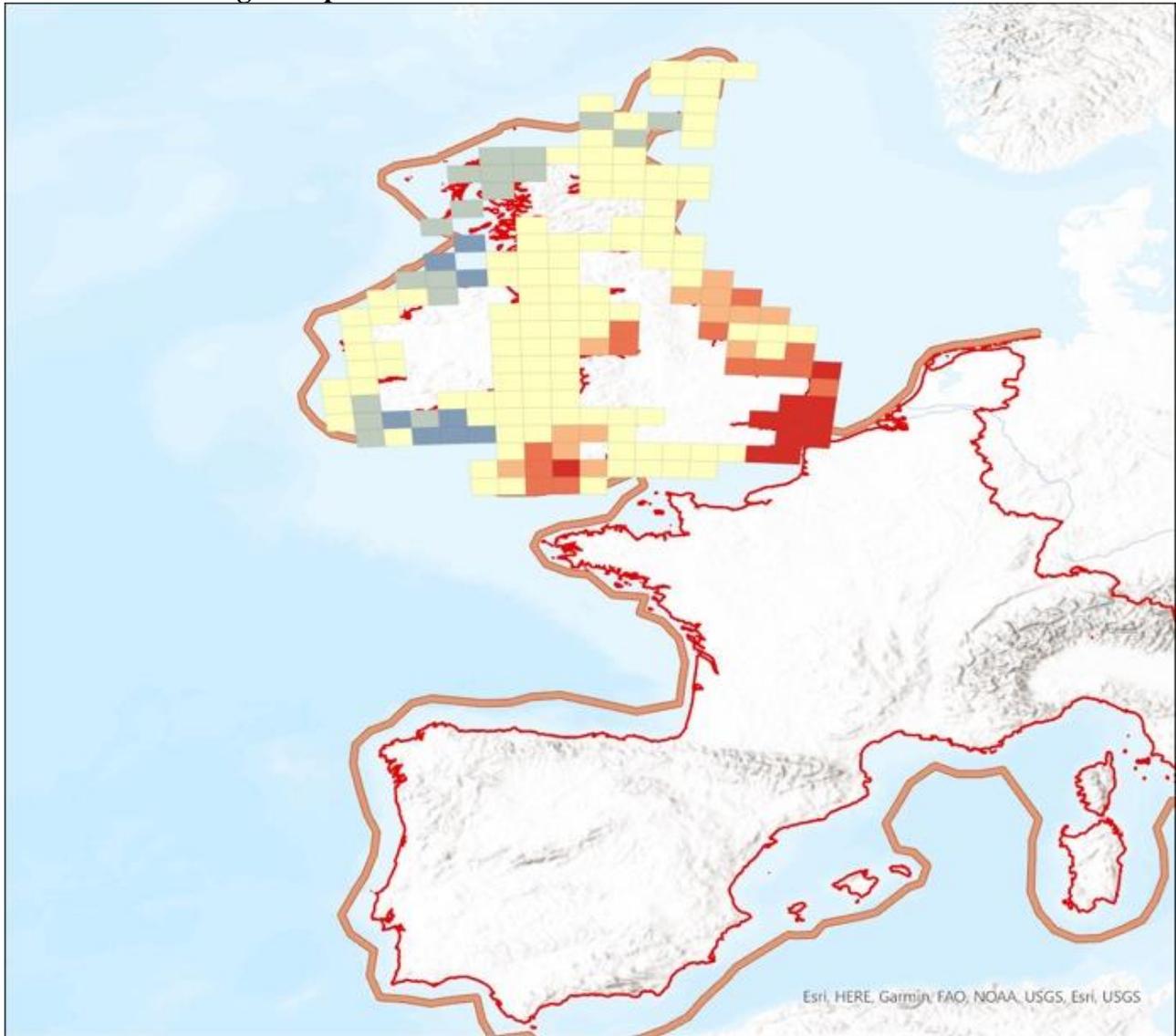


IMAGE 7 Continuous DEM and bathymetric model



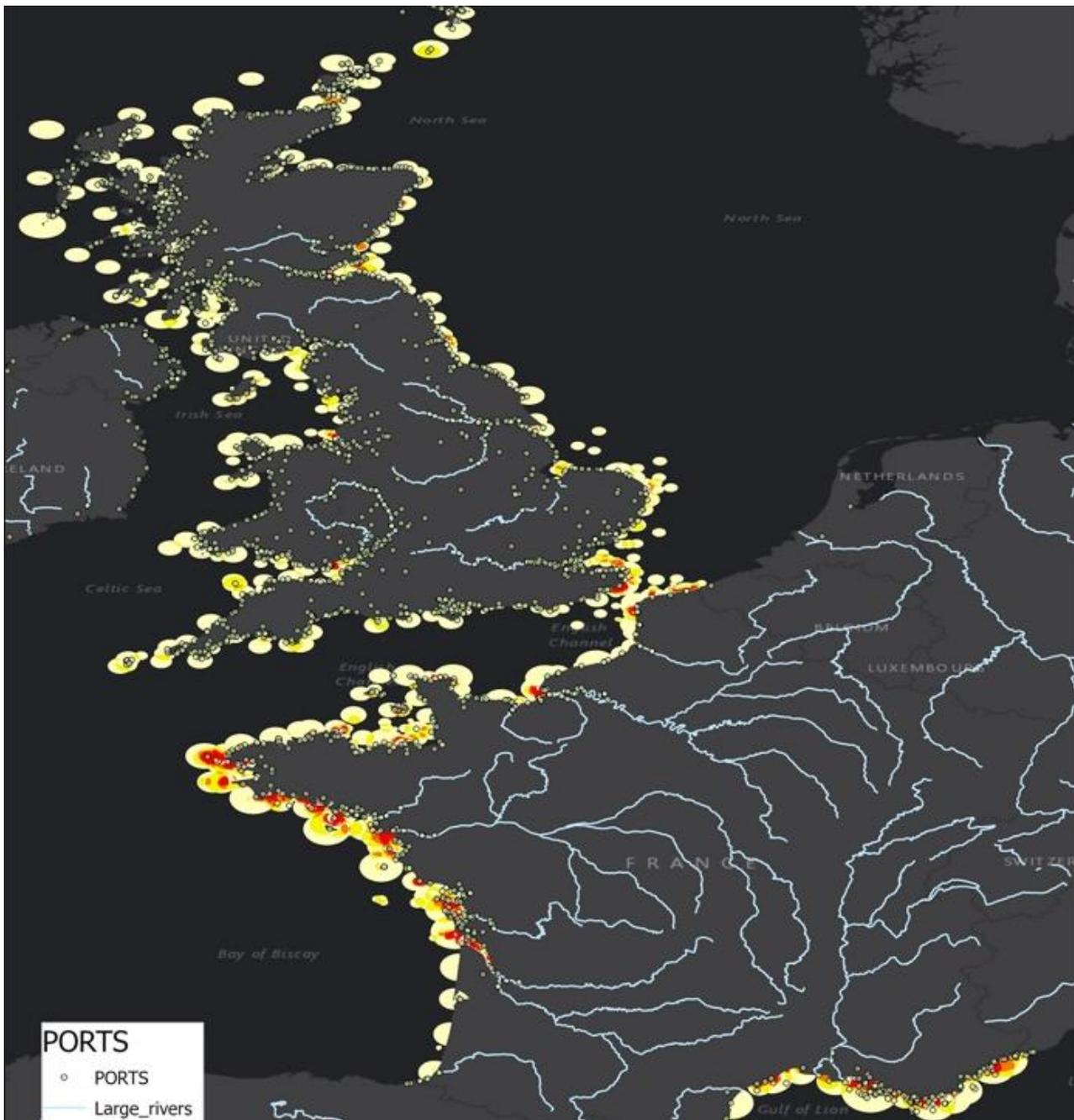
**IMAGE 8 Wreckage hotspots in the 1890s around the British isles.**



*For this project we published, or submitted:*

**8.** A new dataset for French coastal light provisions created from digitized copies of [Raynaud's \*Mémoire sur l'éclairage et le balisage\*](#) (1849), the *Etat de l'éclairage* (1863 to 1929), including key characteristics of lighthouses, lightships, harbour lights and beacons for matching benchmark years. For each light we will record the number of lanterns, visibility range, and elevation. (published in *Data in Brief* [doi.org/10.1016/j.dib.2021.106980](https://doi.org/10.1016/j.dib.2021.106980), and dataset available on UKDS at <https://dx.doi.org/10.5255/UKDA-SN-854607>).

IMAGE 9 1911 illumination coverage, from F-LAN and LAN data.



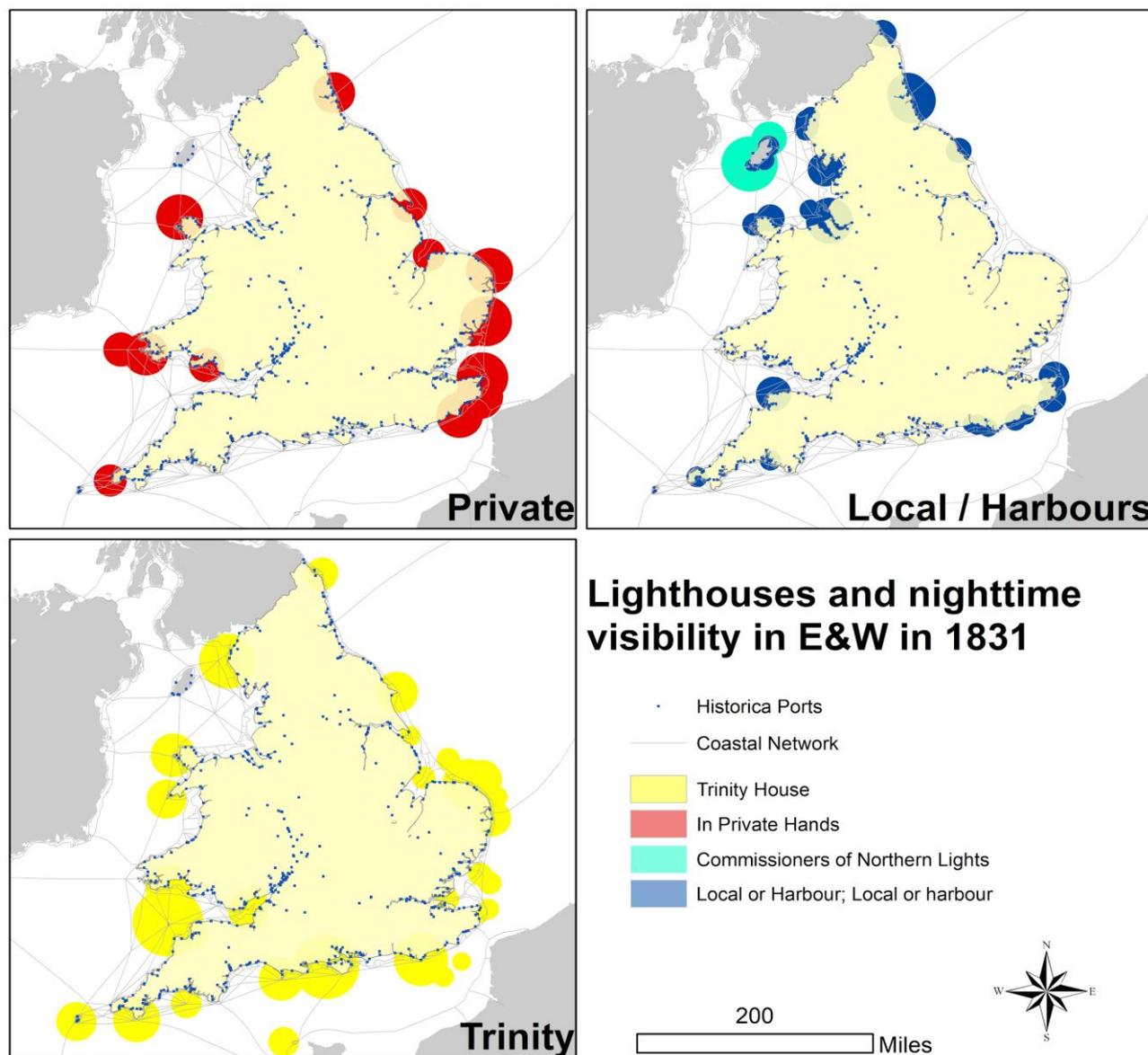
9. We resubmitted a paper to *Economic Enquiry*, following a revise and resubmit: Dunn, O., Bogart, D., Alvarez-Palau, E.J., Shaw-Taylor, L, ‘Organizations and efficiency in lighthouse provision: the English case revisited’. The main findings of this paper were:

- i. That the overall improvements in illumination along the coast between the mid-eighteenth century and 1831 was radically greater than previously realised, contradicting what has been suggested by Coase’s detractors.
- ii. The private expansion of lighthouses on the coast of England and Wales from the late eighteenth century through to 1831 was driven by two authorities, Trinity House, a guild/charity with mixed private-public characteristics, alongside a growing multitude of harbour authorities, some were public - owned by town corporations, some were mixed and others were privately owned. Private building petered out after 1780 as Trinity ran-out the leases of private operators and became more dominant. (IMAGE 10)
- iii. After the peace of 1815 government intervened in lighthouse provision. Trinity was asked by parliament to reduce its fees charged to ships. It did so but other operators did not.
- iv. Trinity (and harbours) were able to exploit their scale and bundling advantages. Trinity possessed a highly efficient national toll collection network of agents that gave it a major

advantage of other private operators. Harbours simply charged low fees and low running costs because they could bundle with other harbour services and didn't face the free-rider problems the others did. Trinity and harbours were alone supported by the state.

This paper has already been cited by Callais and Geloso (2020).

**IMAGE 10 Coastal illumination by type of lighthouse operator in England and Wales**



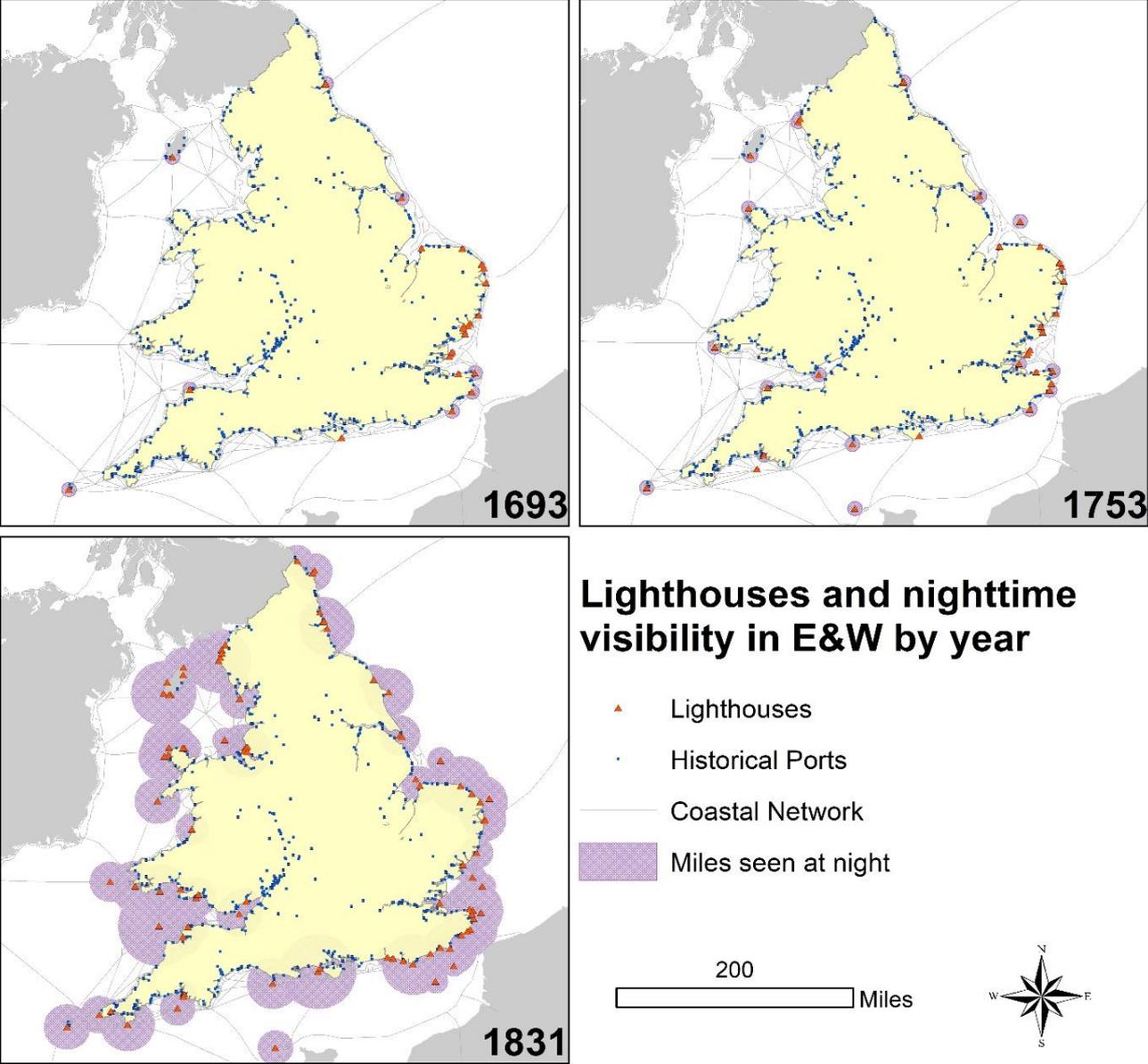
For this project we completed all the research and are in the process of writing, two more articles:

**10.** Shaw-Taylor, Bogart, Dunn, Alvarez-Palau, ‘From private to public lighthouses in England and Wales, 1836- 1911.’ We completed research on this paper which will: (i) analyse the reasons for the quasi-nationalisation of all private lighthouses and their transfer to Trinity House (a public-private institution) in 1836 (ii) explain why harbour authority (mostly private-public in nature) lights were not nationalised (iii) assess the consequences of ‘nationalisation’ for coastal illumination and the cost of lights to coastal shipping. The finished paper will be submitted to *Economic History Review* in due course.

**11.** Bogart, Shaw-Taylor, Dunn, Alvarez-Palau, ‘The Coastal lighting revolution in England and Wales, 1693-1831.’ All of the research for this paper was completed as an unplanned output of the last project and a start has been made on drafting the paper. This paper will document fully, for the first time, the building of lighthouses in England and Wales 1680-1830 and the implications for coastal lighting. We make two key contributions to the literature. Firstly, whilst the increasing number of lights over time is well known (if not precisely documented) in the literature, the real revolution in coastal lighting has been entirely overlooked. We quantify, for the first time, the spectacular increase

in areal coverage of coastal illumination (IMAGE 11) consequent on improved lighting technologies, which we dub the coastal lighting revolution. Second, we demonstrate that Trinity and private groups both adopted new technologies for coastal lights after 1790, but Trinity's role increased with time. Third, harbour authorities, virtually ignored in the literature to date, made crucially important contributions, but mainly through building lights for safe passage into harbours.

**IMAGE 11 Lighthouse and night-time visibility in E&W by year.**



## Part 2: Internal report to the managers

For this project we created: seven new datasets, published one peer-reviewed data; submitted a revised version of another article, deriving from our last Keynes project to *Economic Enquiry*, which was more or less a new paper; began work on two more papers; developed a working partnership with two new research groups; and created a short film about our Keynes funded work on lighthouses. Project deliverables are in the list of outputs below. Starred items are additional material produced which were not promised in the grant application.

### DATASETS

1. TOLLS\_UK\_XLS: light duties revenues, 1680-1911, c.230 obs.
2. F-LAN\_XLS: French coastal light provisions, 1775-1930, c.800 obs; including geolocation, visibility range in different weather conditions, fuel and optic types, [doi.10.5255/UKDA-SN-854607](https://doi.org/10.5255/UKDA-SN-854607), (ANIMATION 2 and IMAGE 9)
3. LIGHTS\_FR\_SHP: approx. 800 lighthouse observations covering the full French coastline. ANIMATION 1)
4. \*LIGHTS\_SCOT\_SHP: approx. 436 lighthouse observations covering the full Scottish coastline, including geolocation, visibility range in different weather conditions, fuel and optic types (ANIMATION 1 and IMAGE 9).
5. SPEED\_ENGW\_XLS documenting 3,100 journey times.
6. WRECKS\_SHP: 1854-1911 geolocating all documented wrecks and accidents, 60,000 obs. (IMAGES 3, 4, 5 and 8)
7. MOON\_PHASES.XLS: documenting moon phases for any night since 1500.

### METHODOLOGY DEVELOPMENT

8. \* A new experimental methodology to create real-world coastal routing models by using both available light provision and environmental variables. (IMAGE 6 and 7)

### PUBLICATIONS

9. A paper, 'Data set for French Historical Light Aids to Navigation (F-LAN) covering the period 1775-1929', DIB-D-21-00212, published in *Data in Brief* (2021). [doi.org/10.1016/j.dib.2021.106980](https://doi.org/10.1016/j.dib.2021.106980)
10. \* A revised paper for *Economic Enquiry* following revise and resubmit. Dunn, O., Bogart, D., Alvarez-Palau, E.J., Shaw-Taylor, L, 'Organizations and efficiency in lighthouse provision: the English case revisited'

### PAPERS NOT YET COMPLETED

11. Dunn, Bogart, Alvarez-Palau, Shaw-Taylor 'From private to public lighthouses in England and Wales, 1836- 1911', All of the research for this paper was completed within the project. However, we did manage to complete the data analysis or draft the paper as planned. There were three factors. The primary reason was when we received the revise and resubmit from Economic Inquiry on the paper from the previous project, the editor said, this needs to be two papers not one. That, together with referees' reviews required a very substantial revision to revise and extend one half of the paper and this took up most of the time that had been allotted to Dunn for analysis and writing. On the positive said, we have half the material for another unanticipated article (see next entry). That Dr Dunn and his wife had a third child just after the project started provided a further constraint as did Covid and home schooling (affecting Dunn and Shaw-Taylor). Alvarez-Palau and his partner also had a baby during this period. The Economic Inquiry paper has been revised and resubmitted and we are applying for some modest further funding in or proposed new Keynes project to complete this paper, but with Shaw-Taylor as the paper's lead author.

12. Bogart, Shaw-Taylor, Dunn, Alvarez-Palau, ‘The Coastal lighting revolution in England and Wales, 1693-1831.’ We are applying for some modest further funding in our proposed new Keynes project to complete this paper for submission to the Economic History Review. See output (11) above for details of the key findings.

### COMMUNICATION

13. We also produced a short summary of the work undertaken in a short film for the Faculty Website and social media platforms. A preview is available here: [FILM LINK](#). It will soon be uploaded both on Campop’s and the Keynes Fund’s websites.

14. **Bogart, D.**; Alvarez-Palau, E.J.; Dunn, O., Satchell, M.; Shaw-Taylor, L.: “Transport and urban growth in the first industrial revolution”. Yale University, 5th October 2020.

15. Bogart, D.; **Dunn, O.**; Alvarez-Palau, E.J.; Shaw-Taylor, L, ‘England’s historical lighthouse network: successful public-private partnership/amateurish corrupt regime’. CamPop ‘Brown Coffee’ Research Seminar series, 22<sup>nd</sup> October 2020.

16. **Bogart, D.**; Dunn, O.; Alvarez-Palau, E.J.; Shaw-Taylor, L.: “Organizations and efficiency in lighthouses: the English case revisited”. George Madison University, 28th January 2021.

17. Bogart, D.; **Dunn, O.**; Alvarez-Palau, E.J.; Shaw-Taylor, L, European Social Science History Conference: Coastal Navigation: Modelling England’s Coastal Shipping Networks 1690-1911: Routes, Ports, and Lighthouses, 25<sup>th</sup> March 2021.

### RESEARCH SYNERGY BETWEEN WORK STREAMS

This project has allowed us to establish an important partnership with one major research project, PORTIC, funded by the French National Research Agency (ANR) to exchange data they collected from French port books, and the geolocation of French historical ports.

This has also allowed us to develop a working relationship with the [EU Copernicus programme](#) (EU environmental data collection agency) and the [SHOM](#) (the French National Hydrographic Service) to establish our methodology for the new routing engine.

Finally, we have been able to create a working partnership with archaeologists, especially Joseph Lewis, to develop a probabilistic least-cost-path approach to routing, which will be crucial for any future development of the methodology. Joseph will also use our data to develop further his own model.

### CAPACITY BUILDING

This project has supported two ECRs, Oliver Dunn and Alexis Litvine, to carry on their research at Cambridge. Alexis Litvine has also developed a new expertise in geospatial probabilistic modelling.

### **Part 3: Overall assessment**

Overall, we were able to exceed our objectives: **i)** by using support from Cambridge Digital Humanities to digitise the Scottish dataset, **ii)** by collaborating with archaeologists interested in route modelling to develop a completely new methodology, **iii)** by developing a new partnership with the PORTIC ANR-funded research project in France to obtain data on French historical ports and trade volume.

One promised paper was not finished, but we radically revised and resubmitted another paper and have embryonic versions of two more.

The COVID-19 pandemic had only a minor impact on our work. We were not able to access any of the French archives we hoped to consult during the life of this grant, so we could not carry out our initial investigation of the archives of the Commission des Phares in the Archives Nationales in Paris. However, as we had foreseen this eventuality, a mitigation strategy was in place, and the project deliverables were not impacted. Overall, we are very proud that in spite of the difficult working conditions, all objectives bar one have been met and others have been exceeded and on balance we have delivered more than was promised.

#### **Part 4: Future plans**

This grant has set up the empirical bases for a new analysis of the key issues surrounding market failures in coastal lighting provision. We are applying to the Keynes Fund for further funding to carry out this analysis and publish our findings and arguments in a major article published in a top economics journal.

Also, as one of the reviewers of our previous application (Reviewer 2) had noted, 'it is somewhat regrettable that the investigators have overlooked the more obvious comparisons with the behaviour of the distinct authorities that managed the Scottish and Irish lights. During the early nineteenth century more lighthouses were built in these parts of the U.K. than in England and Wales.' Our follow-up project will exploit this opportunity by creating the missing data for Scotland and Ireland.

We plan to apply, probably to the Leverhulme Trust again, for substantial research project funding, likely this summer to continue work on our transport project and in particular to produce a book on the 1680-1830 period, which will include a summary of the work on lighthouses. The funding we have received from Keynes to date has been crucial in allowing us to bring to publication the research undertaken on our earlier Leverhulme project and new work on lighthouses. These publications make a renewed Leverhulme bid at this stage credible, and we would like to express our thanks to the Keynes Fund for its support.