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Persistence and Risk - Salt production in post-medieval Ireland

Wes Forsythe, Rosemary McConkey and Colin Breen

Centre for Maritime Archaeology, Ulster University. Contact author: w.forsythe@ulster.ac.uk

Abstract

Salt was a common trading commodity in a post-medieval Europe of expanding horizons and populations. It was, however, expensive and laborious to produce in northern Europe and foreign supplies were vulnerable to disruption. Its importance was especially pronounced in countries such as Ireland, which failed to industrialise on the scale of Britain, and relied on its agricultural produce and exports. This paper explores the changing fortunes of salt in Ireland by examining a complex of sites at Ballycastle. In operation for three centuries, it was one of the more enduring and resilient sites of manufacture. It identifies individual agency, innovation and legislation as key factors for its relative success. Conversely, the business was periodically jeopardised by social and political unrest, factionalism and incompetence. As part of the wider Atlantic world Irish salt and salted provisions exploited emerging colonial networks of trade, however these market forces perpetuated social inequalities with attendant risks to food security.

Keywords: Post-Medieval, salt, industry, Ireland, colonialism, Atlantic, economy, pans

Introduction

Archaeological issues of vulnerability and risk are often expressed in climatic, food security, and resource terms (e.g. Cooper and Sheets 2012; Ribot 2014; Logan 2016). This paper seeks to explore those themes by concentrating on an emerging commercial endeavour in an era of nascent modern capitalism. The Irish salt industry would have a global resonance through processes of colonialism, emerging commercial networks and expanding markets. These economic developments also precipitated risk, in particular by over-specialization and creating food dependencies. The archaeological examination of a site which witnessed three centuries of salt production serves as an exemplar of two distinct colonial outcomes – 1) British colonialism as it affected Ireland, its society and commerce; and 2) colonial expansion as commercial opportunity and one which knowingly or unknowingly reinforced social vulnerability by embedding structures of inequality and exploitation. The paper calls into question European perceptions of marginality and peripherality by recognising the inter-regional opportunities afforded by such colonial commercial developments (see e.g. Metcalf 2007) but argues that this progress was often a chimera that masked the vulnerability of society across the Atlantic world. Finally, while technological and commercial development can be traced in the archaeological complex under examination, the paper also identifies the structural forces that contributed to the industry's resilience and failure.

The production of salt has been of crucial importance to coastal and inland communities for domestic and commercial purposes for centuries. Most commonly used as a food preservative, it was also employed in numerous industrial processes and has been a highly prized commodity throughout human history. In Europe its mode of production varied greatly, dependant on environmental and climatic conditions, as well as the range of sources and processes used to extract it. On the Atlantic coasts solar evaporation of seawater took place from Portugal to France (Rau 1884, Hémery-Poisbeau 1980). However, to the north of France solar evaporation is less effective due to an increasingly cool, maritime climate (Cranstone 2012). In the late- and post-medieval periods northern European countries remained vulnerable to the vicissitudes of supply as indigenous salt production could not keep up with demand. Scandinavian and Baltic countries relied on Portuguese salt, particularly from Setúbal (Rau 1951, 1963); while French and Spanish salt also made its way to Britain and Ireland (Longfield 1924, 328; Ludlow 1993, 150; Horta 2005). In an era of competing power blocs and overseas expansion, supply was periodically affected by conflict and blockade which threatened dependant commercial interests. As such it remained imperative that northern European nations encouraged native efforts to manufacture salt or develop alternative means to preserve foodstuffs.

The vulnerabilities affecting the production of salt in northern Europe are exemplified by a complex of sites at Ballycastle in Ireland. Production at the site had to cope with issues of political and social conflict, access and transportation, competition and monopolies. Conversely, there was opportunity, technological change, innovation and ultimately survival as it stayed in operation for three centuries. During this period Ireland had to contend with changing national and international political and economic conditions, beginning with the reassertion of English power from the late 16th century, which effectively closed some of its long-standing continental trading links. A large-scale colonisation project (the Plantation of Ulster) saw the composition of Irish society change and attempts to modernise the economy. However, this also caused unrest and conflict and it was only by the 18th century that the country experienced an extended period of peace and economic growth (Cullen 1987). As its fortunes became bound up with Britain, Ireland's salt manufacture was both restricted and incentivized by British policy and similarly it was drawn into the network of imperial opportunities and rivalries experienced by its neighbour. Ireland, however failed to industrialise on the scale of Britain and much of Europe. The common reason cited for such failure is the lack of native mineral resources, particularly coal (Rynne 2006, 82). Other factors included access, lack of capital and education (Kane 1845). As a result the country's economy remained predominantly agricultural in nature. Salt-making and economic activity in general took place within a discourse informed by the colonial project and Improvement. This tended to exhort progress and potential while blaming native flaws (popularly indolence and religion) for failure to advance. Nevertheless in many cases it is possible to detect a gap Improvement rhetoric and the material outcomes of industrial schemes (see e.g. Barnard 1982; 2008)..

Salt-making in Ireland

Northern Europe exploited geological sources of salt to supply its needs where available; but in the absence of these was forced to rely on alternative methods. These include exploiting marine salt contained in shoreline sedimentary deposits or suitable species of marine vegetation to create a concentrated brine, which could then be boiled and the water evaporated (Cranstone 2012; Van Geel and Borger 2005). A further alternative was extracting salt directly from seawater, again through boiling and evaporation. The brine methods were highly laborious but more fuel-efficient, while direct boiling of seawater was less laborious but required greater quantities of fuel. In some regions of Europe near-coastal groundwater approaches 20% salinity, most notably at the Danish island of Læsø (Hansen 2010; Vellev 2002; Jørgensen 2002), however, generally northern Europe's seas contain only 3.5% salt.

Early evidence of salt making activity is rather sparse in Ireland and it is only in the post-medieval era that the industry emerges from obscurity (Ludlow 1991, 1993, 1994a, 1997). Documentary evidence is not as plentiful as in neighbouring Britain where, e.g. medieval cartularies provide indications of salt production in the vicinity of major monastic foundations (see e.g. Hall 2006). However, in common with Britain the field signatures for salt-making sites are often inconsistent or absent, even where manufacture was highly likely or attested. The indicators of processes such as winning salt from tidal muds (sleeching) or peats (selnering) are unknown to date, and therefore direct boiling of seawater, later in combination with rock salt, is the most common method encountered.

Early in the 17th century salt production in Ireland becomes visible historically and Ballycastle, on the north coast, emerges as an area of importance (Fig. 1). Other sites producing salt in the seventeenth century include Dublin Bay, and a scattering of coastal locations near ports or isolated rural enterprises (Ludlow 1991; Rynne 2006, 301). The great impediment to salt production from seawater was the lack of convenient and inexpensive sources of fuel required for the evaporation process throughout the country. With a ratio of 6 tonnes of fuel to produce 1 ton of salt, the lack of native coal resources and widespread deforestation (partially as a result of the colonisation project) hampered the industry (Whatley 1987, 9).

At the beginning of the 18th century English rock salt began being imported into Ireland, while restrictions remained in place for British works. By dissolving rock salt in seawater the salinity of the brine was increased, reducing the amount of fuel required to extract one ton of salt from eight tons of coal to one ton. Rock salt first appears in the Irish customs records in 1719 (Ludlow 2010). By 1750, 10,000 tons of rock salt were imported, rising to 20,000 by the end of the century (Hamond 1998). The number of salt works around the Irish coast also increased in this period and was noted by contemporary commentators (e.g. Brownrigg 1748, 139). In 1743, Hugh Boyd told a Parliamentary Enquiry that in 1721 his Ballycastle salt works was the only such concern between Drogheda and Lough Swilly; however since then about twenty had been established almost 'at every port and creek' (*Journ. Irish House of Commons* 31/1/1743, 539).

Some of the more important centres were naturally located around larger port towns such as Cork. The city had a particularly important role in supplying provisions (meat and butter) for transatlantic markets from the middle of the 17th century (see Cullen 1987, 11-12; Mandelblatt 2007). Salt was imported from Portugal and Spain in the 17th century, then in the following century rock salt was imported from England.. By the mid-19th century very little refined salt was imported and Cork had

nine manufactories (Rynne 2006, 301). As well as legitimate commercial activity, the differing tax regimes in Britain and Ireland favoured the import of smuggled Irish salt. Lord Dundonald, writing in 1784, estimated (rather controversially) that three quarters of western Scotland was supplied by illicit Irish salt, losing the revenue £34,896-3-6 (Dundonald 1784, 4-6). Johnston (1794, xxxii) also noted 'by some unaccountable distinction in the laws, the people of this country [Scotland] are denied'; resulting in the smuggling of rock salt into western Scotland – an indirect means of obtaining an English commodity. In 1825 the taxes and duties on all salt were abolished rendering the Irish trade (lawful and otherwise) less competitive and many refineries went into swift decline.

The Ballycastle sites

One of the more important areas of salt production was Ballycastle Bay on the north coast of County Antrim adjacent to Fair Head – the most north-eastern promontory of Ireland (Figs. 1 and 2). It comprises three sites producing salt from seawater, and later rock salt, from the 17th to 19th centuries. Salt making in Ballycastle is inextricably linked to the mining of coal deposits found in the Carboniferous strata that line the cliffs in the Bay. Fifteen mines were opened over three centuries in operation, with production at a maximum in the mid-18th century. As well as supplying Ireland's cities, local industries also stimulated demand for coal and its exploitation had a direct influence on infrastructural improvements in the district (Hamond 1991).

[Figure1.]

[Figure2.]

Much of north Antrim was in the hands of the MacDonnell family. Part of a Gaelic lordship originating in western Scotland, they had by the 16th century established a lordship over a large section of north-east Antrim and strategically created marriage alliances with the preeminent Gaelic families of Ulster. The 16th century saw the dynasty engaged in territorial disputes with Gaelic rivals and the English government who sought their acquiescence. Showing a shrewd sense for political survival they managed to retain most of their Antrim holdings while retaining their Catholicism into the 17th century. This period saw the consolidation of English power in Ireland through the colonisation of Ulster with Protestant settlers from England and Scotland. While this plantation project initially restricted the traditional connections between the MacDonnells and the west of Scotland, Sir Randal

MacDonnell made efforts to modernise his estate under the new regime and was made Earl of Antrim for his good service to the Crown in 1620.

The earliest known reference to salt-working (and coal mining) in the district comes from the will of the first Earl dating to 1629 (McGill 1988). In this document the Earl leaves to his wife 'all my salt workes, and my coal workes' (Hill 1873, 437). Reference to salt works is repeated in a lease issued ten years later and the mid-17th century Down Survey map shows two sites marked 'salt pans' in the Bay (PRONI D2977/3A/2/36/1; D597/1/14). The accompanying parish description adds, 'Neare unto this point are two salt pans where salt is artificially made by the boyling of salt water with pit coale which coal pits are very near to the pans aforesaid and yield great profit to the possessour....' (PRONI D597/2/56).

Salt production had to contend with disruption due to political developments and social unrest in this early period, e.g. discontent toward the new regime erupted in the 1641 rebellion, which saw British settlers killed at the pans (TCD Ms. 838, fols 074r). The Irish economy became more stable after the 1660s but remained vulnerable to unrest. During the Williamite wars (1689) the salt works were seized by the Duke of Schomberg on behalf of the King in order to supply his army (PRONI D1375/3/27/4). This led to a protracted campaign into the following century to recover rents and arrears covering the period of the seizure (PRONI D1375/3/27/6). Nevertheless, production continued with references to new pans and pumps in 1708 (PRONI D1375/3/27/6).

Ballyreagh Lower and Tornaroan

The archaeological indicators of salt production comprise a series of rectangular reservoirs cut into the intertidal bedrock in the townlands of Ballyreagh Lower and Tornaroan (McGill 1988, 1989; Fig. 1). The sites correspond well with the location of the salt works shown on the Down Survey map (see above, PRONI D2977/3A/2/36/1; D597/1/14). These were connected to the open sea by a narrow channel – admitting seawater at high tide which could then be retained by means of a sluice gate or other arrangement. These seawater reservoirs, known as 'bucket pots' in Scotland (see Whatley 1987) provided a convenient supply of seawater to salt makers at all states of the tide; in addition they allowed impurities to settle on the bottom of the basin providing cleaner water for evaporation. Similar features have been noted in Wales (Wilkinson *et al.* 1988) and Scotland (Yeoman 1999) dating to the Late Medieval and Post-Medieval eras.

At Ballyreagh Lower a rectangular reservoir (5.9x3.8m) orientated north-south, has been cut into the bedrock (Fig. 3). It has a narrow opening (0.6m) to admit seawater at the north-west corner –

presumably some form of sluice gate was in operation at this point but no trace of its position can be detected in the bedrock. The overall depth of the basin is 2.1m, and the sea fills it at high tide to an average of 0.9m. To the rear of the site a stony beach gives way to a steep, grass bank rising to the base of the cliffs. This area was the site of the Gobb colliery, and the remains of an embanked service road can still be detected. Much of the hillside has an overburden of spoil material from the colliery that has altered the original topography; therefore locating the pan house represented a significant challenge. However to the east of the reservoir a V-shaped indentation in the rising scarp suggested that spoil migrating downslope had been interrupted by an upstanding structure. A small test trench excavation within this area successfully located two walls and uncovered fragments of coal and bone but little artefactual evidence.

[Figure3.]

In 1720 the Earl of Antrim let the shore between the old church at Bonamargy and Fairhead for £3,500 for 31 years. The lease mentions the ‘two townlands...of Ballyreaghs [i.e. Ballyreagh Upper and Lower]’ with ‘all the saltpans and other works thereon’, indicating they were still operational (PRONI D2977/3A/2/36/2A). They were let to Richard and William McGuire, who also secured the collieries and associated buildings. In 1721 they sold shares in the lease to Richard Nutley, Richard Stewart, Thomas Burgh, Richard Stone, John Hall and Hannibal Hall. This raised five thousand pounds, which the partners used to fund improvements to the output of both the collieries and the salt works (McGill 2007, 85). The new shareholding partnership formed the Irish Coal Yard Company and they appointed Hugh Boyd and a Mr Peck as managers. The latter figure is of interest as he may be Daniel Peck, a Cheshire merchant with substantial and wide-ranging interests in salt, coal and minerals (Stobart 2004; Harrison 2003).

In Ballycastle, Boyd and Peck planned to invest £13,500 on improvements to coal mines, quays and shipping. In addition they proposed ‘*That after the Coal Works are established as afores'd which may be affected in a few months; more salt pans to be erected to Boyl Seawater after the method now practiced with success in Northumberland and Cumberland, the number of w'ch may be so far enlarged as to supply the whole Kingdom with better salt than that which is imported or made from rock salt.*’ (PRONI D/562/1191).

At Tornaroan a further bucket pot was located on the rocky foreshore. Measuring 5.65x5m, it features a rock-cut channel (1.13m wide, 12m long) admitting seawater at the northern corner (Fig. 4). The basin appears somewhat incomplete with bedrock still in place along the bottom of the north-western quarter. It is 0.5m deep on average but the southern corner is set into the rising bank to the rear and is 3m deep. Much of the foreshore in Ballycastle Bay has been subject to quarrying into the 19th century and this may be the reason for such variation. The site appears on a map of 1790 as 'old salt pans' – showing an unroofed building (Williamson 1790). In 1817 it is similarly depicted as an unroofed gabled building with one wall in a state of semi-collapse (Ayre 1817). Directly above the southern corner is a walled yard which presumably housed the original pans. In the early 19th century it was converted for use as a coal yard (it features a date stone of 1817) and today a modern house occupies the interior. To the west of the bucket pot are a series of postholes in the rock that once facilitated a wooden pier.

[Figure4.]

In 1730 Hugh Boyd sold his share in a Dublin glasshouse to John Hall and bought Hall's share in the Irish Coal Yard Company. By this time the McGuire brothers and some of the other partners were deceased paving the way for Boyd to secure complete control of the Company (McGill 2007, 86-7). Hugh Boyd (1690-1765) became a key figure in the industrial development of Ballycastle, developing the salt works, collieries, and other industries as well as communications and the town itself (Dallat 1975; Hamond 1991). Boyd came to prominence after an extended period of peace had allowed economic growth in Ireland. It coincided with increasing demand for coal, and the improved profitability of salt manufacture. These circumstances are likely to have led Boyd to abandon the site at Ballyreagh and open a new, larger salt works at Broughanlea, which is closer to Ballycastle town and its harbour.

Broughanlea

The Broughanlea works appear to date to the early 18th century – The Irish Coal Yard Co. are recorded as erecting salt works in the 1720s and it was clearly the intention of Hugh Boyd to establish an improved facility (Anon. 1733, 11; PRONI D/562/1191). The works appear to have operated successfully at Broughanlea for the rest of the 18th century. After the death of Hugh Boyd in 1765 his son, also Hugh, inherited his estate but lacked his father's business acumen and sobriety (Dallat 1975,

13; PRONI D1375/3/30/16). Boyd considered selling the saltworks in 1788, when according to Edmund McGildowney, his salt works manager, it was worth £200 p.a. (PRONI D1375/3/30/21). Upon deciding to lease the works to Archibald McDonnell in 1789 Boyd and McGildowney parted company acrimoniously. The 1789 lease describes these works as ‘saltworks and salt houses, salt pans and salt stores’. Boyd undertook to ‘supply the said Archibald McDonnell with good coal from the colliery of Ballycastle for the purpose of accommodating the said salt works....’, and stipulated ‘vessels leadened with salt rock....shall and will at all times have a priority to all other vessels...’. Boyd also promised not to establish any other salt works on his land, and not to supply coal to any other works established within six miles of Ballycastle (PRONI D509/773).

The site at Broughanlea comprises a series of rock-cut features on the foreshore, part of the previous salt works building and enclosing walls of a yard, and the remains of the evaporation pans in situ. By 1817 a map of the colliery by Ayre shows the ‘Salt pans’ as comprising up to six buildings enclosing a yard and approached via an arched, iron gate (McGill 2008, 8). To the east a line leads from a building to a feature on the foreshore depicted as a circle inside a square. The feature is the site of a partially destroyed bucket pot, the line presumably representing a piped supply to the building where the remains of the pans currently lie (6m to the southwest). This reservoir is 8.6x6.8m and features a rock-cut channel 20m long entering at the northern corner (Fig. 5).

[Figure.5]

[Figure.6]

A further series of features are located on ‘Pans Rock’ to the northwest of the bucket pot and evaporation pans (Figs. 5 and 6). A natural cave known locally as the ‘Devil’s churn’ contains a seawater pool (c.4x3m), and has been modified at both seaward and landward ends. At the landward end access is provided by seven rock-cut steps (4.8m long, 1.4m wide) which descend toward the pool. The steps feature a transverse recess in the tread of one of the lower steps to accommodate some sort of fitting; as well as text carved on the tread of the third step. This has been rendered indistinct by sandstone weathering, but appears to be a name – possibly ‘Meadden’ – and an eighteenth-century date of ?1781. To the seaward end of the pool the cave entrance is 2m high, 0.7m wide. A low ridge of bedrock at the entrance cuts off the pool within from the sea at low water. A sinkhole directly outside the cave entrance allows seawater to enter via a submerged passage below, and water can be observed flooding through to the cave interior as the tide rises (Fig. 6). Seaward of this hole a series of beam slots have been cut into the bedrock. These represent the position of a barrier that would have

prevented water entering during stormy conditions. The slots (1.8-2m long) are set horizontally, at the top of the entrance, midway and at the base; with a recessed edge between them for an upright. The Devil's churn would therefore have admitted seawater to the inner pool of the cave in a controlled manner, allowing the water to settle and impurities to fall to the bottom. Accessed by steps, water may have been removed in buckets or via a piped arrangement.

A final feature of note on Pans Rock is the tunnel in the bedrock to the landward side of the Devil's Churn (Fig. 5). Six rock-cut steps lead to a low entrance (1.5m high; 1.6m wide) to the tunnel, which is 9m long and turns slightly to the north. Chisel marks are present along the length of the passage, which terminates close to the Devil's Churn but they are not connected. The purpose is likely coal mining – there was a colliery to the rear of the site and seams were located close to sea level. Over the years subsidence in the gardens of nearby houses has indicated the locations of former adits.

[Figure7.]

[Figure8.]

Although much of the original complex of salt buildings is gone at Broughanlea, details such as former doors, windows and gables can still be seen in surrounding garden walls. Most remarkable however is the survival of the iron evaporation pan, exposed by the effects of weather and tide, at the eastern edge of the site (Fig. 7). It comprises partially buried metal plates (c.5x2m) riveted together with the edges turned upward. Clear evidence of repairs in the form of patches may be observed and it appears to be resting on brick supports and a bed of cobbles (Fig. 8). The presence of vitrified stone and coal would suggest this was the fire pit and the pans are *in situ*. The extant pan likely dates to the end of the site's working life in the 19th century, as the process of boiling seawater meant a rapid turnover of equipment (see e.g. Whatley 1987, 18).

The closing of the last works in Ballycastle coincides with the accepted date of decline in the Irish industry - the removal of salt tax and duties in 1825 and resulting loss of competitiveness (Ludlow 2010, 37). However, Irish salt production did remain viable for most of the 19th century, being stimulated in particular by the 1850 discovery of a native source of rock salt at Carrickfergus, Co. Antrim (Kelly 1869).

Discussion

The Ballycastle Bay sites reveal some of the technological and socio-political challenges facing salt production in the post-medieval era. These include common northern European problems associated with fuel resources and costs, interruptions to supplies of foreign refined or unrefined salt, legal obstacles and protectionism. Other issues relate specifically to the experience of Ireland and, by extension, Britain. Efforts to modernise the economy in 17th-century Ireland were linked explicitly with the 'civilising' mission of the British, and given increasing prominence under the discourse of Improvement (Drayton 2000; Barnard 2008; Forsythe 2012;). Indeed, the political imperative to contain and subdue Ireland would extend to salt production. Writing in objection to proposals to grant an Irish company salt-making privileges in 1633, Lord Deputy Wentworth opined: 'all Wisdom advises to keep this Kingdom as much subordinate and dependant on England as is possible' (Knowler 1739, 193; Ludlow 1994b). In the earliest phase of salt production in Ballycastle the landowner, Randal MacDonnell, sought to neutralize suspicion concerning his Catholicism by embracing the new Protestant regime and its ambitions to transform Ireland. This early 17th-century colonial phase saw MacDonnell attempting to modernise his estate and accommodate new settlers. He re-established a series of towns and settlements including sites at his stronghold of Dunluce, and an estate administrative base at the fortified headland of Dunineny (Breen 2012; McNeill 2004). The establishment of salt production centres in Ballycastle Bay were a conspicuous demonstration of MacDonnell's economic reforms, exploiting natural resources to make a contribution to the national interest, as well as improving his own estate and landholdings.

Despite the challenges of operating in the volatile atmosphere of the colonisation project, the works demonstrate considerable ingenuity. For example, the seawater reservoirs which indicate nearby salt production are likely to be a Scottish introduction in this period. Superficially, their siting on the shores of Ballycastle Bay suggest a lack of understanding of the local tidal regime, which would render them unsuitable. With a mean tidal range of 0.9m, the north-east coast of Ireland has one of the narrowest fluctuations in the country (the typical coastal range is 3m). Consequently, these reservoirs never fill to their potential. Nevertheless, the reservoir at Ballyreagh could hold 20.2m³ of seawater on an average high tide. In 1720, Henry Kalmeter claimed the average capacity of Scottish evaporation pans were 5.9m³ (Smout 1978, 41). Evaporation took place over 22-28 hours and the given the salinity levels in Ballycastle Bay (3.4%) the pan would have to have been refilled approximately four times over this period (Atkins 1997, 31-2; Whatley 1987, 28). Using Kalmeter's figure as a guide, it would have been quite possible for the Ballyreagh reservoir to supply enough seawater for the necessary refills over three high water events (assuming the operation was timed to make efficient use of tidal conditions). Similarly, the reservoir at Tornaroan, with a capacity of 25.4m³ would have been capable of supplying a pan based on Kalmeter's dimensions. The quantity of salt produced over a 24-hour period by each

pan would have been c.1003kg. The Hearth Money Rolls (1669) mention 'four fires' taxed at two shillings each at the salt pans - suggesting two pans were in operation at each site (PRONI T307). Should they have been employed concurrently the reservoir at Tornaroan would have held enough water to supply both, while that at Ballyreagh would struggle.

The key legislative stimulus to Irish salt production was the unintentional consequence of a 1702 Act restricting the refining of rock salt in England and prohibiting its export to Scotland. Unrestricted exportation to Ireland for refinement and re-export in the form of salted provisions laid the foundation for a century of expansion in the salt industry (Ludlow 1993, 156-7). In Ballycastle Bay the establishment in the 1720s of the works at Broughanlea and subsequent growth to the most sophisticated site in the area is indicative of new-found profitability. The new complex was accompanied by key infrastructural improvements, such as a tramway and harbour (*Journ. Irish House of Commons* 1743; PRONI D/562/1185). The seawater reservoirs continued to be a feature of the sites. At Broughanlea two intertidal features appear to fulfil this function – a standard 'bucket pot' and the modified sea cave known as the 'Devil's Churn'. The standard reservoir would have been capable of holding 52.6m³ of seawater and as such was a significantly larger facility than those at previous sites. It hints at a larger evaporation pan, or use of multiple pans housed in the enlarged salt works complex. The 'Devil's Churn' seems to be an opportunistic modification of a natural feature, and has a capacity of only 10.8³. Whether it operated in tandem with the other bucket pot, or was superseded by it is not known, although it demonstrates that the operation at Broughanlea sought to maximise the amount of seawater available.

The expanded capacity at the Broughanlea site is reflective of wider transformations in industrial production and the nature of business in the 18th century. As well as the economic impetus offered by legislative measures, an increased sense of connectivity in industrial enterprises is witnessed in the involvement of British engineers, prospectors and merchants. These included Daniel Peck (see above) a merchant with interests in mining, and Thomas Steers, a Liverpool-based engineer who was consulted in designing the harbour facilities (Stobart 2004, *Journ. Irish House of Commons* 1743, 533-34). Both Peck and Steers had offered technical advice on salt production or had personal investments in the industry. Ultimately, the participation of such figures was due to individual entrepreneurs and landowners. Ireland's much maligned landholding class were crucial to the success of such endeavours, whether directly or by identifying innovative lessees such as Hugh Boyd. On the other hand, the over-reliance on talented individuals (or far-sighted landlords), could be a weakness to the long-term sustainability of such enterprises and in this case they collapsed into personal recriminations, monopolisation and protectionist measures.

Conclusion

Like much of northern Europe, Ireland struggled to manufacture salt of suitable quality and in sufficient quantity to supply national demand. The industry was vulnerable to social conflict, foreign competition, fluctuating prices, and transportation challenges. It is clear too that individual agency in the form of entrepreneurs was key not only to improving the works and scale of production, but also addressing infrastructural and transport problems. Conversely this reliance on individual agency put the business at risk when left in the hands of those with less aptitude.

The demand for salt – and coal – reveal the basis of Ireland's economy and ambition in the post-medieval era. Ireland relied heavily on its agricultural output to supply the burgeoning cities of Britain, as well as overseas colonies and dependants. Salted meat, butter, and fish were among the key commodities that relied on the production of adequate quantities and stable availability of salt. As the Irish landscape – or seascape was reshaped by colonial engagement so too were the colonies and communities touched by new networks of trade and contact. Morrison and Hauser (2015) examined the place of rice as a foodstuff illustrative of the colonial nature of inter-regional commerce around the Atlantic. While the diversity of food networks expanded in the 18th century, the structural inequalities embedded within colonial relations were perpetuated and created conditions of vulnerability (377). Similarly the trade in salt, or salted provisions reinforced the social order by defining availability, accessibility and quality. Irish salt transported to the fisheries of Newfoundland in the 18th century may not have been as highly regarded as French or Portuguese; but it was superior to coarse La Tortuga salt, which was used for the refuse fish that fed West Indies slaves (Antczak 2018, 63-4; Mannion 2000). Superior salted provisions making their way to the markets of the Caribbean could be obtained by slaves at the discretion of owners or by trading their small agricultural surplus (Morrison and Hauser 2015, 379). Over-reliance on colonial food networks and the exclusive nature of food availability reveal risk as a social consequence of market forces, and this was cruelly exposed in the face of natural disasters such as hurricanes in the Caribbean (Morrison and Hauser 2015, 380). In Ireland, gradual over-reliance on an inexpensive but nutritious New World introduction (the potato) ushered in a disastrous famine when the crop failed in the 19th century. Despite the country's agricultural economy and role in the provisions trade, the poor were disproportionately effected and decimated as a result.

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Figure Captions:

1. Location map of Ballycastle and associated sites.
2. Ballycastle Bay viewed from the Ballyreagh site looking west, and indicating the positions of the other two salt works and Ballycastle town.
3. Plan of the salt works site at Ballyreagh is evidenced by the rock-cut bucket pot. In 2012 test excavation nearby uncovered the walls of a building to the rear of the pot.
4. Plan of the salt works site at Tornaroan features a rock-cut bucket pot situated below the 19th century coal yard wall (replacing the older salt works structures). Also revealed at low water is a series of rock-cut cavities to accommodate the upright posts of a pier structure.
5. Plan of the salt works complex at Broughanlea showing the position of the extant iron pans, the partially quarried bucket pot to the northeast, and 'Devil's Churn' to the northwest. See figure 6 for section.
6. Section A-B through the 'Devil's Churn' feature at Broughanlea.
7. Photograph of the Broughanlea salt evaporation pan *in situ* (T. Corey).
8. Evidence of repair in the form of patches riveted to the evaporation pan