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The Building of Bullock Harbour

Elizabeth Shotton



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Article abstract

There are hundreds of small harbours on the Irish coastline that were used for trade or fishing until the mid-twentieth century when these activities were centralized to major ports. Many date back hundreds of years, representing a system that linked local economies, which are critical to understanding Irish history. Yet, because many were built by estate owners or local communities, archival records rarely exist. Understanding the development of these modest structures demands a new methodological approach: through the innovative use of LiDAR scan data to interrogate what little visual and textual evidence exists to figuratively unearth the location of earlier structures.

The Building of Bullock Harbour

Elizabeth Shotton

University College Dublin
Ireland

RÉSUMÉ Des centaines de petits ports sur la côte Irlandaise ont servi au commerce ou à la pêche jusqu'au milieu du xx^e siècle, lorsque ces activités ont été centralisées dans les ports principaux. L'établissement de ces ports remonte à plusieurs siècles. Ils constituent un système reliant les économies locales, essentielles à la compréhension de l'histoire irlandaise. Pourtant, comme beaucoup ont été construits par des propriétaires de biens ou des communautés locales, les archives sont rares. Comprendre le développement de ces structures modestes nécessite une nouvelle approche méthodologique : grâce à l'utilisation innovante des données de numérisation LiDAR qui permet d'analyser le peu de preuves visuelles et textuelles disponibles. Il est désormais possible de découvrir virtuellement l'emplacement de structures en place auparavant.

ABSTRACT There are hundreds of small harbours on the Irish coastline that were used for trade or fishing until the mid-twentieth century when these activities were centralized to major ports. Many date back hundreds of years, representing a system that

linked local economies, which are critical to understanding Irish history. Yet, because many were built by estate owners or local communities, archival records rarely exist. Understanding the development of these modest structures demands a new methodological approach: through the innovative use of LiDAR scan data to interrogate what little visual and textual evidence exists to figuratively unearth the location of earlier structures.

HISTORICAL STUDIES OF MARITIME HERITAGE

Studies of harbours have conventionally been the domain of economic historians, such as the review of British ports by Jackson¹ or the more recent international network analysis by Ducruet², which examine the flow of goods between ports to describe the rise and fall of economic systems through the study of shipping records. These methodologies have also recently been adapted to study the material culture of societies at particular historical junctures by tracking the types of goods moving between ports³. As to the physical structures of the harbours, though Jackson's *Ports* discuss this aspect to some degree, particularly the timing of their construction, studies in economic history or material culture broadly ignore the details of these structures as they are perceived to be irrelevant to the primary research.

Construction comes into focus in the other main school in harbour research; engineering studies in the field of construction history. The focus of this research is principally, though not exclusively, on the engineers that designed the structures,

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1. Gordon Jackson, *The History and Archaeology of Ports*, Tadworth, Surrey, World's Work Ltd., 1983.
 2. César Ducruet, "Maritime Flows and Networks in a Multidisciplinary Perspective", in César Ducret, eds., *Maritime Networks: Spatial Structures and Time Dynamics*, London/New York, Routledge, 2015.
 3. Susan Flavin, *Consumption and Culture in Sixteenth-Century Ireland: Saffron, Stockings and Silk*, Suffolk, Boydell Press, 2014.

a preoccupation described by Jarvis as “the beautification of engineers”⁴. These studies typically focus on a single port, such as Ash’s research on Dover Harbour in Britain⁵, or a series of structures designed by a single engineer, as in Hadfield’s exploration of the work of William Jessop⁶. The most comprehensive engineering studies of this kind are of harbours managed by long-standing port companies, such as Gilligan’s *A History of the Port of Dublin*⁷ in Ireland, or by government agencies as was the case for Dover Harbour. Unlike their counterparts in economic history, these historians rarely explore harbours as a network, thus tend to overlook the more modest harbour structures, such as Bullock Harbour in County Dublin, Ireland, which operated in tandem with major ports and served local communities for hundreds of years. Yet, as argued by Jackson, Jarvis and more recently Le Bouedec⁸, even modest ports represent an infrastructural network of transportation and commerce and thus, by extension, of technical knowledge on the subject of marine engineering, and deserve to be drawn into the discourse.

The methodologies used in the field of construction history influence this preoccupation with major ports or the careers of engineers, as they rely primarily on archival research and are thus limited to works that have been well documented and where the documents have been actively preserved. Ports of a significant scale of the operation, or major ports, have often been managed by state or semi-state companies for much of their existence,

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4. Adrian Jarvis, “Port History Some Thoughts on Where It Came from and Where It Might Be Going”, in Lewis R. Fischer and Adrian Jarvis, eds., *Harbours and Havens. Essays in Port History in Honour of Gordon Jackson*, Liverpool University Press, 1999, pp. 15–17.
 5. Eric Ash, “A Perfect and an Absolute Work: Expertise, Authority, and the Rebuilding of Dover Harbor, 1579–1583”, *Technology and Culture*, vol. 41, n°2 (2000), pp. 239–268.
 6. Charles Hadfield and A. W. Skempton, *William Jessop, Engineer*, London, David & Charles, 1979.
 7. Henry A. Gilligan, *A History of the Port of Dublin*, Dublin, Gill and Macmillan, 1988.
 8. Gerard Le Bouëdec, “Small Ports from the Sixteenth to the Early Twentieth Century and the Local Economy of the French Atlantic Coast.”, *International Journal of Maritime History*, vol. 21, n°2 (2009), pp. 103–26.

resulting in the accumulation of a wide range of archival documents held either by the port itself or by a local or national archive. In Ireland, this is the case for the current major ports (Cork, Dublin and Belfast) as well as several mid-sized ports that had significant levels of trade historically (Waterford, Drogheda, Dundalk), much of which was diverted to the major ports with the introduction of containerization in the mid-twentieth century. Likewise, focus on the collected works of particular engineers is driven by the abundance of archival material lodged with professional bodies, such as the Institute of Civil Engineers (UK) or national libraries and archives.

Beyond the well-documented major harbours is a much longer list of local harbours, which would have served either regional trade routes and/or local fishing. Within Britain and Ireland these local harbours can have equally lengthy histories as the major ports, some dating back to the medieval period when little, if any, harbour infrastructure existed. Structures were inevitably built to support the increasing size of ships and evolving regional trade patterns, which were adapted to local topographical features and generally evolved incrementally over centuries. Thus, these minor harbours tend to be limited in size and eccentric in their construction and form, in contrast to the much more regular forms and technologies found in major ports. While many of the minor Irish harbours, particularly fishing harbours, were built by the government from the mid-nineteenth century onward, so are reasonably well documented, the oldest minor harbours were privately built, either by landowners, religious orders, or local communities, which has resulted in a near absence of archival documentation.

Due to the lack of archival documents, little is known regarding the evolution and construction of most minor harbour structures, as historical evidence rarely exists beyond maps, the occasional text reference in state records, or sporadic images such as sketches or paintings. The history of maritime engineering

offers little to enlighten us, as what history exists, principally compiled from the mid-nineteenth century onward, takes as its focus major works starting from that century and built by the emerging profession of engineering, with occasional references to ancient Roman structures⁹, but a complete absence of commentary for the intervening period when most of these small harbours were originally formed. Earlier technical manuals are rare, dominated by Belidor's eighteenth-century treatise “*Architecture hydraulique, ou L'art de conduire, d'élever et de ménager les eaux pour les différens besoins de la vie (Hydraulic Architecture)*” published in France¹⁰, with modest references to the subject in earlier architectural treatises such as “Palladio's *I Quattro Libri Dell'architettura (The Four Books of Architecture)*” published by Palladio in 1570, or Alberti's “*De re Aedificatorian (the Art of Building)*” of 1452, the latter drawing heavily on the work of the Roman architect Vitruvius, who published the “*De Architectura (Ten Books on Architecture)*” between 30 and 15 BC. In Ireland, the earliest technical manual to appear was Semple's *A Treatise for Building in Water* in 1776, which drew extensively from the works of Belidor, Palladio and Alberti¹¹. Thus, the historical period between the great marine works of the Romans and the work of professional engineers, that surfaces in earnest in the late-eighteenth century, is limited. As a result, these minor harbours, though they may represent the best source of plausible evidence for the evolution in maritime engineering, are difficult to study, barring wholesale excavations.

Ireland's major ports have been carefully documented and researched based on the considerable archival documentation that has been preserved. In contrast, most minor harbours,

9. Leveson Francis Vernon-Harcourt, *Harbours and Docks: Their Physical Features, History, Construction, Equipment, and Maintenance with Statistics as to Their Commercial Development*, 2 vols. vol.1 (Text), Oxford, Clarendon Press, 1885.

10. Bernard Forest de Belidor, *Architecture hydraulique, ou L'art de conduire, d'élever et de ménager les eaux pour les différens besoins de la vie*, 4 vols. vol.1-4, Paris, L. Cellot, F. Didot, 1782–1790. (first imprint 1737–1753).

11. George Semple, *A Treatise on Building in Water: In Two Parts: Illustrated with Sixty-Four Copper-Plates*, Dublin, J. A. Husband, 1776.

though once intrinsic to the economic wealth and the welfare of local communities, have been overlooked and are falling into disrepair as the industries that once generated their development have been centralized to the major ports. Rising sea levels and increased extreme storm activity threaten to permanently damage these structures, making it critical to document these harbours to describe and elaborate the entwined nature of their development with the communities they once served. The interrogation of the history and development of these modest structures demands a new methodological approach to the analysis of the scant historical material that exists, drawing on both conventional and unconventional sources, made possible through the innovative use of three-dimensional LiDAR point cloud data, derived from laser scanning techniques.

LiDAR is an acronym for light detection and ranging, a survey method developed in the late-twentieth century using lasers to measure distances to objects¹². A LiDAR scanner works by sending out pulsed beams of light that are reflected by solid objects and measuring the reflected light with a sensor to estimate distance to the object. The result is a series of data points representing an object's surfaces in three-dimensional space, called a point cloud. Despite its use by port companies for monitoring the condition of harbour infrastructure and its common use to document land-bound heritage monuments, from which three-dimensional models are generated¹³, the use of this technology is uncommon in harbour research. More common to the study of such intertidal sites is the use of side-scan sonar from boats, which generates similar three-dimensional digital data, deployed by archaeologists on underwater archaeological

12. National Ocean Service and Atmospheric Administration (NOAA), “What is LiDAR?”, [online], <https://oceanservice.noaa.gov/facts/lidar.html>, (page consulted on February 22nd, 2019). See also Wikipedia, “Lidar”, [online], <https://en.wikipedia.org/wiki/Lidar>, (page consulted on February 22nd, 2019).

13. Stephen Fai and Jesse Rafeiro, “Establishing an Appropriate Level of Detail (Lod) for a Building Information Model (BIM)—West Block, Parliament Hill, Ottawa, Canada.”, *ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences* II-5, (2014), pp. 123–30.

sites¹⁴. However, as minor harbours are relatively small and tend to run dry at low tide this enables the use of terrestrial-based LiDAR scanning rather than side-scan sonar. The use of LiDAR addresses the difficulty of capturing the eccentric form of minor harbours accurately through conventional survey methods, as it can document harbour structures in a full-scale three-dimensional digital point cloud to within 2 mm, thus recording both the form and constructive detail of the structures. This accurate three-dimensional representation of the harbour can then be used as a baseline to interrogate historic evidence and postulate the location of earlier structures that are no longer visible or extant, contributing new knowledge to the understanding of the evolution of these harbours.

A RECONSIDERATION OF CONVENTIONAL SOURCES AND METHODOLOGIES

The Case of Bullock Harbour

The rocky cove that formed the base of the now fully built harbour of Bullock in south County Dublin (*Figure 1*) has been described as being in use since at least the fourteenth century as a fishing haven by Cistercian monks, forming part of the larger land holdings of St Mary's Abbey in Dublin¹⁵. Following the dissolution of monasteries in Britain and Ireland in the sixteenth century it passed through a number of private hands before it was finally leased in the early nineteenth century by the Dublin Port and Docks Board (now Dublin Port) for the shipment of quarried stone, latterly becoming one of their many subsidiary outports for trade¹⁶. As a result of the length of time it has been in use, and the evolution in its use, the harbour has been subjected to a

14. Rory Quinn, Wes Forsythe, Colin Breen, Martin Dean, Mark Lawrence, and Steve Liscoe, "Comparison of the Maritime Sites and Monuments Record with Side-Scan Sonar and Diver Surveys: A Case Study from Rathlin Island, Ireland", *Geoarchaeology*, vol. 17, n°5 (2002), pp. 441–51.

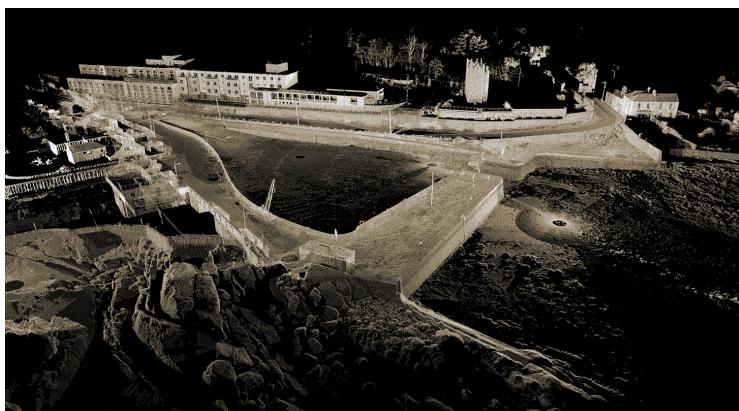
15. John D'Alton, *The History of County Dublin*, Dublin, Hodges and Smith, 1838.

16. Gilligan, *A History of the Port of Dublin*, pp. 236–7.

number of re-buildings through the course of at least 350 years. Archival records are scarce, with only the occasional text reference or image for use as evidence for various constructions until control was assumed by Dublin Port.

Figure 1.

Bullock Harbour from northeast, LiDAR scan—Shotton, Semar, Lennon, 2016.



The presence of Bullock castle adjacent, presumed to be of twelfth century origin¹⁷, evoked considerable interest from artists, historians, antiquarians and archaeologists alike, the earliest evidence being an illustration by Frances Place in 1699 (*Figure 2*). The relative influence of the castle's presence is made manifest from the dearth of such images for the two harbours immediately to the north and south of Bullock: Sandycove and Coliemore have similarly complex histories, but have been broadly overlooked by artists and historians alike. As a result, despite its modest size there are several published works on the history of Bullock, or Bulloch as it is sometimes known. The most commonly

17. F. Elrington Ball, *History of the County of Dublin: Monkstown, Kill-of-the-Grange, Dalkey, Killiney, Tully, Stillorgan, and Kilmacud*, vol. 1, Dublin, Alex. Thom & Co., 1902, p. 34.

cited are concise narratives by De Courcy¹⁸ and Gilligan, though earlier versions exist, such as the more fulsome, though inconsistently referenced, description in *The History of County Dublin* by D'Alton in addition to a more recent work by local historian Smyth in *Bullock Harbour: Past and Present*¹⁹. In each version the history of the building of the harbour is under-represented. Its origin is described as a medieval pier on the west bank below the castle, first described as being built by the Cistercians²⁰ by Donnelly, who appears to be the original source for this information, though he unfortunately fails to provide evidence. This was assumed to have survived the raging seas until a complete building of the harbour in 1818–20 by Dublin Port, complete with quay walls, slip, and piers to both east and west. A simple history, built on assumptions rather than facts, as factual evidence was in such short supply. Most historians would be unaware of how implausible the survival of a pier for 400–600 years would be, nor do they pause to question whether the Cistercians built anything at all in what had been a sandy cove sheltered from the vagaries of the sea by rocky outcrops.

Aside from the improbability of a medieval pier withstanding the ravages of the sea for such a length of time before it was rebuilt, these histories overlook the more complex evolution of this harbour, failing to account for the range of pictorial evidence and government documents available, which expose a more elaborate history when examined forensically. The true complexity of the evolution of Bullock Harbour has only been identified by virtue of interrogating this limited pictorial and textual evidence relative to the LiDAR scans made by the author and their research team in 2016. Beyond this scan data, which offers a full-scale three-dimensional digital representation of the harbour's current form, the historical evidence used in this research is not

18. John W. de Courcy, *The Liffey in Dublin*, Dublin, Gill and Macmillan, 1996.

19. Donal Smyth, *Bullock Harbour: Past and Present*, Dublin, Published by the Author, 1999.

20. Nicholas Donnelly, *Short Histories of Dublin Parishes*, vol. 4, Dublin, Catholic Truth Society, 1905, p. 129.

fundamentally different from the sources that underpin existing histories (*Table 1*), though additional privately-held images were sourced from art auction catalogues and further fragmentary text references surfaced. It is the methodology deployed to interrogate this material that offered new insights into the complexity of the building sequence, made possible through the interrogation of the historic images relative to the current configuration of the harbour documented in a three-dimensional digital format.

Figure 2.

Bullock Castle & Harbour, Frances Place, 1699—© National Gallery of Ireland.

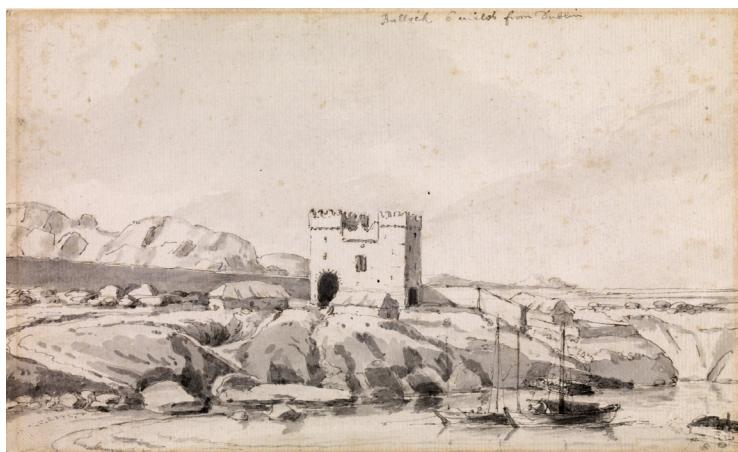


Table 1.

Catalogue of Sources: Bullock Harbour, Dalkey, County Dublin, Ireland.

Date	Type	Author/Organization/ Source	Information	New
12 th C.	Text.	James Donnelly, <i>Short Histories of Dublin Parishes</i> (published 1905), p. 129.	Monks had “constructed a small harbour” and castle, cited by Gilligan.	
1401.	Text.	Patent Roll 3 Henry IV, TCD Circle.	Landing at Blowyk harbour.	◆
1541.	Text.	Extents of Irish monastic possessions, 1540–1541.	No mention of haven or “key”.	
1611.	Text.	D’Alton (published 1838), patent of ownership to Fagan.	First mention of haven.	
1654.	Text.	Civil Survey.	“a Seaport and... good haven”.	
1699.	Drawing	Francis Place, National Gallery of Ireland (NGI)	Bullock Castle	
1757.	Text.	Irish Revenue Board and Irish Board of Customs Minute Books, The National Archives UK (TNA).	Revenue Cruiser stationed at Bullock harbour.	◆
1765.	Text.	Journal of the House of Commons of Ireland, vol 8, Royal Irish Academy (RIA).	Petition to extend “new quay” and build a “jette” on opposite shore.	◆
1770.	Text.	Peter Wilson, <i>The Gentleman’s Magazine</i> , and <i>Historical Chronicle</i> .	New stone quay “hath lately been built”, cited by D’Alton.	
1786.	Text.	Journal of the House of Commons of Ireland, vol 12, RIA.	Notice regarding building a road to “Dalkey” harbour.	◆
1788.	Painting.	John Thomas Serres, NGI.	Bullock Castle & Harbour.	
1788.	Drawing.	Christopher Machell, NGI.	Structure to east.	
1800.	Text.	William Bligh, <i>Report on the Port of Dublin</i> .	Pier at west side, ruinous breakwater to east, cited by D’Alton.	

1804.	Map.	William Duncan, A Sketch of the Coast from Black-rock to Bray Head, British Library	Pier at west side, ruinous breakwater to east, creek.	
1807.	Text.	Journal of the Proceedings of the Corporation for Preserving and Improving the Port of Dublin, vol. 6, National Archives of Ireland (NAI).	Continuation of west quay by 231 feet.	
1813.	Text.	Journal of the Proceedings of the Corporation for Preserving and Improving the Port of Dublin, vol. 8, NAI.	Continuation of west quay by 88 feet, new slip.	
1813.	Painting.	Charles Pratt, Adam's Auction House.	Old Breakwater called the Danish Pier.	◆
1813.	Drawing.	Charles Pratt, Irish Architectural Archive (IAA).	Broad Quay/pier at west, breakwater to east.	◆
1818.	Text.	Lighthouse Journals, vol. 3, Bailey Lighthouse.	New east quay and pier, cited by Smyth.	
1820	Etching	J. Greig, Excursions through Ireland	Broad Quay/pier at west, road wall	
1820.	Text.	Journal of the Proceedings of the Corporation for Preserving and Improving the Port of Dublin, vol. 10, NAI.	New west quay and pier “finished in same manner [as] opposite side”.	
1820.	Painting.	William Brocas, National Library of Ireland.	New harbour, cranes and pilot houses.	
1900.	Photo.	Robert French, National Photographic Collection (NPA).	Detail on original slip.	
1940.	Photo.	Cardall Photographic Collection, NPA.	Detail of west quay wall.	

Innovations in Methodology

As the three-dimensional data captured in a LiDAR scan represents a precise and full-scale digital model of the harbour, it can be used to identify the spatial relationship between the harbour's current configuration and structures illustrated in early drawings or paintings. This is enabled by the precision with which topographical artists of the seventeenth and eighteenth centuries illustrated landscapes and buildings through the use of perspective. As three-dimensional digital modelling software can also display the LiDAR scans in perspective, the images and scan data can be overlaid and aligned to one another through the use of key reference points, such as the still extant castle. This can be achieved through several methods.

The first involves uploading a digital image of the historical drawing as a screen background in the LiDAR scan software environment *Cyclone* and rotating the digital scan of the harbour until a registration with reference points in the image is achieved²¹ (*Figure 3a & 3b*). In the case of Bullock, the relative position of the castle in perspective is correlated between scan and image, which defines the approximate location of the piers documented by Place in 1699 relative to the harbour's current pier structures. However, this methodology only provides a very general impression of the location of the piers, which from the overlay appears to be in the same position as the current pier structure, supporting previous assumptions regarding the evolution of the harbour. To more fully interrogate the image, a second modelling software is used, *Rhinoceros*, or *Rhinocad*. As scan data creates very large files, in the order of 7–30 GB each depending on the size of harbour, to model in any software other than the native *Cyclone* is difficult. To overcome this only partial scan data is exported from *Cyclone* and uploaded to *Rhinocad*. Within *Rhinocad* the user can model in three dimensions with up to four active view

²¹ Elizabeth Shotton, "Augmented Maritime Histories: Text Point Line" In Frederic Migatrou, Laura Allen and Luke Pearson, eds, *Drawing Futures*, London, University College London. 2016.

ports (see *Figure 4*), which is useful in registering the modelling process in the plan, elevation, and perspective simultaneously. This facilitates the modelling of missing historic elements relative to reference points such as the castle and the existing quay and pier structures. Rhinocad also allows an image to be uploaded as a screen background, such as the Place drawing in the case of Bullock, which can be used to model hypothetical pier locations and verify their placement and size relative to the perspectival image drawn by Place. This results in a conjectural mapping of the pier structures of 1699 relative to the current configuration of the harbour in three dimensions, thereby defining their location in plan, height relative to the castle, and approximate size (*Figure 4*).

Figure 3a & 3b.

3a. Bullock Castle & Harbour, Frances Place, 1699—© National Gallery of Ireland.

3b. Bullock Castle & Harbour, LIDAR scan in perspective rotated to match Place image—Shotton, Semar, Lennon, 2016.

During the actual modelling process the Place drawing would appear as background underlying the scan data illustrated in 3b, however due to copyright restrictions National Gallery images cannot to be printed with any overlay obscuring the image



Figure 4.

Screenshot of Rhinocad modelling of piers from Place drawing.

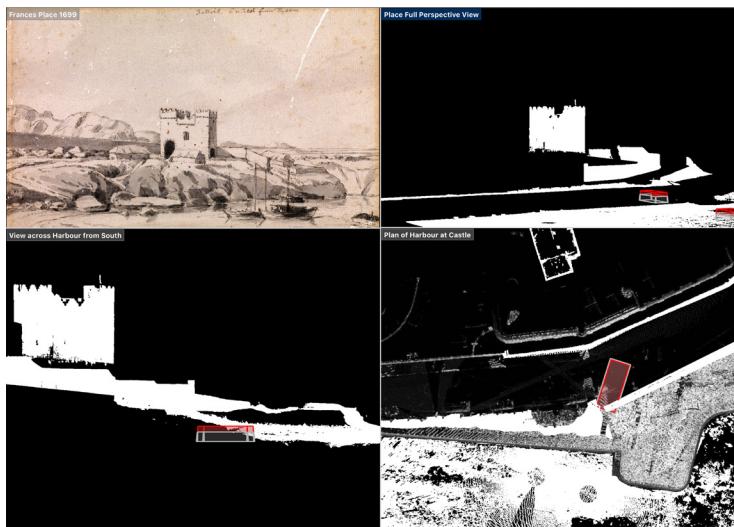
Top Left: Bullock Castle & Harbour, Frances Place, 1699—© National Gallery of Ireland.

Top Right: LiDAR scan data in perspective to match Place drawing with piers modelled (red, with surface below water line in grey).

Bottom Left: LiDAR scan data in elevation with modelled piers (red, with surface below water line in grey).

Bottom Right: LiDAR scan data in plan with location of historic west pier (red) relative to current pier—Shotton, 2019.

During the actual modelling process the Place drawing would appear as background underlying the scan data illustrated in the top right perspective.



An inverse process of modelling using *Adobe Photoshop* can also be used to identify relative positions of objects in a historical image, deployed successfully on a painting of Bullock castle and harbour by John Thomas Serres (*Figure 5*). Using the “Vanishing Point” tool in *Adobe Photoshop*, a perspectival grid was used to three-dimensionally model the spatial relationships

between the castle and pier in the Serres' painting. This method requires knowledge of fixed dimensions of some elements in the image to appropriately scale the perspectival grid. In the case of Bullock, the continued presence of the castle coupled with the dimensional accuracy of the LIDAR scan allowed for the verification of the dimensions of the perspectival grid. An early marine survey by Bligh²², undertaken in 1800 before the rebuilding of the harbour by Dublin Port, provided further dimensions to verify the height of the pier. Once constructed, this vanishing point grid can be exported as a three-dimensional shape in a digital .dxf [or .3ds] file and uploaded to Rhinocad to be reconciled with points cloud data from the LIDAR survey, providing an approximate location for the pier.

Figure 5.

Bullock Castle & Harbour, John Thomas Serres, 1788—© National Gallery of Ireland.



22. Accounts, &c. Presented to the House of Commons, Relating to the Inland Navigations of Ireland, and to the Port of Dublin, London, House of Commons Papers; Accounts and Papers, 1806, p. 55.

Through the use of the “Vanishing Point” tool, the pier was successfully modelled and dimensioned in relation to the castle in *Adobe Photoshop* (red) and translated to *Rhinocad* as a set of three-dimensional surfaces (green) which contained dimensional information on the castle, the horizontal and vertical distances from the castle to the pier, and the dimensions of the elevation of the pier as represented in the Serres painting (*Figure 6*). The transfer of the *Adobe Photoshop* vanishing point grid is not without its problems, as the imported data requires rescaling (relative to known measurements) and reorientation. Within the *Rhinocad* environment the imported surfaces can be registered to partial scan data (white), to successfully pinpoint the location of the pier (red), though its breadth, which was not illustrated by Serres, required verification with an etching by Greig, based on an earlier sketch by Petrie before the 1818–20 rebuilding of the harbour (see *Table 1*). This model can once again be verified by uploading the Serres’ image as a background in *Rhinocad* and viewing the model in perspective relative to the image.

While the Serres painting proved amenable to the use of “Vanishing Point” analysis in *Adobe Photoshop*, the Place drawing, due to the irregularity of the rock surfaces and the limitations of the “Vanishing Point” tool, which only allows for rectangular grids, proved impenetrable. In addition, while these methodologies work well with the very precise perspectival images created by topographical artists, they can rarely be successfully deployed on art works postdating the introduction of photography in the mid-eighteenth century, when artists were liberated from the necessity of carefully constructed perspectival drawing for the sake of accurate representations.

Figure 6.

Screenshot of Rhinocad modelling of pier from Serres painting.

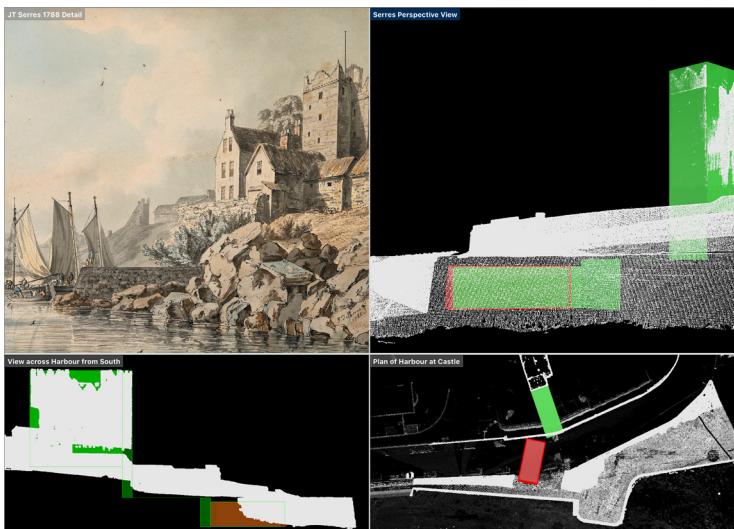
Top Left: Detail from Bullock Castle & Harbour, John Thomas Serres, 1788—
© National Gallery of Ireland.

Top Right: LiDAR scan data in perspective to match Serres detail, illustrating
use of extracted shape file (green) from Adobe Photoshop overlaid on LiDAR
scan (white) with hypothetical Serres' pier modelled (red).

Bottom Left: View of shape file overlaid with LiDAR scan data showing elevation
of historic pier relative to current pier. Bottom

Right: LiDAR scan data in plan with location of historic pier (red) relative to
current pier. (Shotton, 2019)

During the actual modelling process the Serres painting would appear as
background underlying the scan data illustrated in the top right perspective



Explicit acknowledgement of the underlying assumptions that govern matching the LiDAR scan data to any historic image in perspective is also required. The earliest endeavours with this methodology were more art than science, involving the careful rotation of the LiDAR data relative to the image to achieve the best correlation between isolated reference points, such as the castle. Advancing this technique to model more of the Place image in three dimensions, such as the landscape, increased the number of reference points that required correlation, which exposed a variability in possible results depending on the underlying assumptions used to define the perspective view. Critical in defining the perspective are; the position of the artist in the landscape, both in plan and elevation; the cone of vision used for the perspective view, and location of the “picture plane” which acts as a boundary to frame the image. All of these can be actively managed by enabling the “camera” tool in *Rhinocad*, but require clarification and justification.

In the case of the Place drawing from 1699, which is currently being modelled in its entirety in an effort to further understand the early harbour condition, there are clues within the image that defined the position of the artist. The perspective in the drawing, defined by the vanishing lines of the castle and piers, establish that Place’s eye-level was at the midpoint of the castle height. Only “Old Bullock” rocks, on the east side of the harbour, would have provided a vantage point this high. Though much quarried in the early nineteenth century, the LiDAR scans establish that this is still a reasonable hypothesis based on the current height of the rocks and extent of quarrying. The position in plan is defined by the relative proportion of the south and east walls of the castle drawn by Place, while the picture plan is set at the visible edge of the east pier.

Establishing the appropriate cone of vision, or “camera focal length” as described in *Rhinocad*, was responsible for much of the variability in earlier trials. A traditional cone of vision for

perspective drawing would be 60 degrees. However, considerable trials showed that the best matches were achieved with a “camera focal length” approaching 43 degrees. This was true of all three drawings analyzed for Bullock Harbour. This is a function of the underlying software code used in *Rhinocad*. Although *Rhinocad* describes the three-dimensional view as a perspective, the code appears to be operating on the principle of camera lens geometries, which have different properties to a perspective. This is apparent from the consistency of the 43-degree cone of vision, as this represents the camera lens focal length that most closely approximates human vision²³.

As images are more comprehensively modelled using this methodology, beyond the matching of a single reference point, the relative position of all the features as well as the position of the artist are clarified and refined to give a more accurate result. Future modelling of the entire context visualized in the Place drawing of 1699 currently underway will clarify the topography and configuration of the original shoreline, which for the moment is conjectural, based on early nineteenth-century maps of the coastline.

RECONSTRUCTING THE TIMELINE OF BULLOCK HARBOUR

The claims made by various historians regarding the presence of a medieval pier built by the Cistercian community are not founded on evidence, but on assumptions regarding the fleeting references made to landings at Dalkey Harbour found principally the Irish Chancery Rolls, now digitized on the *CIRCLE* database at Trinity College Dublin (TCD). These references are conflated with the illustration made by Place in 1699, which when published²⁴, is commonly cropped in such a manner that the eastward pier is no longer visible, resulting in a preoccupation with the pier under

23. Cambridge in Colour, “Cameras versus the Human Eye”, [online], *Cambridge in Colour*, <https://www.cambridgeincolour.com/tutorials/cameras-vs-human-eye.htm>, (page consulted on August 20th, 2019).

24. De Courcy, *The Liffey in Dublin*, p. 54.

the shadow of the castle to the west. D'Alton is the only historian who recounts the remains of an eastern pier, with much of his description taken verbatim from a report of 1800 (published 1806)²⁵ by Captain William Bligh on the state of Dublin Harbour, which provides precise dimensions of the ruinous east pier. This conflation is then reinforced by Serres' painting of 1788, which appears to be illustrating a pier in the same location, leading to the misattribution that this pier had been in existence since at least the fourteenth century. There are reasons to discount this narrative, based on both textual evidence in addition to discoveries made during the course of interrogating these images using LiDAR scans of the current harbour.

The Medieval Pier Hypothesis

References to landings at Dalkey Harbour found throughout the ancient records may well refer to Bullock, however, as there were known to be several landing sites at Dalkey, including Coliemore, Castle Harbour and Brenan's Quay, there is no certainty to this attribution. In addition, Gilligan makes a sound argument in his work on Dublin Port that Dalkey Harbour should be understood as Dalkey Sound, a deep-water passage between the mainland and Dalkey Island, where ships had sufficient depth and shelter to anchor, accessing the various landing places with small boats²⁶. The only reference specific to Bullock (spelled Blowyk) is found in Patent Roll 3 (Henry IV)²⁷ for a landing in 1401, which fails to mention any pier structure. Evidence for a haven, a term usually understood to mean a natural cove, is cited by D'Alton, from the transfer of property to the Fagans in 1611²⁸ and is found again in

25. Accounts, p. 55.

26. Gilligan, *A History of the Port of Dublin*, p. 9.

27. Peter Crooks, ed., "Blowyk", [online], CIRCLE A Calendar of Irish Chancery Letters, c. 1244–1509, Trinity College Dublin, <https://chancery.tcd.ie/>, (page consulted on March 11th, 2019).

28. D'Alton, *The History of County Dublin*, Dublin, Tower Books of Cork, 1976, p. 881.

the Civil Survey of 1654²⁹. Useful in the interpretation of what a haven might mean at this early date are the inventories taken of the Irish monastic lands at the time of their dissolution in 1540–41³⁰. Instances of built harbour structures are clearly called out, as at the Priory of Holmepatrick to the north of Dublin, where a *key* (an early variant of the spelling of quay) is described, yet, at Bullock no reference to a *key* or even a haven appears³¹. The absence of such descriptions in the historical record exposes the assumptions that have been made regarding the need for built structures to facilitate fishing. During the medieval period in Ireland fishing most often involved the use of weirs for catching fish³² that was hauled in with small boats, which could have easily been drawn up onto the sandy beach present at Bullock at that period. Though there is no evidence to confirm or deny the presence of structures at this period, as harbour structures rarely survive intact for 400 years or more, there is reasonable doubt as to the piers illustrated by Place being of early medieval origin.

Monastic lands were redistributed to those loyal to the King following the dissolution of the monasteries, with the property at Bullock held by the Crown but leased to Peter Talbot in 1542. Though the property was held by the Talbot family until 1611, the early death of Peter Talbot in 1555³³ lead to the lands being assigned to the Fagans of Feltrim during the sixteenth century in advance of the King granting these lands to John Fagan in 1611³⁴. The Fagans retained tenure until the beginning of the eighteenth century, during which time Place illustrated the early stone piers, but lost the property due to perceived

29. Robert C. Simington, ed., *The Civil Survey A.D. 1654–1656: County of Dublin*, vol. viii, Dublin, Irish Manuscripts Commission, 1945, p. 268.

30. Great Britain, *Extents of Irish monastic possessions, 1540–1541*, Dublin, Stationery Office, 1943.

31. *Ibid.*, pp. 11, 49.

32. Colin Breen, “A Medieval Fishery at Rossglass, Co. Down”, *Ulster Journal of Archaeology*, vol. 58 (1999), pp. 153–55.

33. Ball, *History of the County of Dublin...*, p. 37.

34. A. T. Lucas, “Furze: A Survey and History of Its Uses in Ireland”, *Béaloideas*, vol. 26 (1958), p. 22.

disloyalty to the Crown in 1702³⁵. It was then sold in 1703 to the Allen family, later to become the Earls of Carysfort. There is a *haven* noted in the historical record at the time that the Fagan family assumed ownership in 1611, which suggests a natural cove rather than any built structures, implying that the piers illustrated by Place were built by the Fagans after this point, though no evidence has been found to verify this hypothesis. The only certainty is that piers did exist at the time of the Fagan tenure in the late seventeenth century.

LiDAR Interrogation of Early Harbour Constructions

Given that most histories suggest that the medieval pier survived intact until the harbour's rebuilding in the early nineteenth century, there is an implied assumption that the piers illustrated in the Place and Serres images are the same structure. The Place drawing is well known, though the Serres painting less so, as it is rarely shown in the National Gallery of Ireland, who only gained possession of it in 1984. However, though Serres' painting would not have been in broad circulation, there was an etching made from this work by Francis Grose and published in the 1795 edition of *The Antiquities of Ireland*, which was more commonly available. This may have served to reinforce the view commonly implied in the histories of Bullock, but the veracity of this assumption is dispelled through the aid of comparative modelling undertaken on both images with reference to the LiDAR data. The interrogation of these images confirms that the western pier in these two illustrations are not coincident, with the northern face of the Serres' pier located south of the pier in Place's drawing (*Figure 7*), though its width is undefined. The rubble of rough stone pictured adjacent to this pier in the Serres illustration may well be the ruins of the older pier, a hypothesis given some credence by the local community resident in Bullock

35. G. T. Stokes, "The Antiquities from Kingstown to Dublin. Part I", *The Journal of the Royal Society of Antiquaries of Ireland*, vol. 3, n°4 (1893), p. 355.

referring to the entry of the current harbour “as the harbour ruin”³⁶, though no ruin is now present.

Figure 7.

Bullock Harbour in plan showing conjectural piers modelled from Place and Serres images superimposed on LiDAR scan in white for clarity, with width of Serres pier uncertain (transparent white)—Shotton, 2019.



Text-based evidence from a petition by the Merchants and Traders of Dublin to Irish Parliament supports the rebuilding of this eastern pier in the eighteenth century, as they petition for “continuing the new quay” in 1765³⁷. This not only suggests that the western pier in Place’s drawing had collapsed but it is clear from the language of the petition that a new pier (described as a quay) was built on the western shore prior to the petition, which was soliciting its enlargement. For clarity, the terms quay and pier are often used interchangeably, though technically a pier is a structure built perpendicular to the shore line, while

36. Bullock Community, “The Harbour Ruin”, Elizabeth Shotton, *The Building of Bullock Harbour*, Dalkey Heritage Centre, Bullock Harbour Bicentenary Lecture Series, 2019.

37. Ireland, *Journal of the House of Commons of the Kingdom of Ireland*, 4th Edition, vol. XII, (1765).

a quay is parallel. While the exact building date of this “new quay” is not clear from this evidence, there was a King’s Barge, otherwise known as a revenue cruiser, for monitoring the coastline for smuggling activity stationed at Bullock in 1757³⁸. It is known that landlords of large estates were actively petitioning for the placement of cruisers near their coastline in the eighteenth century, as both Fethard dock (1741) in Wexford³⁹ and the quay at Portrane (1756) in Fingal County⁴⁰ were built by estate owners for the Revenue Commissioners. On this basis, it appears reasonable to propose that this “new quay” or pier was built prior to 1757 by the Earl of Carysfort for use by the Revenue Commissioners. Though the construction of the piers illustrated by Place is unclear, beyond being stone, detail in the Serres illustration suggests roughly dressed and coursed stonework, reminiscent of the still extant Sandycove pier known to have been built by the Earl of Carysfort in the early eighteenth century, which is roughly dressed, coursed and mortared stonework, lending weight to this proposition.

Given the view in Serres painting, the width of the pier was impossible to define, but similar analysis on an etching by Greig from *Excursions through Ireland* provides evidence as to its dimension following the extension proposed by the Merchants and Traders (*Figure 8*). Though the etching was published in 1820⁴¹, after the complete rebuilding of the harbour, it is based on an early undated drawing by George Petrie. The Petrie drawing was clearly made before the rebuilding, as the stone wall retaining the road to the harbour at the right side of the castle extends into the water, while in 1819–20 a quay was built in front of this wall. Evidence for the date of building of this road wall comes from a

38. Irish Revenue Board and Irish Board of Customs, *Minute Book*, CUST 1/61, London, National Archive UK (1757).

39. Elizabeth Shotton, “Commissioners, Lords and Moles: The Story of Fethard Dock”, *On the Hook*, Wexford (2018).

40. Thomas King Moylan, “The Peninsula of Portrane: Part I”, *Dublin Historical Record*, vol. 16, n°1 (1960): pp. 22–33.

41. Thomas Cromwell, George Petrie and John Greig, *Excursions through Ireland*, London, Longmans & Co., Paternoster Row, 1820.

1786 notice to build the road and wall in the Journal of the House of Commons of Ireland⁴². This was apparently undertaken after the Serres painting of 1788, which fails to illustrate this wall, and may date to as late as 1807, given evidence of a road constructed by Dublin Port between Sandycove and Bullock harbour at that date⁴³. Examination of the etching relative to the LiDAR scan confirmed this is the same road wall that currently exists and provided evidence for the width of the pier built by Carysfort and extended by the Merchants and Traders of Dublin in 1765, apparently in both directions to create an extremely wide pier (at the top of *Figure 9*), thus justifying its description as a quay.

Figure 8.

Bullock Castle, Co. of Dublin, J. Greig after George Petrie, In Excursions through Ireland, 1820—© The Board of Trinity College Dublin.

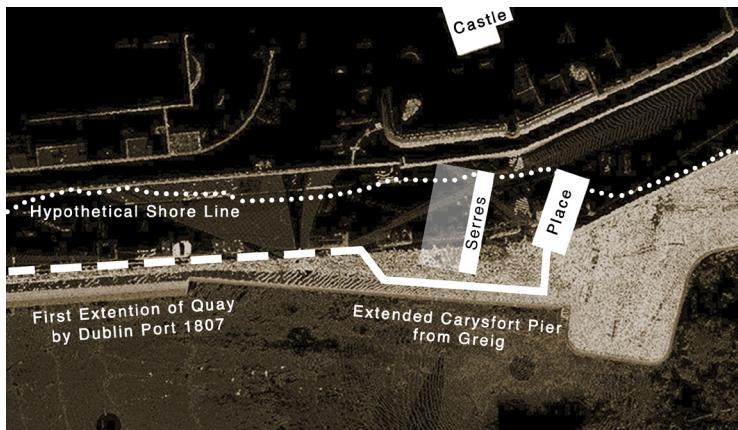


42. *The Journals of the House of Commons of the Kingdom of Ireland*, 22 October 1761–30 April 1762. Second ed. vol. 12, Dublin, Abraham Bradley, 1778.

43. *Journal of the Proceedings of the Corporation for Preserving and Improving the Port of Dublin*, vol. 6, BR/DPDB 1/6, Dublin, National Archives Ireland, 1806–1808, pp. 141–142.

Figure 9.

Bullock Harbour in plan showing modelled piers from Place and Serres superimposed on LiDAR scan in white and edge of wider, extended Carysfort pier illustrated in Greig (white solid line) and first quay extension by Dublin Port (dashed white line)—Shotton, 2019.



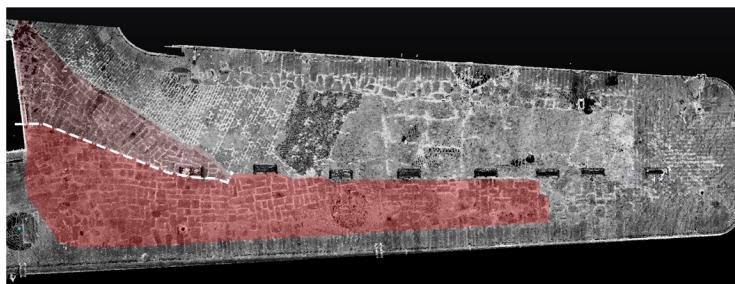
Topographical artists, such as Place and Serres, built their reputation on the accuracy of their representations and Place's considerable reputation holds up well under scrutiny with the scan data, as does the illustration of the castle and *Old Bullock* rocks (from which the name of the harbour is derived) in Serres' painting. Yet, there is reason to doubt the overall composition by Serres, as he has edited the perspective in an effort to illustrate the *Old Bullock* rocks adjacent to the Castle for picturesque effect, effectively eradicating the harbour itself. Thus, the eastern edge of the harbour, where another pier, or ruin of a pier, should be located is obscured by this editing and Serres' carefully positioned, finely drawn boats. However, in the same petition from the Merchants and Traders of Dublin, there is a request to build a jette on the opposite shore, where one would anticipate finding the remains of the east pier from Place's illustration. Technically a jette is a structure to train the course of a river, though can be used to mean a breakwater, which is more

likely in this context. This was certainly built, as by the time of Bligh's report remnants of an old quay to the east are described, later illustrated in Pratt's painting, *Bullock Castle, Co. Dublin from the Old Breakwater called the Danish Pier* of 1813 as well as being partially visible in the foreground of the Greig print.

Physical evidence of this is clearly exposed in the high-resolution LiDAR data (*Figure 10*) in which the physical remains of a rough-hewn stone structure is visible within the larger ashlar (dressed) granite construction built by Dublin Port. The rough-hewn stone construction in the scan may consist of two independently constructed structures (toned in red), as there is a continuous joint present (white dashed lines). The lengthier section at the bottom of the image closely matches the dimensions quoted by Bligh and given the irregularity of its edge condition it appears likely that it had partially collapsed. The smaller remnant near the top left of the scan may relate to an earlier pier but its position has not been adequately correlated to the eastern pier illustrated by Place in the analysis to date. The surface of the remainder of the pier is irregular due to multiple repairs undertaken following the removal of the original cranes.

Figure 10.

LiDAR scan of east pier of Bullock Harbour in plan with red highlighted area showing rough-hewn stone work indicative of earlier construction (white dotted line indicates continuous joint)—Shotton, 2019.



There is an abundance of factual threads that can be linked together by virtue of this analysis that provides a more substantive history of the early constructions at Bullock harbour. This aids in moving the record from a naïve faith in the durability of piers that can survive hundreds of years, to a clearer lineage of construction, from the early sandy cove governed by the Cistercians, which may or may not have had piers, to the two stone piers likely built by the Fagans, which were in ruin by the mid-eighteenth century. A rebuilding of the west pier by Carysfort in the early to mid-eighteenth century, similar to the roughly coursed and mortared structure at Sandycove, is quickly followed by its extension at the request of the Merchants and Traders of Dublin in addition to the construction of a rough-hewn stone breakwater to the east, part of which may still be buried in the current granite pier built in the early nineteenth century. Though much of this history could be discerned from a closer reading of the textual evidence than has been done previously, only by virtue of the visual analysis using the LiDAR scan data was it possible to verify that these previous piers were not coincident by providing evidence as to their location.

Construction Works by Dublin Port

The sequence of constructions before the harbour and the surrounding lands were leased to Dublin Port is far more complex than the simplified versions published to date. This more nuanced narrative is possible largely due to the comparative visual analysis of historic imagery to isolate features, which can be verified against textual data. However, this simplification in the history of the building of Bullock Harbour is not limited to its early history. Works undertaken by Dublin Port are likewise reduced to a summary retelling of the construction of the finely dressed granite quays and piers to both east and west starting in 1818 and described, erroneously, as completed by 1819. Some authors, notably Smyth, also took note of the earlier building of the pilot

houses in 1806. Missing from these narratives is the sequence of quay extensions and minor elements such as slips, in addition to a misattribution of the timing of the final stages of work that took place on the west quay and pier, all of which ties back to the presence of what can now be described as the Carysfort pier under the castle, built in the early to mid-eighteenth century.

The building of the pilot houses by Dublin Port is relatively common knowledge, possibly because of their longevity on site, as they were only demolished in the late twentieth century. Evidence for their building is found in the journals kept by the port⁴⁴ that Smyth used as a source for his short history on the harbour. Despite Smyth's use of the archived journals, he failed to elaborate on the fuller complexity of the construction sequence of the harbour itself, likely because his preoccupation was with the community of Bullock, rather than its infrastructure. These journals in tandem with the Lighthouse journals⁴⁵ provide ample evidence for the sequence of construction (*Table 2*), starting with the pilot houses in 1806 and continuing to 1820, when the harbour in its current form was completed. The untimely separation of the Commissioners of Lights (responsible for lighthouses in Ireland) from the Dublin Port & Docks Board in 1818 has a bearing on oversights by researchers looking at the history of Bullock, as their formerly shared journals were separated, leading to the displacement of a number of journals to the Commissioners of Lights, now housed in an archive in Baily Lighthouse. This has resulted in the early works by Dublin Port, up to 1815, being recorded in journals held by the National Archives of Ireland (NAI), with the building work of 1818–19 recorded in the Lighthouse Journals, and the final stage of building works found, once again, in the journals at the NAI.

Equally, due to the manner in which memoranda in these journals are framed, it is often less than clear as to what the text

44. *Journal*, BR/DPDB 1/6, p. 142.

45. *Corporation Lighthouse Journals*, vols. 2 & 3, Dublin, Baily Lighthouse Archive, 1814–1818, 1818–1822.

is referring to, as in an early note about wall building from 1807, where neither the description of a wall “at the back of Bullock Quay” or a wall “inside Bullock Quay” provides sufficient information as to where these walls are actually located, or what function they might be performing:

George Smith proposes building a good dry stone wall at the back of Bullock Quay 144 feet long, 12 feet high, 7 feet at the foundation and 5 feet at the top... [and]... also proposes building a wall inside of Bullock Quay 231 feet long 12 feet high 5 feet at the foundation and three feet at the top.⁴⁶

The use of LiDAR scan data coupled with the previous analysis and location of constructions that existed before this proposal enabled the ambiguity of this text to be clarified, as dimensions were verified, not to existing features, but to the modelled historic elements no longer present or visible on site, discovered in the earlier visual analysis.

Setting these dimensions against the location of the hypothetical enlarged Carysfort pier, coupled with the knowledge that a few years later “it [had] become necessary to continue the Quay Wall about Eighty feet farther to prevent the sea acting on and washing away the road”⁴⁷ and providing a slip clarifies this ambiguity. The wall of 231 feet described as “inside of Bullock Quay” represents the quay wall built in 1807–08 extending from the enlarged Carysfort pier and is the appropriate dimension to link the later 80 feet of wall to the slip (*Figure 11*), while the wall built “at the back of Bullock Quay” is the boundary wall between the harbour and the grounds of the castle. This proposition is verified by an early photograph of the harbour wall from the slip, c. 1940 (*Figure 12*), which shows that the west quay wall was clearly built in two stages. The wall adjacent to the slip (left side of image) is formed of roughly hewn, un-coursed stonework, which then transitions to coursed work, the latter not currently

46. *Journal*, BR/DPDB 1/6, p. 142.

47. *Journal*, BR/DPDB 1/8, p. 306.

visible due to a much later (c. 1960) concrete wall cast against the failing structure.

Figure 11.

Bullock Harbour in plan showing Dublin Port constructions (white lines) of an extended quay wall built 1807–08 extending from enlarged Carysfort Pier, further quay wall and slip additions in 1813–15 and road wall, superimposed on LiDAR scan of current harbour. Thin dashed white lines indicate earlier constructions. The eastward edge of the harbour (bottom of the image) would have been unbuilt save for the ruinous breakwater (solid white line)—Shotton, 2019.

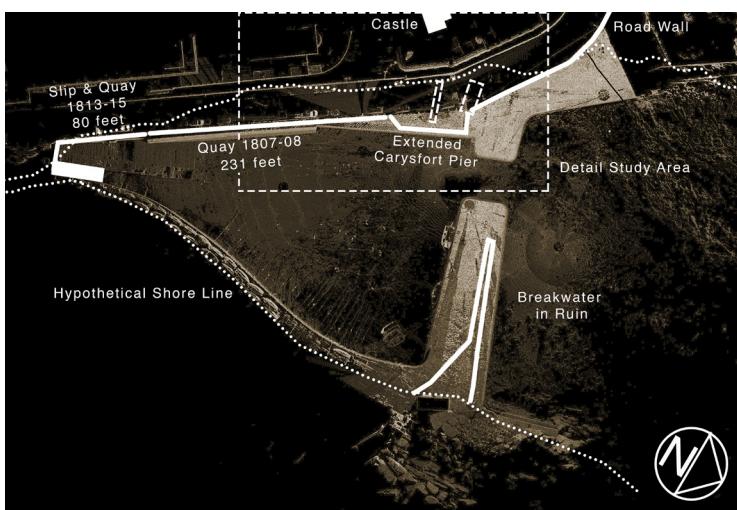


Figure 12.

Bullock Harbour, Cardall Photographic Collection, 1940-60—Reproduced courtesy of the National Library of Ireland CAR 011/012 NPA.



Though Dublin Port appears to have been content to make only modest adjustments to the harbour for the first decade of their lease, by extending quay walls from the enlarged Carysfort pier and adding a slip, by 1818 their Chief Engineer George Halpin made a proposal to build a quay and pier to the east of this cove, complete with very detailed specifications for the works, which was completed by 1819.⁴⁸ It is this specification for works that is referenced by most historians, including Smyth, for dating the building works that resulted in the current configuration of the harbour. Though the text is clear regarding the extent of work, which is “building a new pier and quay wall”⁴⁹, not two piers or two quay walls as was ultimately done, this fine distinction is not made by any historian. Of interest is that the works planned for in 1818 and completed by 1819 make it clear that Dublin Port had intended to continue to use their earlier quay walls, slip

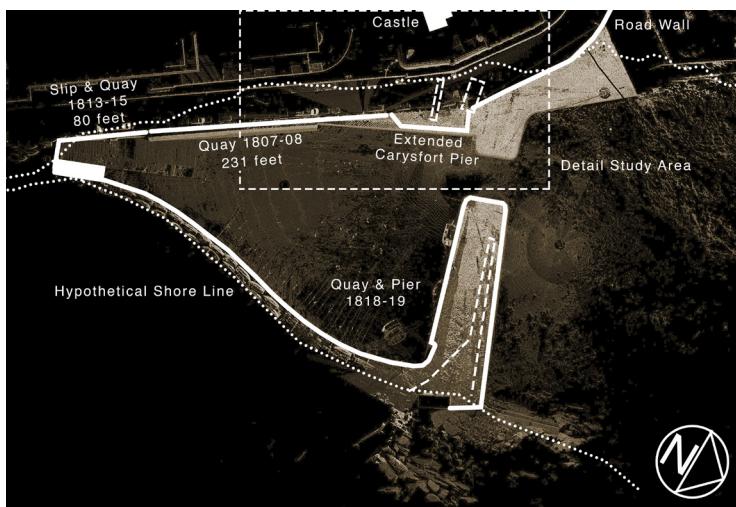
48. *Corporation*, vol. 3, pp. 21–23.

49. *Ibid.*, p. 21.

and the enlarged Carysfort pier as part of their harbour structure (*Figure 13*).

Figure 13.

Bullock Harbour in plan showing outline of harbour structure in 1819 as white solid line, including reuse of extended Carysfort pier, superimposed on LiDAR scan of current harbour. Thin dashed white lines indicate earlier constructions—Shotton, 2019.



There is no rationale recorded for why Dublin Port, having completed the planned works in 1819, then chose to extend the contract to building a similar ashlar (dressed) granite quay and pier on the west side of the harbour to match the east. This work was completed in 1820 by the same contractor, George Smith, and met the same specifications. What is possibly more interesting, at least to the historian or an archaeologist, is that the otherwise inexplicable change in direction of the long-west quay wall takes on meaning when viewed in tandem with the placement of the Carysfort pier (*Figure 14*). The new ashlar quay wall starts at precisely this change in direction, visible in *Figure 12*,

and suggests that Smith built this new quay wall directly in front of the seaward edge of the Carysfort pier, rather than dismantling the older structure before building. A much later trenching operation in the road surface to lay a new drainage system in 1957 likely destroyed much of this Carysfort pier, though elements could still be buried under the road at the base of the castle.

Figure 14.

Bullock Harbour plan showing outline of harbour structure in 1820 superimposed on LiDAR scan of current harbour with extended Carysfort pier buried behind 1820 quay structure. Thin dashed white lines indicate earlier constructions—Shotton, 2019.

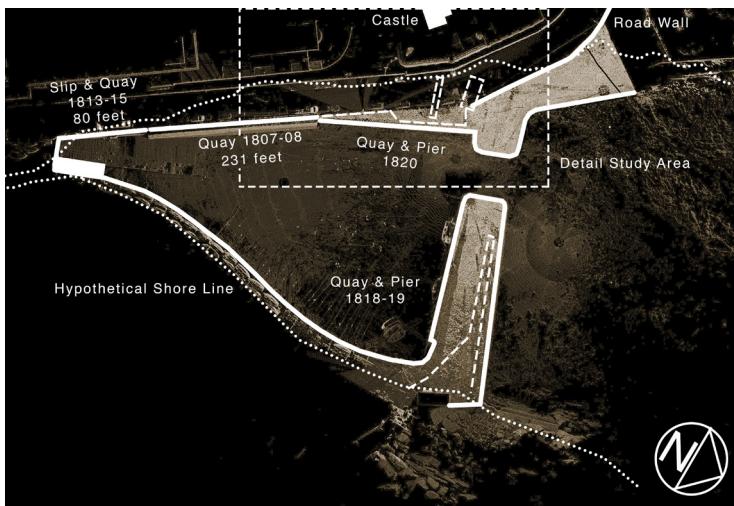


Table 2.

Construction Timeline: Bullock Harbour, Dalkey, County Dublin, Ireland

Date	Owner	Harbour Construction	Evidence	Notes
c. 1200 to 1400.	St Mary's Abbey.	Unknown.	Donnelly, Gilligan, D'Alton, de Courcy, Smyth.	Structures unconfirmed. Sandy beach may suggest no structures were required for small boats.
c. 1600.	Fagan of Feltrim.	Two stone Piers.	Francis Place.	Possibly built by Fagan.
1757.	Allen, Earl of Carysfort.	Building of western pier.	Revenue Cruiser stationed at Bullock Harbour.	Hypothesis based on date and constructive detail of Sandy-cove pier.
1765.	Allen, Earl of Carysfort.	Extension of western pier (described as quay), jette built on opposite shore.	Journal of the House of Commons of Ireland, vol. 8.	Petition to extend "new quay" and build "jette".
1788–1807.	Allen, Earl of Carysfort/ Leased to Dublin Port 1805.	Building harbour road and wall to sea.	Journal of the House of Commons of Ireland, vol. 12 and BR/DPDB 1/6.	Notice of building a road to "Dalkey" Harbour 1786, not in Serres (1788). Dublin Port records show building of road, but not wall, in 1807.

1806.	Leased to Dublin Port.	Building of Pilot houses.	Journal of the Proceedings of the Corporation for Preserving and Improving the Port of Dublin, vol. 6 (BR/DPDB 1/6).	Two earlier houses pre-existed on site before the building of the pilot houses, the latter demolished in the late 20 th century.
1807–8.	Leased to Dublin Port.	Extension of western quay/ road wall; boundary wall to castle.	BR/DPDB 1/6.	Extension of quay wall by “231 feet long 12 feet high 5 feet at the foundation and three feet at the top”, and a boundary wall to the castle “144 feet long, 12 feet high, 7 feet at the foundation and 5 feet at the top”.
1813–15.	Leased to Dublin Port.	Extension of quay wall, building of slip.	BR/DPDB 1/8.	“continue the Quay Wall about Eighty feet farther” and “a landing slip to be made”.
1818–19.	Leased to Dublin Port.	Building of east quay and pier.	Lighthouse Journals, vol. 3, Bailey Lighthouse.	“building the pier at Bullock” and “The wall which is to sustain the road leading to the pier”.
1819–20.	Leased to Dublin Port.	Building of west quay (in front of “Carysfort” pier) and new west pier.	BR/DPDB 1/10.	“building that part of the quay of Bullock you showed me [and] finishing it in the manner... done the opposite side”.

VIRTUAL ARCHAEOLOGY AND THE FRAMING OF EVIDENCE

Much of the evidence used to establish this more finely grained history of the evolution of Bullock Harbour would have been available to earlier historians researching this structure and, when assembled as a timeline (*Table 1*), provides a fairly authoritative reading of the building of Bullock harbour. There are still moments in this sequence that remain open-ended hypotheses, such as the existence of pier structures during the medieval period, or the role the Fagans may have played in building the piers illustrated by Place in 1699. However, there were also points where textual and visual evidence, even when viewed in tandem, could not be reconciled into a coherent pattern of evidence without some other form of analysis. It is precisely in this reconciliation of apparently conflicting or ambiguous information that a comparative visual analysis using LiDAR can be effectively used by a historian.

The interrogation of visual evidence relative to the LiDAR scan data was essential in identifying the different locations of the piers illustrated by Place and Serres, effectively dispelling the assumption that a medieval pier persisted at this location until the building out of the current harbour by Dublin Port. It was also central to identifying the width of the pier illustrated by Serres, by superimposing the three-dimensional information drawn out of the etching by Greig onto the pier modelled from the Serres' image. This in turn aided the interpretation of text found in Dublin Port's early journals, establishing the sequence of early construction work by Dublin Port, and explained the apparently random change in direction in the west quay wall, which hints at a still extant, or partially extant, Carysfort pier lying behind the current west quay wall.

The resulting insights as to the location and sequence of different elements of the harbour structure enable a more authoritative history to be developed, which dispels many of the assumptions underlying previous historical narratives. The methodology

represents a paradigm shift for comparative historical analysis of both conventional and unconventional source material. The interpretation of visual material relative to textual information is common in historical research, often employed by construction historians in the study of singular or collected harbour works. However, the ability to interrogate this data through three-dimensional modelling techniques relative to LiDAR scan data can both clarify ambiguities in the textual evidence, by providing a dimensionally accurate framework in which to test evidence or hypotheses, as well as enabling a reasonably accurate method to recreate the sequence and relative placement of historic elements relative to an existing structure. This new methodology allows for the framing of historical evidence through a non-invasive interrogation of its physical form and temporal development—a form of virtual archaeology.