Cultivating Salt: Socio-Natural Assemblages on the Saltpans of the Venezuelan Islands, 17th–19th Century

This paper discusses the socio-natural assemblages of salt cultivation involving humans, other organisms and natural phenomena on the Venezuelan islands of La Tortuga and Cayo Sal from the 17th to the 19th century. The research is based on archaeological, documentary and oral evidence marshalled to understand the dynamics of past solar sea salt production. In the past, a keen knowledge of the climatic conditions, the tides, and the effects of the microorganisms involved in the concentration of brine and the subsequent crystallization of sodium chloride (NaCl) was indispensable to augmenting the quantity and quality of a salt harvest. These natural phenomena could be managed through anthropic intervention to the benefit of a saltpan enterprise by investing in infrastructure and tools such as dikes and pumps, thereby modifying the natural environment of a salt lagoon. This research indicates that the Dutch in the 17th, the Anglo-Americans in the 17th and 18th, as well as the Dutch Antilleans and a US American in the 18th and 19th centuries, approached the process of obtaining salt on the Venezuelan saltpans differently. This resulted in different configurations of the socio-natural assemblages on the saltpans and a variable final product conditioned by distinct market necessities.

Keywords: Saltpans; Seafarers; Solar Sea Salt Production; Socio-Natural Assemblages; Venezuelan Caribbean Islands

Introduction

Archaeological, documentary and oral data relating to the solar salt production process on Venezuelan islands between 1624 and 1880 suggest that for those who worked the saltpans, any line dividing human activity from the natural environment was arbitrary and illusory. Anthropologist Tim Ingold (2011a, 250) contends that ‘as the edge of nature is an illusion, so too is the image of society as a sphere of life that exists beyond it’. Accordingly, this paper discusses solar saltpans within a conception of environment where nature and society are not separated *a priori*, but instead form an integral, inseparable and vibrant socio-natural whole.

To define the socio-natural systems discussed in this paper, the concept of *assemblage* is borrowed from philosopher Manuel DeLanda (2006), via archaeologist Gavin Lucas (2013, 375) who proposes that assemblages are 'collectives or systems of usually familiar entities (which include humans, pots, arrowheads etc.) that cohere in stronger or weaker ways and for longer or shorter durations.' I largely adhere to this basic definition, yet in my reading of the concept I stress that socio-natural assemblages are not merely artificially cobbled-together heterogeneous bits and pieces. Rather, they are dynamic gatherings of corresponding entities entangled through human practice (Ingold 2016, 5; 2015, 154–158; 2011b, 90–94). According to Ingold (2016, 6), correspondence is the process by which beings and things answer to one another through time. In this paper, I propose that socio-natural assemblages on saltpans coalesce through the correspondence of human doings and earthly undergoings (Ingold 2015, 155).

Unlike other solely extractive endeavours in the early-modern Caribbean (such as gold mining, pearl diving, turtle fishing, and logwood and mahogany cutting), solar salt production can be elucidated through simple agricultural metaphors. The vibrant and synergistic correspondence of human and non-human entities on a solar saltpan challenges the idea of a simple salt extraction process, and strengthens the notion of *growing* salt crystals (Ingold and Hallam 2013). The evidence indicates that to obtain high-quality salt, the process of solar salt production has to become one of methodical salt 'cultivation' and 'tending' of a saltpan. Only this leads to a bountiful 'harvest' of a 'crop' of salt.

As it elaborates such a perspective, this paper concerns itself with more than just the way humans in the past corresponded with material things, other organisms and physical and chemical processes on saltpans. It addresses how, through time, this correspondence varied within differing sociocultural, economic and political frames.

Figure 1. La Tortuga Island and the Los Roques Archipelago within the Venezuelan Caribbean.

Seafarers such as the Anglo-Americans arriving at the saltpan on the Venezuelan island of La Tortuga during the late 17th and 18th centuries, as well as various others coming to Cayo Sal in the Los Roques Archipelago during the 18th century, preferred to rake naturally-crystallized salt due to the lower costs. In contrast, the Dutch in the 1620s and 1630s on La Tortuga, and a US American entrepreneur on Cayo Sal in the 1830s invested in large-scale modifications to the salt lagoons. They also invested in the infrastructure necessary to manage the salt cultivation process to obtain a higher-quality sodium chloride product. Through time, the shifting interests of the various social actors engaged in deriving solar salt on Venezuelan islands were reflected in different configurations of the socio-natural assemblages playing out on the saltpans.

The physical environment of the Venezuelan islands

This paper will discuss two saltpans on separate Venezuelan islands. The first is located at Punta Salinas on the south-eastern corner of La Tortuga, a large and flat calcareous island forming part of the continental shelf lying some 100 km to the northwest of the present-day port city of Puerto la Cruz (Fig. 1). This saltpan stretches nearly 1 km from south-west to north-east and lies adjacent to the large Los Mogotes Lagoon to the east (Fig. 2). The second saltpan is found on Cayo Sal, a long, low and narrow island extending some 16 km as it snakes its way along the south-western boundary of the large internal lagoon of the Los Roques Archipelago (Fig. 3). Los Roques, a calcareous oceanic archipelago, is located some 123 km north of the present-day port of Caraballeda on the central Venezuelan mainland (Fig. 1). At the western end of Cayo Sal, nestled between large windward storm terraces and the shallow waters of the archipelago on the leeward side, lie two large internal lagoons that have been partly converted into a saltpan. These lagoons stretch for more than 2.2 km from east to west and are divided nearly in half by a natural 100-meter sandy isthmus (Fig. 3).

Los Roques and La Tortuga are subject to similar semi-arid climatic conditions principally determined by warm and steady east north-easterly trade winds prevailing most of the year, occasionally spelled by inflows from the east south-east (Cervigón 1995, 37). The average annual velocity of the trade winds in Los Roques is 21 km/h, rising to 31–33 km/h from February to June (Méndez Baamonde 1978; Ministerio de la Defensa

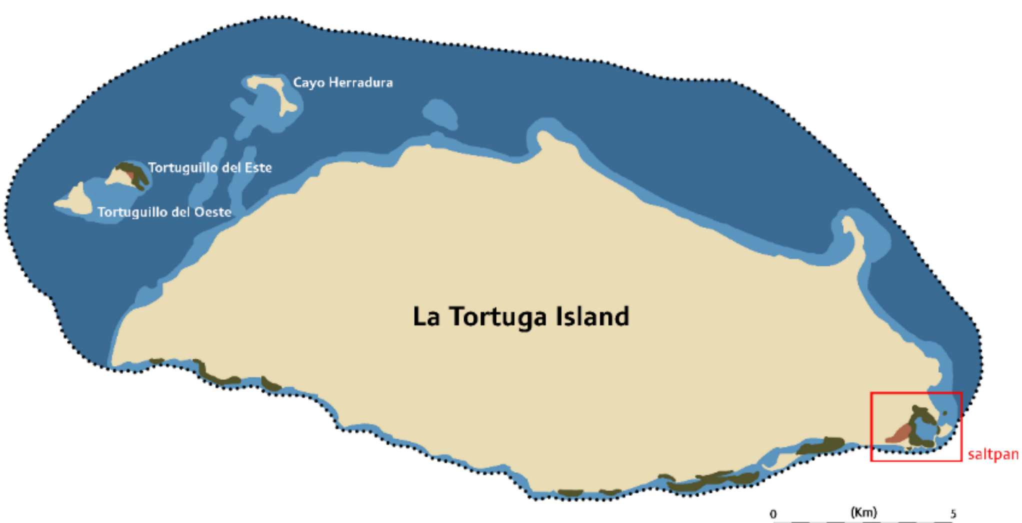


Figure 2. Map of La Tortuga Island highlighting the saltpan at the south-eastern end.

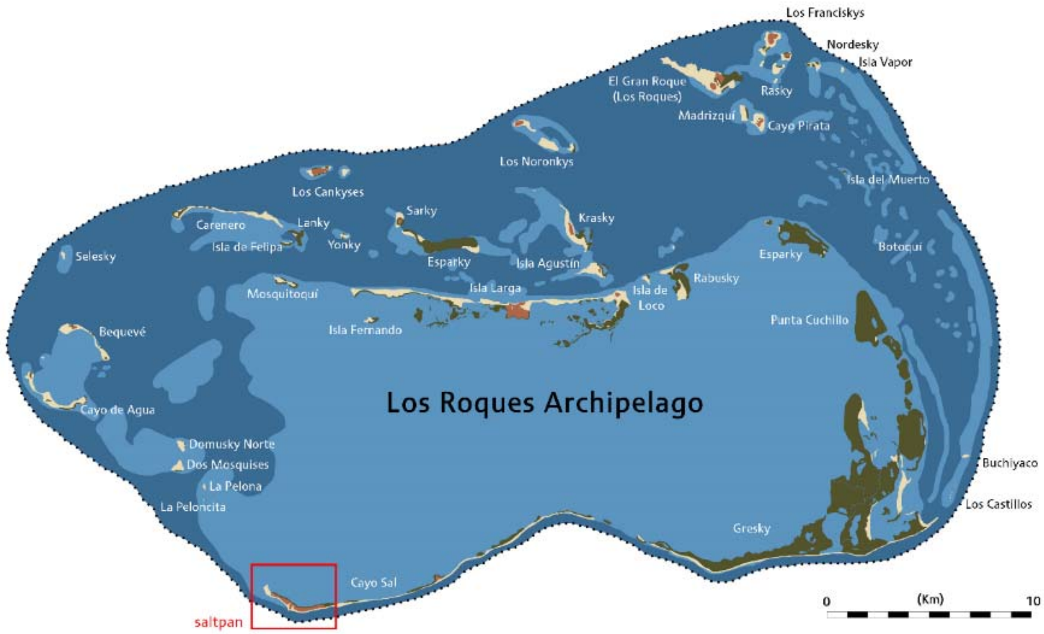


Figure 3. Map of the island of Cayo Sal in the Los Roques Archipelago highlighting the saltpan.

1988). The climate, hot and dry, features an average annual temperature in Los Roques of 28.9ºC (Laughlin et al. 1985). Precipitation is usually in the form of *chubascos*, or intense rainfalls of short duration. Mean annual rainfall of 321.8 mm was recorded from 1961 to 1986 on the nearby island of La Orchila about 40 km east of Los Roques (Ministerio de la Defensa 1988). Most of the rain on La Orchila falls in November and December (although frequent rain showers also occur in July); and the least rainfall occurs from February to June (with a mean of 12.22 mm), coinciding with the months of strongest winds (Ministerio de la Defensa 1988). The Venezuelan islands receive more than 3,000 yearly hours of solar radiation which results in an average annual evaporation of 2.5 m and a maximum daily evaporation of 8.2 mm on La Orchila in April and May (Cervigón 1995, 37–38; Lew 1977, 6–9). The months of major sun exposure on La Orchila peak in June with a mean of 10.5 hours of sunlight a day (Ministerio de la Defensa 1988). The semi-arid climate of the Venezuelan islands, together with strong and warm trade winds and increased solar insolation from February to June, provide ideal conditions for solar salt production during those months.

The solar salt cultivation process

A salina, also often called a saltern or saltwork, is the location where salt is obtained from shallow pools of brine evaporated with the help of solar radiation. Salinas are most often coastal or insular, and although they can be naturally occurring, usually they consist of shallow coastal lagoons, marshes or wetlands artificially transformed into saltworks. The term 'saltpan' is most often ascribed to periodically dried out or ephemeral salinas where halite (sodium chloride as a mineral) crystallizes on the surface in locations such as those discussed in this paper. 'Salt pond' is the term most often given to perennially flooded salinas that produce continuous subaqueous deposits of halite, as is the case with the large Venezuelan salinas on Araya as well as on Anguilla, Curaçao, Bonaire, and other Caribbean islands (Lugli 2009, 323; Reading 1996, 295).

At first glance, solar salt cultivation may seem a simple process, but just permitting seawater to evaporate will not yield an abundant and high-quality product. Seawater contains other compounds that must be precipitated before relatively pure sodium chloride (NaCl) can crystallize. For this reason, saltpans are segmented into successively shallower and smaller ponds and pans. The ideal salt cultivation process on an artificial saltpan is described below.

In a saltpan, seawater is let into the first and largest concentrating pond, or *concentrator*, by means of an inlet. On relatively recently functioning saltpans in the Turks and Caicos, for example, seawater remained at this stage roughly six to eight weeks (depending on the size of the concentrating pond) until its salinity had increased three-fold (Davis 1974, 370; Gregory 1978, 28). By that point, two of the unwanted minerals, calcium carbonate and iron oxide, have all but entirely precipitated. The remaining hypersaline liquid, or brine, was transferred to smaller secondary concentrating ponds where salinity ranges from three to seven times that of seawater (Davis 1974, 370). The brine stood for a few more weeks until the remainder of the calcium carbonate and all of the calcium sulphate (that is, gypsum) had precipitated (Davis 1974, 370; Gregory 1978).

Finally, once the brine reached at least six times the salinity of seawater and all the contaminating minerals precipitated, it was channelled into crystallizing pans or *crystallizers*, also known as 'making pans' (Gregory 1978, 30). These pans, as their name suggests, are smaller in surface area than the ponds and much shallower. Like the concentrating ponds, they are often segmented by dikes made of stone (on Cayo Sal in Los Roques, of coral stones) and made impermeable by the addition of compacted mud. The bottom of these pans is usually tamped down and levelled to minimize brine leakage. It can take some three weeks for the brine in the crystallizing pans to reach the point of sodium chloride saturation and for the halite crystals to fully grow (Harriott 1996, 63).

After most of the water has evaporated and a hard and cakey salt precipitate has appeared, the salt can be harvested. First, however, the bittern or pickle containing unwanted precipitated minerals detrimental to salt quality (including magnesium, potassium, chloride and sulphate) must be removed, oftentimes by pumping or digging an outlet channel through the salt for drainage (Oren 2009, 1). The salt is then broken up with wooden scoops, hoes or metal-toothed rakes. If the pans still contain a substantial amount of brine, the salt crystals can be scooped out with long flattened wooden rakes or shovels (Lemonnier 1980, 104). Usually, salt is raked into conical piles permitting the remaining bittern to drain, thus further improving quality (Baas-Becking 1931, 445–446). Because of the inherent variability of environmental factors including the passing seasons and human practices on saltpans, the resulting final salt product varies in colour, texture, taste and potential uses (Morsink 2012, 108).

Socio-natural assemblages of salt cultivation

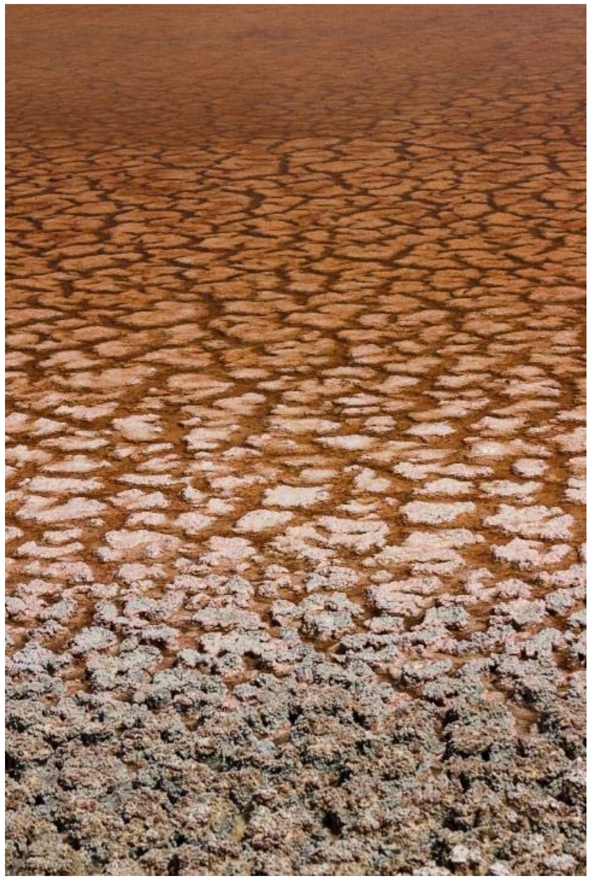


Figure 4. A secondary concentrating pond on Cayo Sal with brown-coloured brine and a gypsum benthic mat (photograph by José Voglar).

The role of human agency in optimal solar salt production is constrained, however, by microorganisms in the saltpans as well as by marine and climatic phenomena – all of which are vital to the effective crystallization of halite. Saltpans are highly diverse biological systems (Oren 2009). Brine shrimp (*Artemia salina*) and a variety of unicellular micro-algae from the diverse genus *Dunaliella* thrive in the large concentrating ponds (Baas-Becking 1931). The dark orange and brown hues (Fig. 4) of these ponds result primarily from green algae (*Dunaliella* spp.) which accumulate β-carotene, but also are caused by pigments from heterotrophic prokaryote communities (Bacteria and Archaea) which impart colour to the brines. These pigments increase the absorption of solar energy into the liquid and raise its temperature, thereby accelerating

Figure 5. A small saltpan at Punta Salinas, La Tortuga, where the brine has neared sodium chloride saturation and the microorganisms have imparted a deep pink hue.

evaporation and the precipitation rates of the various minerals in the early stages of salt cultivation (Davis 1974, 370–371; Oren 2009, 2). Brine shrimp have been identified in salt lagoons on the islands of Los Roques, La Orchila and the Las Aves Archipelagos, and they are also likely present in the saltpan on La Tortuga (Triantaphyllidis et al. 1998, 219). These diminutive crustaceans are essential in the second series of concentrating ponds. As a result of their feeding habits, they strain the brine of any calcium sulphate and calcium carbonate particles by aggregating them in pellets which fall to the bottom. This prevents the brine from becoming turbid as it is passed on to the final crystallizing pans where it must be clear for halite to precipitate effectively (Baas-Becking 1931, 445; Davis 1974, 370; Javor 2002, 43).

The complex and stratified benthic bacterial and algal mats that form on the bottom of the ponds are all but impervious to water and effectively seal them, preventing costly brine leakage (Davis 1974, 370; Oren 2009, 2). This phenomenon is most valuable in the second series of concentrating ponds where the brine approaches sodium chloride saturation. Any percolation of the painstakingly condensed brine at this stage translates into an important economic loss (Davis 1974, 371; Javor 2002, 43; Oren 2009, 5–6). Furthermore, the microbial mats also prevent the mixing of halite with the mud below, thus preventing the incorporation of undesirable manganese and iron ions into the halite crystals (Coleman and White 1993, 626–627; Oren 2011, 17). Finally, in the last stages of sodium chloride precipitation, the organisms that generally inhabit the crystallizing pans are algae from the genus *Dunaliella,* halophilic Archaea, and red rod-shaped bacteria (Elevi Bardavid et al. 2008). It is the pigment of these Archaea that primarily impart striking deep red and pink hues to the crystallizing pans (Fig. 5). The pigment critically aids in increasing the temperature of the brine and its evaporation rate, and also serves as a tell-tale sign to salt workers of a brine's salt content (Davis 1974, 371; Oren et al. 1992, 86–87).

In the past, a keen understanding of the daily, monthly and yearly cycles of tides would have been vital to an efficient saltpan enterprise. However, accurate tidal data for the Venezuelan islands is lacking. As a result, on the basis of personal experience and interviews conducted among inhabitants of the Los Roques Archipelago, it was noted that minimal rainfall and high winds from March to June coincide with the lowest yearly tides (Reyes and Boadas-Gil 2015). Significant percolation of seawater through the loose calcareous sands forming the matrix of the saltpans on La Tortuga and Cayo Sal probably occurs throughout the year in similar fashion to that observed on the coralline island also named Cayo Sal off Chichiriviche, Falcón State, in Western Venezuela (Weiss 1979, 4). The drying of the saltpans from March to June would have been aided greatly by such a phreatic connection with the sea. Moreover, strong wind speeds play a key part in aiding the diffusion of water molecules away from the surface of the brines in the concentrating ponds and crystallizing pans (Akridge 2008, 1454; Davis 1974, 371). High winds and low tides, concatenated with high ambient temperatures, longer days, lower humidity and limited rains from March to June created a window of opportunity on the Venezuelan islands ideal for salt cultivation.

In the past, tending a saltpan without salometers to measure the percentage of sodium chloride in the brine, and without motorized pumps for channelling brine or pumping out bittern involved a close correspondence between humans, microorganisms and physical and chemical processes. In 1799, a shoemaker of Castilian descent who lived in a hut beside the Venezuelan salina of Araya, impressed Alexander von Humboldt with his understanding of 'the formation of salt through the influence of the sun and full moon' (von Humboldt 1995 [1814–1825], 71). The presence of biotic factors and their vital role in sodium chloride crystallization, however, probably went largely unnoticed by the seafarers tending the saltpans on the Venezuelan islands from the 17th to the 19th century. This is still the case in many traditional non-industrial solar saltworks today (Davis 1974, 370). In fact, many of the microorganisms in saltpans were only scientifically identified and studied in the later 19th and 20th centuries (*Dunaliella salina* was identified in 1838) (Bass-Becking 1931; Oren 2009, 7). Even though likely unaware of the fundamental role of microorganisms in effective salt cultivation, salt workers of former times were nonetheless capable of detecting their effects and acting upon the changes in brine coloration. The change from dark brown to dark red and pink hues in the salt gradient from primary and secondary concentrating ponds to the final crystallizing pans (Figs. 4 and 5) caused by microorganisms, and the appearance of small hopper-shaped salt crystals, were the only available clear signs of the state of the brine and its salt content (Gregory 1978, 30). Experienced salt farmers could precisely determine when one brine had to be passed on to the next concentrating pond and when it had to be channelled into the final crystallizing pans (Harriott 1996, 63).

The knowledge-based saltpan management evident in the channelling of brines to successive ponds, the maintenance of the waterproofing mud on the dividing dikes, and the careful raking of salt from the crystallizers in order not to disturb the all-important benthic mats, were essential to maintaining a productive saltpan system. Cognizant of some factors and unaware of others, the seafarers tending saltpans on the Venezuelan islands relied on the correspondence of an array of biotic, chemical, marine and climatic factors that together with their own physical actions conduced to the cultivation of solar salt. The dynamic correspondence of these various factors resulted in socio-natural assemblages of salt cultivation. How these same assemblages functioned and varied on the saltpans of La Tortuga and Cayo Sal between 1624 and 1880 is explored in the following sections.

Historical Archaeological Case Studies

Systematic archaeological surveys of the saltpans of La Tortuga and Cayo Sal as well as excavations at their margins were undertaken during more than a dozen field seasons between 1983 and 2015. The subsequently discussed case studies are primarily informed by pedestrian surveys, GPS mapping of relevant features, analysis of aerial and satellite imagery of the saltpans, and 17th- through 19th-century documentary evidence. Archaeological excavations beside the saltpans have brought to light little direct material evidence of salt cultivation and raking activities on the saltpans themselves. However, they have revealed abundant material evidence of the daily lives of the seafarers at the saltpan campsites (see Antczak 2015; Antczak et al. 2015).

La Tortuga: the Dutch enterprise (1624–1638)

The first case study begins in the 1620s when Dutch salt fleets, compelled by the worsening crisis of constricted salt supply for their vital and lucrative herring fisheries,

Figure 6. Aerial view of the saltpan of La Tortuga at Punta Salinas with Los Mogotes Lagoon at far-right (photograph by José Miguel Pérez Gómez).

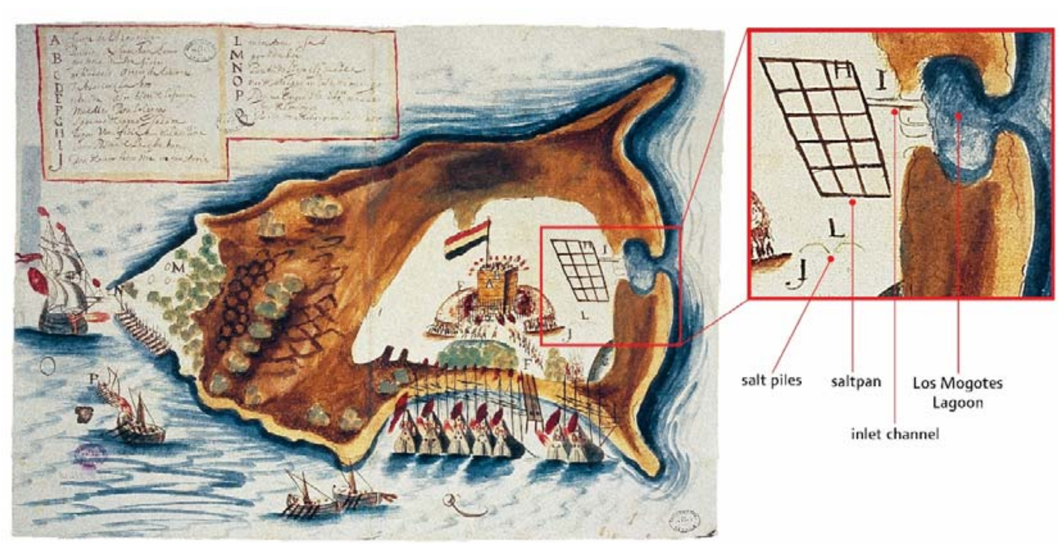
once again started to rove the Caribbean in search of the coveted white mineral (Goslinga 1971, 129). These Dutch *zoutvaerders* (salt carriers) ventured to the Spanish island of La Tortuga, which at the time featured a series of natural internal lagoons at Punta Salinas, capable of producing vast quantities of salt when ingeniously altered by the Dutch to do so (Fig. 6). The Dutch perception of the environment generally sustained the strong Cartesian culture/nature divide borne out in Western thought (Glacken 1976), yet the *zoutvaerders* were at the same time cognizant of a number of natural factors involved in salt crystallization from their previous experiences on Venezuelan (Araya, Unare), Caribbean (Sint Maarten) and other (Setubál, Aveiro and Cape Verde) saltpans. They maximized both salt output and quality on La Tortuga by adopting the semi-industrial use of artificially-flattened pans, wooden boardwalks, buckets, pumps, channels and floodgates. They did so also by synchronizing salt cultivation with the rhythms of the local weather patterns and tides, and the microorganisms in the brine. In 1630 over two and a half months, more than 28,000 wheelbarrow loads, or some 1,400 metric tons of salt were harvested, transported across the saltpan, and loaded onto seven Dutch vessels anchored in Punta Salinas Bay (Antczak et al. 2015, 198).

In 1633, architect Juan Bautista Antonelli the Younger reported with admiration that the saltpan – according to 'precise measurements' – had become so transformed and artificially extended beyond its natural borders that its circumference had increased from over 4,000 m in 1626 to over 10,000 m seven years later (Wright and Van Dam 1934, 137). The vast input of hard labour under the blazing tropical sun converted the underestimated 'natural' Los Mogotes Lagoon into a highly productive saltpan. However, Antonelli had arrived in 1633 to sabotage the Dutch enterprise through an elaborate plan to flood the saltpan. One hundred Cumanagoto Indians and 50 Spaniards dug two canals to the seashore 100 m away (Wright and Van Dam 1934, 137). Due to this periodic scouring effect of tides, the canals have perpetuated themselves to this day, leaving a lasting and visible environmental legacy of the 17th-century colonial Venezuelan

Figure 7. Satellite image of Punta Salinas highlighting the anthropogenic modifications to the saltpan and Los Mogotes Lagoon during the 17th-century Dutch enterprise (imagery from Google, DigitalGlobe).

response to foreign incursion (Fig. 7). Part of the large Dutch saltpan was permanently converted into the perennially flooded Los Mogotes Lagoon.

A map of the 1638 battle between Dutch and Spanish shows the artificial canal the Dutch made after 1633 which connected the lagoon with the saltpan to the west (Fig. 8). The resilient Dutch had begun to use the lagoon as a large reservoir of hypersaline water to feed their saltpan. They had thus created an optimal output from the Spanish sabotage. In fact, after the Dutch were expelled by the Spaniards in 1638, their expert modifications of the salt lagoon and saltpan allowed Anglo-Americans in the following decades to rake abundant salt with very little human management. Apart from the Dutch modifications to the saltpan reported in documentary sources and corroborated through aerial imagery, no archaeological evidence remains of Dutch infrastructure on the saltpan, as this was dismantled by the Spanish in 1638.



Map of Dutch fort on La Tortuga under attack by Spanish forces. The inset highlights depicted features of salt cultivation. Painted by Juan Bautista Antonelli (the Younger) in 1638 (Image courtesy of Archivo General de Indias, Ministerio de Cultura, Spain [MP-Venezuela, 24]).

Even though the Dutch managed much of the saltpan on La Tortuga artificially – by means of modifications and controlling the cultivation process through infrastructure and technological innovation – they necessarily corresponded with the biotic, chemical, marine and climatic factors without which high-quality solar salt could not have been cultivated in such large quantities. The *zoutvaerders'* saltpan enterprise was thus, in effect, a dynamic and highly productive socio-natural assemblage.

La Tortuga: the Anglo-American fleets (1638–1781)

Beginning in 1638, what was at first a trickle of determined Salem merchants heading to La Tortuga to rake salt became a steady stream. By the early 18th century, Boston and other New England ports such as Portsmouth, Newport, New London and New York, along with Bermuda, had joined the salt venture that became the lifeblood of New England's refuse fish industry (Antczak 2015, 162). Low-grade salted fish (cod and mackerel among other species) was the principal staple of the enslaved working on sugar plantations in the Lesser Antilles (Innis 1954, 162–163; Magra 2006, 157–164). From 1700 to 1781, protected by various Anglo-Hispanic treaties and by Royal Navy guard ships, more than 1,000 vessels set sail in annual fleets to rake free sodium chloride on La Tortuga. The humble island became New England's most important source of free salt (Antczak 2015, 162).

The Anglo-American salt enterprise on La Tortuga was considerably larger in total salt output, longer-lived, and much more important to the British Caribbean and Atlantic world economies than the short-lived Dutch enterprise was to the Low Countries. Nonetheless, it featured no more than the gathering of naturally-crystallized salt under minimal saltpan management, and resulted in no perceivable long-lasting physical effects on the saltpan itself. Compared to the Dutch enterprise, Anglo-American salt raking seems to have been much less a proactive affair. Human manipulation of the physical saltpan environment was, at most, limited and dependence on the unassisted natural process of salt crystallization was nearly total. Direct archaeological evidence for anthropogenic modifications from the period is lacking; no visible surface or underground structures of any sort exist. What *is* striking is that archaeological surveys of the saltpan revealed not a single ceramic, glass, metal or bone object within the perimeter of the saltpan. This suggests a strict regime of orderliness keeping campsite trash well away from salt-raking and packing areas.

Upon the annual arrival of the Anglo-American salt fleet in the period between February and May, the saltpan was apportioned according to ship tonnage before the salt was raked (Brownrigg 1748, 24–28). In some cases, it seems the seafarers waited for the salt to crystallize on the pans a second time in order to perform a 'second raking' (Anonymous 1768, 90). To reiterate: management of the natural crystallization process was all but non-existent. Anglo-American seafarers invested no money, time, and effort in building dikes, canals or any other infrastructure on the pans but simply put rakes, shovels, wheelbarrows and oznabrig bags (for salt gathering and packing) to good use (Minutes of His Majesty's Council, Bermuda 1996, 208, 211, 219). The seafarers depended solely on the whims of clime and tide to assist or impede their enterprise. When rains laid waste to the pans and no salt could crystallize, as was the case in 1687, their ships returned to New England empty (Anonymous 1868, 41).

La Tortuga salt was coarse, large-grained and reddish (Sloane 1707: lxxxviii). There was much debate in New England as to the quality of this salt in the second half of the 17th century. As one source states,

> 'More salt-burnt dried cod came from New England than from Newfoundland because the Tortugas salt used at the former place was more fiery than the milder salt from Lisbon and Bay of Biscay that was in use at Newfoundland… Tortugas salt was condemned as being injurious to the best quality of cured fish' (McFarland 1911, 66, 95–96).

La Tortuga salt was criticized specifically in 1670 for containing 'shells' and other 'trash' and for leaving spots on the fish, something that could have been avoided by more careful salt-gathering crews (Felt 1849, 212; Innis 1940, 161). Some merchants in 1750, however, counterintuitively claimed that salt from La Tortuga was of better quality than its English counterpart, its strong characteristics rendering it more favourable to the curing of provisions (Stock 1940, 401–402). Given what was known about the carefully managed cultivation process necessary to produce high-quality salt, however, La Tortuga salt at that time must be considered low-grade. Because the Anglo-Americans raked it with no management of the natural process, it would have crystallized mixed with numerous other minerals from the bittern, making it unpalatable and indeed 'fiery'.

Unlike the Dutch seafarers who worked together harmoniously for the success of the entire West Frisian fleet's salt supply, each Anglo-American ship belonged to a different New England or Bermudian merchant and thus had a different economic goal and interest. This difference between the communal or corporate Dutch approach to salt cultivation and the more individualistic Anglo-American salt-raking style may also explain the lack of any Anglo-American modifications to the saltpan. Moreover, since low-grade salt from La Tortuga was intended for use in the curing of refuse fish sent to the West Indies for enslaved sugar plantation workers, investment in saltpan infrastructure was minimal. Little attention was paid to more sophisticated cultivation which could have resulted in a better product. In short, whilst the Dutch engaged in careful salt cultivation seeking a high-quality product to cure their herring for free (and moneyed) Europeans, the Anglo-Americans were interested only in large quantities of low-grade salt to cure refuse fish for enslaved labourers. Consequently, the Anglo-American socio-natural assemblage of salt-raking was significantly less dynamic than that of the Dutch and much more haphazardly dependent on natural factors.

Cayo Sal, Los Roques Archipelago: Uespen de la Salina (c. 1700–1800)

There are two archaeological sites adjacent to the saltpan on Cayo Sal. The first, Uespen de la Salina (hereafter CS/A), is located on the westernmost end of the saltpan and on the leeward (northern) coast of the cay (Figs. 9 and 10). Analysis of the varied collection of ceramics excavated from the site, as well as the study of extant documentary sources, suggest that the location was visited between 1700 and 1800 by French, Bermudian and Anglo-Caribbean seafarers as well as Curaçaoans and the Spanish from the mainland Province of Venezuela. Archaeological evidence of salt cultivation at the CS/A site includes corroded remains of two shovels, two hoes and a possible pitchfork (probably used for breaking up the superficial hard salt crust) (Fig. 11). It is difficult to establish contemporaneity between the archaeological materials and the earliest dikes on the saltpan, that would allow for a determination of precisely when salt cultivation began on the pans. Nonetheless, it can be confidently suggested that the seafarers who arrived at Cayo Sal in the 18th century engaged at the very least in the raking of naturally-

Figure 9. Aerial view of the internal lagoons and saltpan of Cayo Sal, Los Roques Archipelago.

crystallized salt, much like what Anglo-Americans were doing on La Tortuga at the same time.

Figure 11. Metal salt-gathering implements recovered at the CS/A site. (From left to right, top to bottom): fragments of two shovels; fragment of a pitchfork; fragments of two hoes.

Figure 10. Map of the saltpan of Cayo Sal with the CS/A and CS/B sites indicating possible features pertinent to the salt cultivation process.

Cayo Sal, Los Roques Archipelago: Los Escombros (c. 1800–1880)

The second site, Los Escombros (hereafter CS/B), is located 1 km east of CS/A on a sandy corridor between two large sections of the saltpan lying to the east and west (Fig. 10). The saltpan adjacent to CS/B was sporadically visited and raked by Venezuelans in the 1810s and 1820s. In 1834, the saltpan was rented out by the Venezuelan government for eight years to a US American sea captain and trader by the name of Jeremiah H. Morrell, who was based in the Venezuelan port of Puerto Cabello (Burrows 1975, 1179–1180; Hood 1846, 68). During this period, more than 120 'free coloureds' from Bonaire and Curaçao worked on the saltpan (Bosch 1836, 306–307), which was largely abandoned from the early 1840s to the mid-1860s. Small-scale salt cultivation was again initiated by Bonairean entrepreneur L. C. Boyé in 1866. This halted in 1880 when the Venezuelan government disabled the saltpan by flooding it via a channel cut from the sea (Venezuela 1881, LXVI).

The CS/B site includes the ruin of an overseer's house as well as a salt-packing patio, probably dating to the 1834–1842 period. The saltpan has a large number of coral dikes and walkways crisscrossing it in different directions (Fig. 12). Long-term archaeological surveys indicate two probable seawater inlets and permit a hypothetical layout of the concentrating ponds and crystallizing pans (Fig. 10). Apart from the several large concentrating ponds, there seem to have been five separate sets of crystallizing pans. This saltpan was thus laid out in an ideal manner for optimizing the salt gradient and

Figure 12. Panorama of the coral stone dikes that crisscross the saltpan of Cayo Sal (photograph by José Voglar).

maximizing the salt crop. Some of the double coral stone dikes were wide and included a channel for brine to run to crystallizing pans. Others were primarily used for carting salt on wheelbarrows to the packing patio (Fig. 13). In 1871, English adventurer and chemist James Mudie Spence paid a visit to the saltworks on Cayo Sal. Spence (1878, 197) mentions that 'Several acres [of the saltpan] are covered with large flat tanks, into which a little windmill pumps seawater.' The hypothetical location of this pump is indicated in Figure 10.

Although the documentary evidence is as yet too sparse to paint a more detailed picture of salt cultivation at CS/B, the large-scale infrastructural investment by Morrell displays a carefully thought-out salt cultivation enterprise. His business of the 1830s and early 1840s was established within a legal framework granted by the newly independent government of the Republic of Venezuela. Such legality and relative security – something neither the Dutch nor the Anglo-Americans on La Tortuga enjoyed – would have conduced to longer-term investment in saltpan infrastructure and more careful attention to the process of salt cultivation. Furthermore, it is plausible to suggest that the

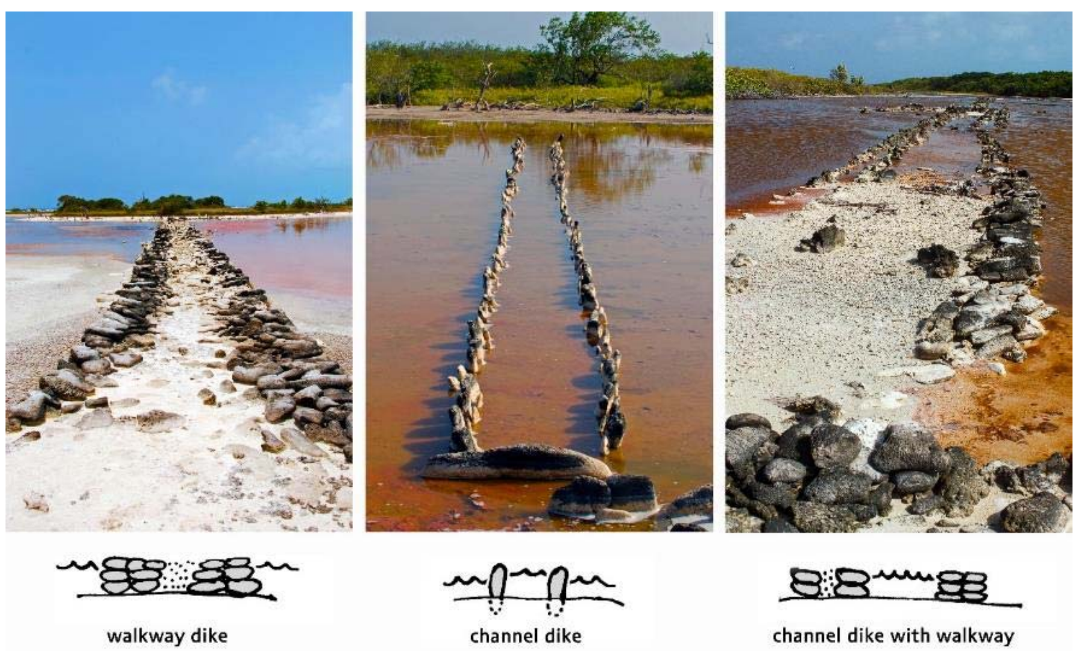


Figure 13. Diagram displaying the three types of coral stone dikes on the saltpan of Cayo Sal (photographs by José Voglar).

environmental knowledge of the Dutch Antillean freedmen (who'd had considerable experience working for *zoutplanters* [salt planters] on the salt ponds of Curaçao and Bonaire) working under Morrell was a key factor in the functioning and success of the saltpan on Cayo Sal. Maximizing a salt harvest would have required knowledge of the optimal distribution of ponds, pans, dikes and pumps; an experienced eye to detect changing brine colours derived from various microorganisms; the careful tending of the organic mats on the bottoms of the concentrating ponds; and a remarkable synchronization of salt cultivation with the tides and the weather. Like that of the 17th-century Dutch on La Tortuga, Morrell's enterprise on Cayo Sal was a dynamic socio-natural assemblage of salt cultivation.

Conclusion

Although obtaining solar salt may at first glance appear to be a merely extractive human endeavour, successful salt cultivating enterprises require humans to correspond intimately with, and depend heavily on, numerous non-human entities and processes. In fact, human correspondence with natural factors is so vital to the saltpan enterprise that uniquely agricultural terms such as salt 'cultivation' and 'harvesting' a 'crop' of salt were still used by salt rakers of the Turks and Caicos Islands in the 1970s (Gregory 1978, 28, 30). Whereas most salt rakers on the Venezuelan islands of La Tortuga and Cayo Sal may have regarded nature and culture as separate domains (Glacken 1976), their practical engagement with the saltpans demonstrates quite the contrary. They were at times knowingly and at other times unknowingly corresponding with and depending on the microorganisms, chemical processes, tides and weather conditions interwoven in optimal saltpan production. Even the Anglo-Americans who did not actively cultivate salt on La Tortuga in the 17th and 18th centuries were highly reliant on a keen knowledge of the tides and rains to rake as much naturally-crystallized salt as possible between March to June.

The now abandoned saltpans on the two Venezuelan islands discussed above bear the visible traces of past human activities. On the saltpans, the meeting of human and non-human entities created socio-natural assemblages of salt cultivation. To successfully cultivate high-quality salt on these islands, humans, their tools and the structures they built had to join, dynamically and synergistically, with the rhythms of microorganisms, chemical compounds, tides, and clouds. It is in this very correspondence of 'earthly undergoings and human doings' (Ingold 2015, 155) that salt crystals were successfully grown.

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Figure 1

La Tortuga Island and the Los Roques Archipelago within the Venezuelan Caribbean.

Figure 2

Map of La Tortuga Island highlighting the saltpan at the south-eastern end.

Figure 3

Map of the island of Cayo Sal in the Los Roques Archipelago highlighting the saltpan.

Figure 4

A secondary concentrating pond on Cayo Sal with brown-coloured brine and a gypsum benthic mat (photograph by José Voglar).

Figure 5

A small saltpan at Punta Salinas, La Tortuga, where the brine has reached close to sodium chloride saturation and the microorganisms have imparted it with a deep pink hue.

Figure 6

Aerial view of the saltpan of La Tortuga at Punta Salinas with Los Mogotes Lagoon at far-right (photograph by José Miguel Pérez Gómez).

Figure 7

Satellite image of Punta Salinas highlighting the anthropogenic modifications to the saltpan and Los Mogotes Lagoon during the 17th-century Dutch enterprise (imagery from Google, DigitalGlobe).

Figure 8

Map of Dutch fort on La Tortuga under attack by Spanish forces. The inset highlights depicted features of salt cultivation. Painted by Juan Bautista Antonelli (the Younger) in 1638 (Image courtesy of Archivo General de Indias, Ministerio de Cultura, Spain [MP-Venezuela, 24]).

Figure 9

Aerial view of the internal lagoons and saltpan of Cayo Sal, Los Roques Archipelago.

Figure 10

Map of the saltpan of Cayo Sal with the CS/A and CS/B sites indicating possible features pertinent to the salt cultivation process.

Figure 11

Metal salt-gathering implements recovered at the CS/A site. (From *left* to *right*, *top* to *bottom*): fragments of two shovels; fragment of a pitchfork; fragments of two hoes.

Figure 12

Panorama of the coral stone dikes that crisscross the saltpan of Cayo Sal (photograph by José Voglar).

Figure 13

Diagram displaying the three types of coral stone dikes on the saltpan of Cayo Sal (photograph by José Voglar).