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"The Salvation of the Seamen"

Ventilation, Naval Hygiene, and French Overseas Expansion During the Early Modern Period (ca. 1670–1790)

▼ **SPECIAL ISSUE ARTICLE** in *Pathogenic Environments*, ed. by Paul-Arthur Tortosa & Guillaume Linte

▼ **ABSTRACT** From the 1660s onwards, France tried to establish itself as a leading maritime and colonial power. The first French East India Company allowed a decisive penetration into the Indian Ocean, while the foundation of the Rochefort arsenal was the starting point of a great shipbuilding effort.

The archives of the State Secretariat of the French Navy, ports, and learned societies, as well as printed scholarly literature, testify to an increasing mobilisation around the health of the "*gens de mer*." Most of the actors involved in this reflection, whether doctors or surgeons, naval officers or engineers, scholars or inventors, agreed in associating seamen's diseases with the poor air quality prevailing within ships. The environment of seafarers was thus definitely regarded as harmful. However, the atmosphere of a ship was also seen through the possibility to reshape it and reduce its dangerousness, with adapted behaviours, careful maintenance, or technical solutions. This was crucial to ensure the circulation of human beings and goods across the French overseas empire, but also to defend it from the threats associated with the major conflicts of the second half of the 18th century.

This article highlights how environments regarded as "pathogenic" were conceived and reshaped during the second half of the early modern period in France, using the example of naval hygiene. It examines the strategies designed and implemented to combat the "noxious" air of French ships, in particular through the regulations

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introduced since the end of the 17th century, and considers how this issue has stimulated the search for technological solutions.
▼ **KEYWORDS** Naval Hygiene, History of Medicine, Ventilator, Health & Environment, History of Science & Technology
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Introduction

From the 1660s onwards, France tried to establish itself as a leading maritime and colonial power among its European rivals. The development of French maritime capacities was of course part of a longer history, which can be traced back to François I, Richelieu, and Henri IV. However, from the Colbert years onwards, a more ambitious maritime programme emerged, supported by substantial investments. While the French Navy had only 18 warships and a dozen galleys left in 1661, Jean-Baptiste Colbert decided to build 133 additional ships and 30 galleys, all of which were completed before 1675.[1] The first French East India Company was also founded during this period, in 1664, under the authority of the royal government. Although it was an economic failure, this marked a turning point in the history of French colonial policy, allowing a decisive penetration into the Indian Ocean and contributing to the success of the new Compagnie des Indes, which was created in 1719.[2] The 1660s also saw the establishment of the Rochefort arsenal.[3] Located on the Atlantic coast, Rochefort became a key position for the Crown's maritime and colonial strategy.[4]

Following these changes, the manpower represented by seamen became a strategic priority. To prevent deaths at sea, the French Royal Navy's health service was reformed, and schools of naval surgery were founded at the three main arsenals: Rochefort (1722), Toulon (1725), and Brest (1731).[5] The archives of the State Secretariat of the Navy, ports, and learned societies, as well as printed scholarly literature, testify to increased efforts to improve the health of the *gens de mer* (seafarers) during the 18th century. The development of a medical literature devoted to this question in France, influenced by British authors such as James Lind, John Huxham, and John Pringle, was also part of this context.[6] The vast majority of the actors involved in this reflection, whether doctors or surgeons, naval officers or engineers, scholars or inventors, agreed that seamen's diseases were associated with poor air quality in ships, especially in steerage. Naturally, other potential causes were also pointed out, such as food and lack of clothing, but no single factor was seen to be as decisive as

1 As Controller-General of Finances (1665) and Secretary of State of the Navy (1669), Jean-Baptiste Colbert (1619–1683) was a key figure in the maritime development of France in the late 17th century. Taillemite (2010, pp. 55–152, esp. 94–95).
2 Haudrère (2005); Ménard-Jacob (2016).
3 An arsenal is a national establishment where warships and their armaments are built, maintained, repaired, and conserved: Vergé-Franceschi (2002, Vol. 1, p. 111).
4 Martin (2015); Acerra (2011).
5 Suberchicot (1997a; 1997b); Sardet (2000); Buchet (1997).
6 Lind (1753); Pringle (1750); Huxham (1750).

the quality of the atmosphere in which the crews lived, whether related to internal factors or those external to the ship (that is, the climate of the sea or of the regions crossed around the globe). The seafarers' environment was thus definitely regarded as "pathogenic," but perceptions of the atmosphere of a ship were also affected by the possibility of reshaping it and reducing its dangerousness through adapted behaviours, careful maintenance, or technical solutions.[7]

Recent historiography has provided new insights into the relationship between environment, air quality, and health in the 18th century. In addition to changing representations of the atmosphere, through meteorology, chemistry, and natural philosophy, the role of lifestyles and material culture in European societies has been highlighted by historians such as Vladimir Jankovic, Marie Thébaud-Sorger, and Sandra Cavallo.[8] These studies show that machines for ventilating confined spaces and combating "bad air" were the subject of increasing interest during the 18th century, especially by public institutions but also for domestic use. Ventilators, as Marie Thébaud-Sorger pointed out, then "became a commonly accepted device of public utility" in France and Britain.[9] The development of mineral acid fumigation methods to purify the atmosphere has also been the subject of important historical works. As with the machines used to ventilate the atmosphere, knowledge about them has circulated widely in Europe and has contributed to rethinking the relationship between health, air, and the environment.[10] In the more specific field of naval hygiene, Paul E. Sampson highlighted the crucial importance attached to ship air quality in the Royal Navy and its implications for the imperial project: "For mid-century physicians and naval administrators, the circulation of air in ships was closely associated with the circulation of human beings and trade goods throughout the British Empire."[11] This imperial dimension is also central to the context of the French navy, but has been little studied so far. However, the development of maritime hygiene regulations and naval medicine were closely tied to France's overseas expansion, and practices related to improving air quality in ships were primarily conceived as a way to prevent scurvy.[12] In the second half of the 18th century, investment in technical solutions such as ventilators was further justified by the defence of France's threatened colonial empire, especially after the Seven Years' War.

Discourses, regulations, and practices relating to air quality in the navy developed with the rise and defence of the French overseas empire. This article argues that the knowledge and experience derived from this context strongly influenced debates on

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7 I will not further discuss the concept of "pathogenic environment" here, as it is defined and contextualised in the introduction of this Special Issue. However, in brief, "pathogenic environments" can broadly be defined as places, regions, or environments whose characteristics are considered to cause disease (or its spread) in the humans who live in, occupy, or work in them.

8 Golinski (2007); Miller (2020); Jankovic (2010); Thébaud-Sorger (2020); Cavallo (2016).

9 Thébaud-Sorger (2020, p. 1091).

10 Garciá-Belmar & Ramón Bertomeu-Sánchez (2016); Le Roux (2016); Serrano (2018); Engelmann & Lynteris (2020).

11 Sampson (2021, p. 6).

12 In the 18th century, scurvy remained the main concern for European navies in imperial contexts: Lawrence (1996); Harrison (2010; 2013); Chaplin (2012); Linte (2019).

air, environment, and health in France during the second half of the early modern period. It stresses the crucial importance of the imperial project in investing in new ways of dealing with "bad air," especially technical solutions such as ventilators.[13] Ships were one of the main places where environmental health hazards were tackled, as were others seen as highly harmful: prisons, hospitals, and mines. Using the example of naval hygiene, this article highlights how environments regarded as "pathogenic" were conceived and reshaped during the 18th century.

I begin by explaining how the ship was perceived as a pathogenic environment, particularly through the way in which air was conceived during this period, characterised by numerous developments in both medicine and chemistry. I then examine the strategies designed and implemented to combat the deterioration of the atmosphere in ships, particularly through regulations introduced following the end of the 17th century. Finally, I investigate how this issue stimulated the search for technological solutions, especially from the mid-18th century. The last section of this article describes the failure of the most important French attempt to deploy on a large scale a technical device designed to improve air quality on board ships in the early modern era: Henri Weulersse's ventilator.

Conceiving of the Ship as Pathogenic Environment

In the 18th century, living conditions at sea were particularly precarious for ships' crews. A seaman's life was essentially confined to the upper deck and, above all, to the steerage. This was the beating heart of a ship, where seamen, soldiers, or poor passengers were gathered. Only officers and wealthy passengers had private spaces. The steerage was a particularly unhealthy and overcrowded place. Crewmen took turns sleeping on shared hammocks or mattresses amid goods and furnishings, but also with living animals, gathered in various enclosures. The presence of animals could be very cumbersome: in addition to oxen, sheep, or chickens for the consumption of officers and sick men, dogs were common on ships (not to mention rats). The extreme insalubrity and inconvenience associated with the presence of animals (odours, noise, faeces, and so forth) meant that the steerage area was regarded as particularly repulsive, even more so at a time when one's sense of smell was considered key to detecting any form of putrefaction, which was particularly associated with disease.[14] Moreover, sailing conditions were exhausting. Highly exposed to the elements, the seamen were often insufficiently equipped with clothing, which they were not always able to change after completing their watch.[15] Royal regulations in

13 For related issues in the British Empire, see Sampson (2020).

14 Corbin (1982); Tullett (2021).

15 This situation is, for example, well described and denounced in an anonymous document addressed to the Minister of the Navy around 1760, entitled "Picture of the life of a seaman in the service of the King": Tableau de la vie du matelot au service du Roy [Dissertation] (ca. 1760), MAR G179/50, Fonds Marine, Archives Nationales, Paris, France (hereafter AN MAR).

this area, often considered insufficient by surgeons and physicians, were by no means always respected.[16]

In the French Royal Navy's warships, conditions were usually even more critical. In addition to the crew, several hundred soldiers—depending on the vessel's size—were likely to board and further overload the steerage area. These conditions were particularly favourable to the development and spread of diseases. In addition to overcrowding caused by the soldiers, the fact that they were not accustomed to the sea and to the movement of the ship was also a source of concern. Many suffered from seasickness, which could cause nausea and vomiting for days. Some naval doctors and surgeons thought that the presence of soldiers without seafaring experience was one of the primary causes for unsanitary conditions on board.[17] When capricious weather prevented seamen from ventilating the steerage by opening the gunports, the steerage was essentially transformed into a cesspool, where the smell of perspiration and all sorts of human and animal waste permeated the atmosphere.

In the 18th century, the environment in which seafarers lived was perceived as highly conducive to disease contraction and transmission. It was primarily through the quality of its "air" or "atmosphere" that this environment's pathogenic nature was defined. In the medical field, authors' theories in the early modern period were based on the heritage of the Hippocratic-Galenic tradition, which espoused various notions for understanding the relationship between health and environment. The treatise *Airs, Waters, Places*, from the *Hippocratic Corpus*, was therefore central to 17th- and 18th-century medical thought, especially in France and Britain.[18] According to this text, environmental influence determines individual health and explains the frequency of diseases in a population. The interpretive framework provided by this treatise was an essential tool for defining the characteristics that make an environment, place, or milieu pathogenic.[19] Furthermore, European societies became increasingly interested in these issues throughout the 18th century. The "surrounding things" (*circumfusa*) were objects of close attention, particularly in urban contexts, while the changing understanding of climate and the "chemical revolution" inspired a new and more detailed analysis of the atmosphere.[20]

Diet was also a fundamental concept in early modern medicine. Already present in the *Hippocratic Corpus*, it was defined through the *sex res non naturales* inherited from

16 Lebeschu de La Bastays (1788, p. 43). On perceptions of regulatory insufficiency, which were particularly prominent in the late 18th century, see, for example, the report on the health of seamen sent by a physician to the *Société Royale de Médecine*: Sabathier (1786), Mémoire sur la santé des équipages [Dissertation], cote 201, d9, no. 1, fol. 20, Archives de la Société royale de Médecine, Bibliothèque de l'Académie de Médecine, Paris, France (hereafter BAM).

17 Dupont (1787), Observations médico-pratique sur le traitement des scorbutiques de la flute du roy La Seine commandée par Monsieur le Marquis de Traversay, SRM 119B, d. 39, fol. 1, Archives de la Société royale de Médecine, BAM.

18 Wear (1992; 2008).

19 On the notion of milieu, see, for example, Taylan (2018); Clarizio, Poma, & Spanò (2020).

20 Schaffer (1990); Beretta (2000); Bensaude-Vincent & Stengers (2001); Thébaud-Sorger (2018); Golinski (2007); Jankovic (2010); Holmes (2000). On urban contexts, see Fressoz (2009).

Galenic medicine.[21] These six non-naturals were parameters considered to influence human health: air, food and drink, movement and rest, sleep and wakefulness, excretion and retention, emotions and passions.[22] Other elements, such as sexual activity, could also be taken into consideration. The way in which Galenic dietetics dealt with the links between health and environment in the 17th century was not vastly different from the so-called neo-Hippocratic conceptions of the late early modern period, especially because the treatise *Airs, Waters, Places* was widely used and disseminated throughout Europe—and beyond.[23]

As early as 1671, the French physician Nicolas Venette considered the quality of the air to be crucial to the health of seafarers. That year, on the occasion of the establishment of the Rochefort arsenal, he published a *Treatise of the Scurvy*, which was undoubtedly the most comprehensive work on seamen's health of its time in France. Venette was a doctor from La Rochelle, the main port near Rochefort, who was used to treating seamen's illnesses. He dedicated his text to the new Intendant of the Arsenal, Charles Colbert du Terron, presenting his treatise as a contribution to French overseas expansion: "Nothing seems to be missing from this great enterprise other than the health of those you employ in it."[24] Describing the causes of disease in the order of the six non-naturals, he referred to the air on board ships as the most decisive parameter influencing health. According to the doctor, a "cold & wet, thick & nebulous" air could almost single-handedly cause scurvy. He precisely described the air inside a ship as "full of vapours & exhalations, which make it thick, cold, damp," especially if the climatic conditions did not allow to refresh it by opening the gunports. Ships' poor air quality was multifactorial, but the physician pointed in particular to "the unbearable stench that comes from the ship's bilges," which according to him was "one of the main causes that most men who travel long distances at sea are attacked by Scurvy."[25] Nicolas Venette's view is interesting: he asserted that the environment in which seafarers live, the interior of the ship, could be changed to "remedy this cause."[26] His opinions put him at odds with some of his (few) predecessors and his more pessimistic contemporaries, who saw the sea air itself as the main cause of scurvy.[27] According to Venette, sea air only becomes dangerous to health if it stagnates in the tween deck, in cases of insufficient ventilation or if it becomes loaded with the noxious exhalations produced within the ship. He thus offered a detailed account of how the atmosphere inside a ship is formed and what makes it harmful to human health. By explaining the difference between the

21 Jouanna (2008).
22 Nicoud (2006, p. 241); García-Ballester (1993). Regarding the "six non-naturals" in the second half of the early modern period, see Kennaway & Knoeff (2020).
23 Wear (2008).
24 Venette (1671).
25 Venette (1671, pp. 23–24).
26 Venette (1671, p. 103).
27 For example, see Fournier (1643, p. 148); Dellon (1685, pp. 6–7). For an overview, see also Linte (2019, pp. 206–220).

external air and the air breathed (and lived in) by the crew, he pointed out the possibility of "correcting" its qualities and consequently improving health on board.

From the mid-18th century onwards, air quality was consistently seen as the most crucial factor affecting seafarers' health.[28] The characteristics of the atmosphere on board were considered products of factors both external and internal to the ship. External factors depended on the qualities of the air in the place sailed through, which, even at sea, was influenced by the local climate. The main internal factors were the emanations from the crowds of men and animals, the heat from their activity, the stagnation of the air due to lack of ventilation, and the stagnation of water and the fermentation of food in the ship's hold. This led to an increase in studies on the atmosphere within vessels, which were carried out primarily by (non-medical) scholars and naval officers, who greatly influenced later medical thought. The "Dissertation on the Corruption of Air in Vessels," written by the naval officer Sébastien-François Bigot de Morogues and printed in 1750, became a reference text on the subject and was quoted extensively in the following decades.[29] It was a simple 15-page text, but its contemporary readers were impressed by the precision of its analysis, which was based on observation and confirmed by experiments conducted shipboard. Bigot de Morogues was a very experienced naval officer who had sailed the Atlantic and North European seas on numerous occasions during the 1730s and 1740s.[30] His success could also be attributed to the ease with which his conclusions, which explained how the corrupted air of ships affected human health, could be applied to the medical ideas of his time. The navy officer was inspired by Stephen Hales, who had invented a new ventilator, the description of which was published in 1743.[31] Hales's work did not only concern ships but also other problematic places in the 18th century, such as mines, workhouses, and hospitals.[32] His influence, however, extends far beyond the simple study of air quality in confined spaces. He followed in the footsteps of the 17th-century investigations on breathing undertaken in England by Robert Hooke, John Mayow, and Robert Boyle.[33] These scientific investigations, based on measurement and experimentation, revealed the presence of a substance necessary for life in the air. Boyle's experiments, involving animals in a closed environment, are one symbol of the progress of knowledge on respiratory physiology.[34] In the wake of his predecessors, Stephen Hales conducted a series of experiments relating to the properties of air and respiration. In 1727, he published a book in London entitled *Vegetable Staticks, or, An Account of Some Statical Experiments on the Sap in Vegetables*.[35] This work gave Hales a favourable reputation in France, where the

28 Lawrence (1996); Sampson (2021); Harrison (2013).
29 Bigot de Morogues (1750).
30 Sébastien-François Bigot de Morogues was also a member of the Académie Royale des Sciences since 1732 and a founding member of the Académie de Marine created in 1752: Vergé-Franceschi (2002, p. 204).
31 Hales (1743).
32 Concerning military or naval hospitals, see, for example, Spinney (2018, pp. 77–117); Tortosa (2021b).
33 Gerhard (1997, pp. 85–87).
34 On this issue, see, for example, West (2015).
35 Hales (1727).

Comte de Buffon, an enthusiastic admirer of his work, prepared a translation. It was printed in Paris in 1735, under a title that placed more emphasis on the general reflections on air than the original: *La Statique des Végétaux et l'Analyse de l'Air* (*Static of Vegetables and Air Analysis*).[36] This text particularly influenced Bigot de Morogues, both methodologically and theoretically. Hales's ideas about the "elasticity of air" and his calculations of the quantities inspired by the lungs permeated the thinking of the French naval officer, who frequently referred to them.[37]

While he did not exclude other diet-related factors leading to illness in crews, in particular the consumption of salted meats, Bigot de Morogues considered air, the environment in which seafarers live, to be the factor that most influenced their health. In his view, air is both humans' "main food" and a fluid whose contact with a human body influences health. He described air as being "similar to a fluid" and specified that "it is generally from the vapours whose air is charged that come some alterations, whose the body feels the effects only when the progress of the damage has already become great."[38] Bigot de Morogues thus considered the ship to be an independent environment with its own atmosphere. Methodologically, through experiments and calculations, he demonstrated the existence of a specific internal atmosphere in the vessel, described its precise constitution (that is, the balance between air and noxious exhalations), and highlighted the origin of its pathogenic nature. According to him, the observation of the flame "of a lamp or a candle" can attest to the fact that "the air in the hold has lost some of its elasticity [*ressort*]."[39] He noted that flames in such conditions lacked "intensity" and "vivacity," like flames that fade once confined under a glass bell. Inspired by the work of Bigot de Morogues, the versatile savant, member of the Académie Royale des Sciences, and navy inspector Duhamel du Monceau recommended the use of the same process a few years later, in a work titled *Means of Preserving the Health of Ships' Crews*, in order to "judge whether the air is in a suitable state for the breathing of the animals."[40] To determine which of two different places contained the healthiest air, it would be sufficient, according to him, to compare the manner in which a candle burns in each place; he asserted that the faster-burning candle would indicate the more favourable atmosphere for human beings. These experiments were once again inspired by those carried out in Britain, and the notion of *ressort* of the air aligned with what Stephen Hales called "elasticity."

The conclusions of the works carried out on ships' air quality in the mid-18th century led further research to focus on two places: the hold and the steerage. According to medical knowledge, the different exhalations from these places mixed with the air and created its pathogenic character. In the hold, these exhalations were seen as coming from the fermentation of the food and stagnant water, especially in the bilge (*sentine*), where dirty water accumulated at the bottom of the hold. In the steerage, the atmosphere's degradation was seen as being caused by the crowding

36 Hales (1735).
37 See, for example, Bigot de Morogues (1750, p. 401).
38 Bigot de Morogues (1750, p. 394).
39 Bigot de Morogues (1750, p. 397).
40 Duhamel du Monceau (1759, pp. 33–34).

of humans and animals.[41] The significance of corrupted air on the degradation of sanitary conditions on ships was no longer just an empirical feeling based on medical theory, as it had been in the time of Nicolas Venette; rather, it was a quantified reality based on physics and chemistry. According to the calculations of Bigot de Morogues, the bad exhalations would occupy a quarter of the total volume of the atmosphere of the steerage (5,000 of the 20,000 m^3 in the vessel he studied). At this time, and with the development of the use of instruments such as the barometer and thermometer during the following decades, the study of air in the 18th century took on "the appearance of an objective science."[42]

Air and Medicine in the 18th Century: "Insensible Perspiration"

In the medical field, though humoral conceptions remained fundamental, profound changes occurred in the 18th century.[43] Already present in the thoughts of Bigot de Morogues and Duhamel du Monceau, these new conceptions became decisive in physicians' and surgeons' interpretations of the dietetics of seafarers. The 18th century was the time of the development of a medical climatology, which centred around the study of atmospheres and climates.[44] If not "rediscovered," the treatise *Airs, Waters, Places* was nevertheless revisited during the 18th century, both in relation to changes in medical theory and in light of the aforementioned new knowledge and conceptions of air. In France, during the last decades of the early modern period, Antoine Poissonnier-Desperrières became the leading French author on the issue of seafarers' health—alongside influential British physicians such as James Lind, John Huxham, and John Pringle. After a tenure as King's physician in the colonies (*Médecin du roi aux colonies*) in Saint-Domingue, he became the adjunct of his brother, Pierre-Isaac Poissonnier, as Inspector-General of Medicine for navy hospitals and the colonies. Pierre-Isaac was the main advisor on health matters to the Minister of the Navy from 1763 and had a great influence on every decision surrounding naval hygiene in the late 18th century. In his *Treatise on the Diseases of Seafarers* published in 1767, Antoine Poissonnier-Desperrières presented his views on how the principles described in *Airs, Waters, Places* could be reconciled with the new knowledge about air. Praising the Hippocratic ideal of observation and experience-based medicine, the physician emphasized an interest in the atmospheric question that dates back to ancient Greece:

> Indeed, if we open the books of the ancient physicians, we will see that the knowledge of the elements, and of the action of the aerial fluid on our bodies was the object of their most assiduous research: the book of Hippocrates, of *Aëre & Licis*, is a clear testimony that this divine man in the art of healing, who had for

41 Bigot de Morogues (1750, p. 398).
42 Faure (1997, p. 287).
43 Mazzolini (1997, pp. 98–99).
44 Barrett (2000, pp. 87–108); Golinski (2007, pp. 137–169); Jankovic (2010).

> compass the observation and the experiment, joined to it the reasonings which could be deduced from the constantly observed facts. He made conclusions which will always make Medicine regret that this genius was born in a century when the nature of the air and its different effects were little known, and when its weight, the most important of its properties, was absolutely ignored. Let us read carefully the works of the ancients, and we will agree that in the treatment of illnesses they had much regard for the time, place and changes that occurred in the atmosphere, although they were not very enlightened about the way in which cold or hot air acted, and about the action of aqueous vapours, and so forth. Experience, in ancient times, was the only guide for Physicians, and it guided them quite surely in their curative method.[45]

Thanks to increased knowledge about air and development of meteorology, atmospheric data occupied a predominant place in 18th-century medical thinking. However, as the physician's comments emphasise, there was no break with the idea of observing the parameters of an environment in order to determine its healthiness for humans. Antoine Poissonnier-Desperrières' discourse was also consistent with developments in medical theory; he relied on a mechanistic vision of the body, in which health is presented as a state of "free exercise of all our functions" and illness, by contrast, arises when these functions are "hindered, vitiated, or partially destroyed."[46] The idea of balance, which had guided European medical thought since antiquity, remained central. The proper functioning of the body's mechanics, synonymous with health, was seen as depending on "the right balance between solids & fluids."[47]

Influenced by the ideas of James Lind, Antoine Poissonnier-Desperrières asserted that sea air had a harmful effect on human health because of its humidity and coldness.[48] According to him, long voyages across the ocean are a permanent and unwinnable struggle against environment, because constantly being surrounded by a ship's atmosphere for a long period put everyone in a state of "scorbutic cachexia" (*cachexie scorbutique*), which was seen as the main health hazard at sea.[49] Such a conception stressed the necessity for investing in more efficient solutions for ventilating vessels than prior standards for transporting humans beings and goods to all corners of the overseas empire and trading ports in Asia. This pessimistic view of the maritime environment broke with the more optimistic vision defended by Nicolas Venette and Bigot de Morogues before him, who had asserted that sea air is "pure" and "healthy." According to Poissonnier-Desperrières, the danger did not only come from inside the ship; it was not only breathing the atmosphere that was considered unhealthy, but also the fact that bodies were immersed in it. In his view, such an atmosphere, "which we are surrounded by while sailing," prevented a certain form of perspiration that

45 Poissonnier-Desperrières (1767, pp. 3–4). This book that was republished in a revised edition in 1780: Poissonnier-Desperrières (1780).
46 Poissonnier-Desperrières (1767, p. 2).
47 Poissonnier-Desperrières (1767, p. 26).
48 Poissonnier-Desperrières (1767, p. 23).
49 Linte (2019, pp. 333–335).

is essential to health: insensible perspiration (*perspiratio insensibilis*).[50] This notion had first been advanced at the beginning of the 17th century by the Italian physician Santorio Santorio. Thanks to his famous chair, he demonstrated that the difference between the quantity of food ingested and that of excrement is not correlated to body weight.[51] He then posited the existence of an imperceptible vaporous evacuation from the body, which he termed "insensible perspiration."[52] In the 18th century, insensible perspiration was an integral part of the representation of human physiology.[53] It was conceived as a vapour invisible to the human eye and discharged through the pores of the skin. Robert James's *Medicinal Dictionary* (1743–1745) described this phenomenon in the article dedicated to the skin (*cutis*):

> Another Use of the Epidermis is, to regulate the cutaneous Evacuations already mentioned; the most considerable of which is insensible Transpiration. By this we understand as a fine Exhalation, or a kind of subtle Fume, which flows out of the Body imperceptibly, and in different Quantities.[54]

The clarification of this notion is essential, as authors discussing the health of seafarers in the 18th century relied on this conception of perspiration in their writings. For Antoine Poissonnier-Desperrières, the consequences of this phenomenon included damage to the body's fibres, the new reference unit of medicine at the end of the 18th century:[55]

> the atmosphere, then charged with as much water as it can be, prevents that which comes out of the bodies by transpiration from being easily absorbed; it stays longer on the surface, & remains between the meshes of the vessels from which it leaves: the vessels are necessarily overloaded with it, & the fibres, by a very simple consequence, being more watered with serosities, become slacker & softer.[56]

Insensible perspiration thus became a key concept in late early modern naval hygiene. Several theories concerning air quality on ships and the diseases of their occupants were based on this physiological mechanism. Antoine Poissonnier-Desperrières' pessimistic view of the maritime environment was by far the most widespread in France during the last years of the Ancien Régime. This coincided with growing pessimism about the issue of acclimatisation among physicians, particularly in the British Empire.[57] A handwritten text sent to the Société Royale de Médecine (Royal Society of Medicine) in 1786 by Antoine Chaumont Sabathier, a navy doctor in Brest, makes

50 Poissonnier-Desperrières (1767, pp. 28–29).
51 Santorio's chair was a kind of weighing scale that he used to compare variations in his weight according to what he ate and drank, and what came out of his body (urine, excrement, and so forth). On the emergence of quantitative medicine and Santorio, see Barry & Bigotti (2022).
52 Gerhard (1997, pp. 79–80); Wear (1995, pp. 353–356).
53 Dacome (2001; 2012); Renbourn (1960).
54 James (1743–1745, Vol. 2, "Cutis"). Definition faithfully translated in the French version of the dictionary: James (1746–1748, Vol. 3, pp. 919–920).
55 Ishizuka (2012); Porter (1995, pp. 393–495).
56 Poissonier-Desperrières (1767, p. 30).
57 Harrison (1996).

clear that physicians still subscribed to the idea that humidity and cold were the causes underlying most of the illnesses of seafarers.[58] Despite this, the idea that it was possible to influence air quality on board ships remained, and became increasingly important in the second half of the 18th century. This idea thus guided choices in terms of prophylaxis and therapeutics. The efforts of the various actors invested in the health of seafarers, as well as the means mobilised by France, were channelled more toward devices intended to purify and renew the air, rather than, for example, toward improving crews' food rations or working conditions.

Cleaning, Airing, and Perfuming the Ships

While questions concerning assistance at sea, the composition of rations, the presence of animals, and the provision of clothing were present in both medical discourse and regulations of the late 17th century, the most detailed prescriptions were generally those relating to the renewal and purification of the air as well as to ship maintenance. These were important points in the fight against the deterioration of the seamen's working environment and the atmosphere in which they lived. In his 1671 treatise, Nicolas Venette proposed various means to combat this deterioration and to enhance the quality of the air on board. He asserted that it was essentially between the decks of the ship that action should be taken. His advice was both rudimentary and easy to implement, at least when the weather permitted. This consisted of opening all the steerage gunports as much as possible in order to promote air circulation and carrying out regular fumigations with rosemary, laurel or juniper wood.[59] Additionally, Venette recommended that great attention be paid to ship maintenance, and he specifically insisted that it was necessary to wash the decks with water and vinegar, especially when passing through the tropics, where climatic conditions were known to be particularly detrimental to sanitary conditions.[60] This advice was common not only in the rare medical texts concerning the health of seafarers that were printed at the time, but also in archival documents testifying to the increasing attention paid to health problems linked to the multiplication of transoceanic voyages. In 1708, the first King's physician to be installed in the French colony of Martinique, Mr. de La Martinière, warned of the risks of epidemics caused by insalubrious conditions on ship, especially in hot climates. He was convinced that the disease then ravaging the island—the "Siam disease"—had developed on board ship due to the foul air. He urged the Minister of the Navy to keep ships cleaner and to fumigate them by "evaporating vinegar, or burnt bread, or any other perfume that may be indicated, if the former

58 Sabathier (1786), Mémoire sur la santé des équipages [Dissertation], SRM 201, d9, no, 1, fol. 12, Archives de la Société royale de Médecine, BAM. It was also spelled "Sabatier"; for biographical information, see Brisou & Sardet (2010).

59 Venette (1671, pp. 103–104).

60 Venette (1671, pp. 104–105).

are not sufficient for the air to be corrected."[61] Cleaning a ship was thus conceived as a means of improving the air quality. Similarly, fumigating and perfuming were carried out based on the same logic because bad smells were perceived as revealing the noxiousness of the atmosphere.[62] La Martinière's observations emphasise the importance given to maintaining clean air on board ships, which was regarded as a crucial issue for the achievement of the French imperial project. This was not only about ensuring the safe transport of human beings and goods across the ocean, but also about protecting the overseas territories from the epidemic risks produced by the transoceanic voyages themselves.

These issues were increasingly prioritised by the royal government at the end of the 17th century. Under Colbert and then Seignelay, as Minister of the Navy, two major marine ordinances, central to the history of maritime regulation in France, were published in 1681 and 1689.[63] Regarding sanitation, the 1689 ordinance, which affected the French Royal Navy (while the previous ordinance regulated maritime activity as a whole), provided directives with a previously unseen degree of precision. The text introduced practices aimed at improving sanitary conditions and conserving food supplies, and it mobilised a large number of actors to implement these changes.[64] For example, the boatswain was responsible for keeping his ship as clean as possible: "scraping, cleaning & washing his ship, so that it is always clean."[65] The carpenter had to examine "every day if the gunports are well caulked [and] if the water of the rain does not pass through some seam," while the captain had to check that the officers "& the people of his crew do not sleep undressed."[66] The 1689 ordinance also included a series of articles that address crucial points for maintaining the cleanliness of the ship and, above all, its air quality. The first rule consisted of prohibiting the degradation of the living spaces, particularly the steerage, by forbidding men from relieving themselves there.[67] The subsequent articles set out precise rules for the maintenance of the ship and the renewal of its air. They ordered crew to sweep and clean every day and to ventilate the ship by opening the gunports "as often as the weather permits," as well as to pay particular attention to the maintenance of animal enclosures. The "pens & cages of sheep, poultry, & other cattle" were to be washed twice a day, "by throwing water & sweeping them." These measures were not intended to be mere indications; the ordinance constantly specified that this work had to be carried out under the supervision and authority of various actors afloat. For example, a naval officer had to be present during the cleaning operations, while the officer of the watch was responsible for checking that "the ship is as clean and tidy as

61 La Martinière (1708, Feb. 10), Mémoire sur les moyens de lutter contre la maladie de Siam [Medical report], cote COL C^{8B} 2, no. 90, fol. 1, Archives Nationale d'Outre mer, Aix-en-Provence, France (hereafter ANOM).

62 Corbin (1982/2008, pp. 133–163); Engelmann & Lynteris (2020).

63 *Ordonnance de Louis XIV, roy de France et de Navarre, donnée à Fontainebleau au mois d'Aoust 1681, touchant la Marine* (1681); *Ordonnance de Louis XIV pour les armées navales et arcenaux de marine* (1689).

64 On the conservation of foodstuffs on French ships, see Sueur (1993).

65 *Ordonnance de Louis XIV pour les armées navales et arcenaux de marine* (1689, p. 42).

66 *Ordonnance de Louis XIV pour les armées navales et arcenaux de marine* (1689, pp. 55–56).

67 *Ordonnance de Louis XIV pour les armées navales et arcenaux de marine* (1689, p. 98).

it is ordered."[68] It is interesting to note that, at that time, issues of cleanliness were more the responsibility of those exercising authority and enforcing discipline than of the ship's surgeons.

The rules established by the ordinances of 1681 and 1689 remained valid until the end of the Ancien Régime, but they later became more precise and focused more on epidemic treats.[69] On September 16, 1733, the "Regulations Concerning the Navy of the East India Company" once again reiterated the standards established in 1689 regarding ships' cleanliness and seamen's behaviour.[70] After the Seven Years' War (1756–1763), however, the new naval ordinance of March 26, 1765 was promulgated; this was much more precise and stipulated that greater attention be paid to the sick berth, the area set aside in steerage for receiving and treating patients. The ordinance specified that the patients be "separated, as far as possible, from the other members of the crew" and this area be "kept very clean."[71] The great epidemics of "vessel fever" during the previous decades had impressed all contemporaries and encouraged the authorities to reinvest in combating naval health issues.[72] In 1780 and 1786, new regulations were issued that placed more emphasis on hitherto relatively neglected aspects of hygiene, such as personal cleanliness. However, the crucial issue of air renewal remained central. Published at the end of the early modern era, the "Regulations Concerning the Cleanliness of Vessels, & the Preservation of Crews" of January 15, 1780, followed by the "Regulations on the Order, Cleanliness and Salubrity to be Maintained on Board of Vessels" of January 1, 1786, described solutions for the issue of naval hygiene within a highly precise normative framework.[73] The articles comprising these regulations demonstrate the influence of emerging naval hygiene. The evolution of the practices described and the vocabulary used testify to the medicalisation of naval prevention issues in the late 18th century. Even in the first article, which addressed disinfection prior to embarkation, the terms employed reveal the influence of naval hygiene; this article drew on medical language when it called for action against the "putrid miasmas" responsible for disease:

> First Article
> ALL the walls of the steerage and hold of the Vessels and other King's ships being armed, will be coated with two or three layers of very liquid lime water, in order to eliminate all insects and putrid miasmas that could have been left in the previous armament. The interior of the Vessels will then be well ventilated & dried, as much as possible. The stone ballast will be embarked only after having been washed with fresh water.[74]

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68 *Ordonnance de Louis XIV pour les armées navales et arcenaux de marine* (1689, p. 98).
69 Linte (2021, pp. 13–14).
70 *Reglement touchant la marine de la Compagnie des Indes* (1733, p. 44).
71 *Ordonnance du Roi concernant la Marine* (1765, p. 272).
72 Goubert (1974); Chaline (2018).
73 *Ordonnances et règlemens concernant la Marine* (1786).
74 "Règlement concernant la propreté des vaisseaux, & la conservation des équipages" (1780, Jan. 15), p. 1, Library of the Ancienne Ecole de Médecine Naval, Rochefort, France (hereafter AEMN).

The 18th-century recommendations concerning the cleanliness of the ship and the healthfulness of its air aligned with those of the previous century. Bigot de Morogues, in his "Dissertation on the Corruption of Air in Vessels" (1750), provided advice intended to make the atmosphere less harmful to human health. Of the nine points the officer listed, few described new practices, and some just provided instructions for implementing the 1689 ordinance. But some parts of the ship, mainly the hold and the place used to gather the sick, received more specific attention than before.[75] The miasma emitted by the sick was considered likely to corrupt the air and spread disease. In a book entitled *La Prévoyance du marinier* (1753) and intended for surgeons of the Compagnie des Indes, Pierre Decan de Villeneuve—a doctor from Montpellier—also recommended the use of vinegar to clean the steerage room, in order to "make the air less coarse."[76] Instructions issued by doctors, officers, and other experts interested in the health of seafarers were intended to provide for the implementation of the obligations established by the regulatory texts. Antoine Poissonnier-Desperrières wrote in 1767 that "the Marine Orders are formal" and that, concerning the rules for keeping a ship, "it is only a matter of ensuring their execution."[77] For example, the doctor specified that, although it was imperative to wash the interior of the vessel frequently, "this should never be done when the hatches and gunports cannot be kept open" as doing so could lead to increased humidity in the air. He attributed almost all pathologies of seafarers to humidity, which he believed caused the retention of "insensible perspiration." Duhamel du Monceau had already insisted on this point a few years earlier, prescribing that the steerage be washed "only during the heat of the day, so that the humidity has time to dissipate before nightfall."[78]

In addition to practices for preventing the corruption of the air on board ships, the authors focused their attention on ways to renew and purify the atmosphere. Fumigation was already prescribed in the 17th century and continued to be encouraged until the end of the 18th century.[79] However, by the end of the Ancien Régime, some doctors (Sabathier in 1786, for example) began to question its effectiveness, asserting that it altered the purity of the air.[80] This was particularly the case for acid-based fumigation, which, as Thomas Le Roux showed, remained contested in the late 18th century despite the fact that it acquired an improved reputation in France and abroad following Guyton de Morveau's experiments in the 1770s.[81] Nevertheless, even for those who defended this practice, perfuming a ship was never considered sufficient to ensure the quality of its atmosphere, and the idea that air renewal was the only effective remedy for restoring the healthfulness of the atmosphere was unanimously

75 Bigot de Morogues (1750, p. 405).
76 Decan de Villeneuve (1753, p. 22).
77 Poissonnier-Desperrières (1767, p. 382).
78 Duhamel du Monceau (1759, pp. 71–72).
79 On the history of fumigation in the maritime context, see Engelmann & Lynteris (2020).
80 Sabathier (1786), Mémoire sur la santé des équipages [Dissertation], cote 201, d9, no. 1, fol. 18, Archives de la Société royale de Médecine, BAM.
81 Le Roux (2016, pp. 160–161). The spread of Guyton de Morveau's ideas in Spain has been well studied recently: Garciá-Belmar & Ramón Bertomeu-Sánchez (2016); Serrano (2018).

accepted. Airing was thus the first form of prophylaxis conducted at sea at that time. Nevertheless, given the frequent impossibility of simply opening the gunports, the French Navy increasingly experimented with technical solutions in the 18th century, including bellows, ventilators, and so on.

Using Technology to Alter the Atmosphere of the Ships: The Case of Henri Weulersse's Ventilator

From the 1740s onwards, the use of methods or machines to renew the air in ships became increasingly common in France, especially as the Royal Navy became increasingly interested in these techniques. Among the various technical processes used in the 18th century was the "sleeve" (*la manche*), which some authors considered to be Danish in origin; this was a "long canvas sleeve" with a flared mouthpiece suspended from a yardarm. It was used to capture outdoor air, which rushed through it into the steerage. According to the accounts of Bigot de Morogues and Duhamel du Monceau, it seems that the sleeve was used frequently during the 18th century. The former stated that it was "the machine that has so far appeared to be the most convenient for carrying air into the bottoms of ships," and the latter that "the use of this sleeve is very well known in the ports."[82] However, the use of this equipment was accompanied by several constraints. The first was that its effectiveness depended on weather conditions. It was useless when the wind was not blowing but also when the wind was blowing too much, creating draughts that were considered responsible for "fluxions of the chest."[83] Though rudimentary, the sleeve was perhaps the most widely used device during this century. Machines, which were less practical and more expensive, were more difficult to deploy on a large scale—a point I return to shortly. The use of the sleeve until the end of the early modern period is reflected in the 1780 regulations, which still encouraged its use and praised its effectiveness:

> Art. XXXIII
> The use of the sleeve being one of the most appropriate means of expelling the foul air from the bottom of the vessels, will be frequently employed; but then it will be carefully observed to make all the crew pass on deck, to evacuate through the gunports the air from the hold forced into the steerage, and to guarantee the sick berth from this foul air with canvas. At the same time, all the portholes will be opened to let the wind flow in.[84]

From the 1740s onwards, as interest grew in the use of technical devices to improve the air quality of ships in France, several inventors approached the Ministry of the

82 Bigot de Morogues (1750, p. 406); Duhamel du Monceau (1759, p. 92).
83 Bigot de Morogues (1750, p. 407).
84 "Règlement concernant la propreté des vaisseaux, & la conservation des équipages" (1780, Jan. 15), p. 11, AEMN.

Navy to promote their work.[85] Boule de la Sorbiere was one of them. In February 1744, he wrote to the Count of Maurepas, the current minister, offering to fit the king's ships with a machine he had developed in 1730.[86] The inventor was not connected with maritime activities; he was "Captain of the Miners" in Douai, in the north of France. This once again highlights that the discourses and practices associated with the different environments identified as pathogenic were closely linked. In addition to the discourses held by physicians such as John Pringle relating to the fever of "prisons," "vessels," or "hospitals," concrete examples of using common technical solutions to deal with bad air can be observed. The versatility and equal effect of the ventilators in different contexts or climates was intended by their inventors. According to Marie Thébaud-Sorger, "ventilator design reshaped and in a way extended the boundaries of human action over the natural world."[87] A printed text from 1741 presenting Boule de la Sorbiere's machine clearly indicates its initial purpose: "Note on the construction of a new vacuum machine for use in mines."[88] But he soon advanced it as a suitable option for other contexts, especially ships. The minister asked Duhamel du Monceau for an expert opinion on Boule de la Sorbiere's machine. The latter's opinion was negative: "M. Duhamel finds it similar to the others [machines], with small differences that have little impact."[89]

Despite this failure, Boule de la Sorbiere did not stop promoting his invention; he revised his machine and proposed it twice more, in May 1744 and September 1757. For this last attempt, he decided to give himself the best chance of success by organising a trial of his machine on a frigate called *La Rose*.[90] Presented as a machine "used to change and purify the air in the mines," its capacity to renew the "putrid air" in the hold was showcased.[91] Once again, the minister consulted Duhamel du Monceau to evaluate the machine and, once again, received a negative opinion. Duhamel du Monceau, who was particularly well informed about recent technical innovations in Britain, both contested the fact that Boulle de la Sorbiere was the machine's inventor, or even the first to suggest its use at sea, since Jean Théophile Désaguliers had already done so in London in 1735, and found it less efficient than Hales's machine.[92] He wrote to the French Minister of the Navy:

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85 Regarding the issue of innovation in France in the 18th century, especially in relation to the navy, see Henrat (1990); Hilaire-Pérez (2000a); Llinares (2006); Llinares & Ulbert (2017).

86 Boule de la Sorbiere to J.-F. P. de Maurepas [Letter] (1744, Feb.), MAR G119/1/3, AN MAR; J. H. Villarzel to F. M. P. de Mauras [Letter] (1757, Sep. 14), MAR G119/1/5, AN MAR; Boule de la Sorbiere to F. M. P. de Mauras [Letter] (1757, Sep. 14), MAR G119/1/6, AN MAR.

87 Thébaud-Sorger (2020, p. 1099).

88 Boule de la Sorbiere (n.d. [1741?]), "Mémoire sur la contruction d'une nouvelle Machine aspirante à l'usage des Mines, avec une Explication de sa Construction & des avantages qu'elle a sur toutes les autre Machines à cet usage," MAR G119/1/1, AN MAR.

89 H. L. Duhamel du Monceau to J.-F. P. de Maurepas [Letter] (1744, Feb. 6), MAR G119/1/2, AN MAR; Boule de la Sorbiere to J.-F. P. de Maurepas [Letter] (1744, Feb.), MAR G119/1/3, AN MAR.

90 Boule de la Sorbiere to F. M. P. de Mauras [Letter] (1757, Sep. 14), MAR G119/1/6, AN MAR.

91 J. H. Villarzel to F. M. P. de Mauras [Letter] (1757, Sep. 14), MAR G119/1/5, AN MAR.

92 Thébaud-Sorger (2020, p. 1090); Désaguliers (1735).

> The bellows in question cannot therefore be considered as an invention of Sr. Boulle, but it is recognised as being very good for the use he wants to make of it; I would nevertheless prefer Mr. Hales' one, which is easier to use and sucks in a greater quantity of air. The trials that have been made of it have all been to his advantage.[93]

In the middle of the 18th century, two British machines attracted attention in France: Stephen Hales's ventilator and Samuel Sutton's air-pumping machine.[94] The text describing the Hales ventilator, presented to the Royal Society in London in May 1741, was translated into French by Dr. Demours in a book published in Paris in 1744.[95] Samuel Sutton's invention, first presented in London in 1741, was the subject of a publication in 1745, which was translated and printed in Paris in 1749.[96] Sutton's machine, a pump that used the heat of the kitchens to draw air from the hold to the outside, had one major drawback: it was not suitable for French ships, whose kitchens were laid out differently to those of the British ships. This did not prevent it from arousing admiration in France, encouraging Duhamel du Monceau to suggest that the kitchens of the king's ships be adapted to accommodate the invention.[97] Despite the support of the physician Richard Mead, the British Royal Navy did not prefer Sutton's device over its rivals.[98] Nonetheless, Stephen Hales's ventilator was unanimously acclaimed on both sides of the Channel. In France, Duhamel du Monceau praised it as an efficient, cheap, and easy-to-use invention, and wrote a positive report on its implementation at the Hôtel Dieu hospital in Paris.[99] Hales's ventilator was not intended only for ships, but also for mines, hospitals, and workhouses—all places that Alain Corbin described as "the laboratories where the future deodorisation of private space is being experimented with."[100] Bigot de Morogues also praised the use of Hales's machine, which he had seen in operation: "it is certain that Mr Hales' ventilator combines many particular advantages with all those of the sleeve, & that it is of excellent use, as I have recognised from the experiments I have made."[101] The naval officer had experimented with using Hales's ventilator on a vessel in the 1740s. The hold was the part of the ship he considered to contain the moistest and foulest air, so he decided to conduct his experiments there. The machine required two men to operate its levers. In Bigot de Morogues' experiments, the ventilator was placed at the back of the ship, under the forecastle. The air was carried from this point to the hold through a wooden pipe, which had been caulked beforehand. Duhamel du Monceau depicts this installation in his book on the "conservation" of seamen's health (Figures. 1 and 2).

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93 H. L. Duhamel du Monceau to F. M. P. de Mauras [Letter] (1757, Oct. 1), MAR G119/1/7, AN MAR.
94 Regarding ventilation on British ships, see Zuckerman (1976; 1987).
95 Hales (1744).
96 Sutton (1745; 1749).
97 Duhamel du Monceau (1759, p. 127).
98 Zuckerman (1976).
99 Thébaud-Sorger (2020, p. 1090).
100 Corbin (1982/2008, p. 156).
101 Duhamel du Monceau (1759, p. 106).

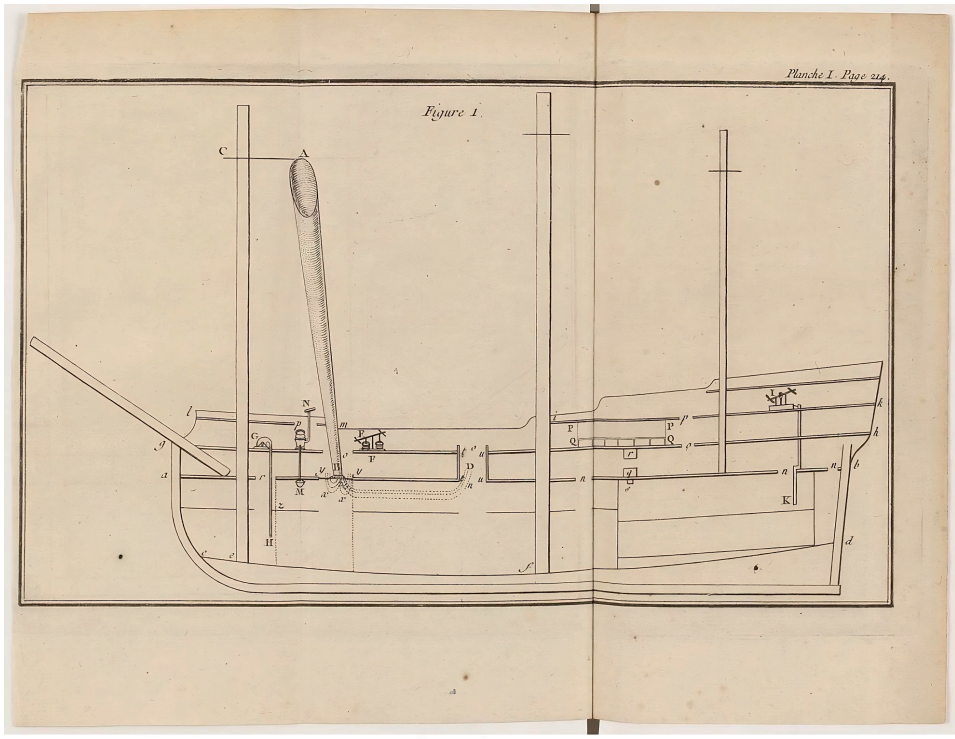


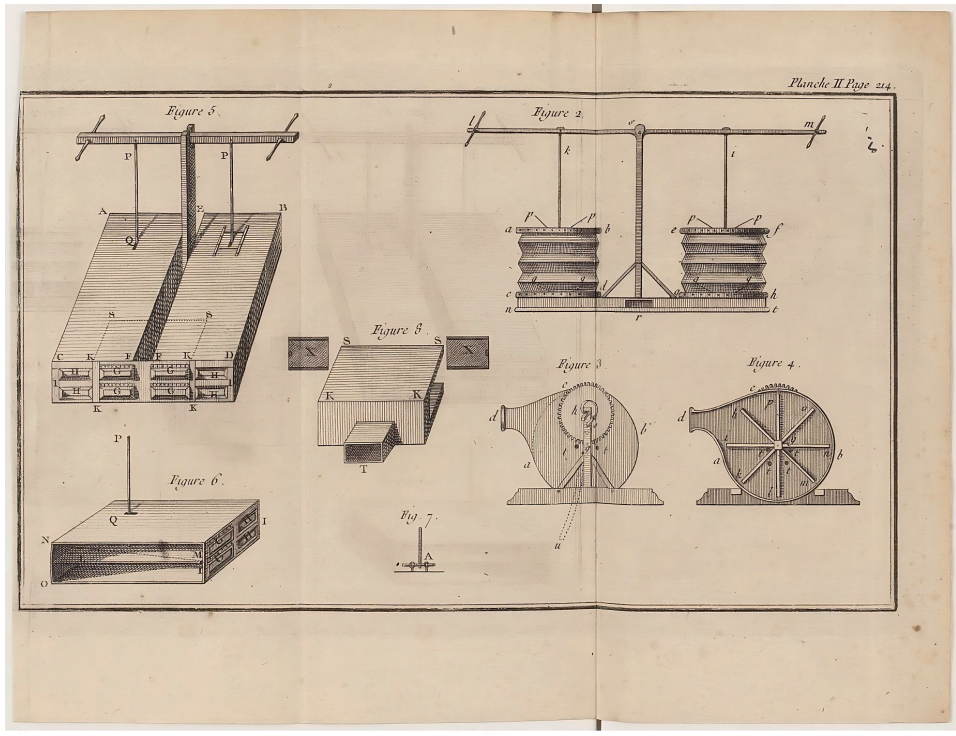
Figure 1. Several devices installed on board a vessel. Hales's ventilator is represented towards the back of the vessel, letters I–K; the sleeve towards the bow, letters A–B. From *Moyens de conserver la santé aux equipages des vaisseaux* (planche I, p. 214), by H.-L. Duhamel du Monceau, 1759, Paris: H. L. Guerin & L. F. Delatour. Accessed via the Bibliothèque Nationale de France (gallica.bnf.fr).

The experiments carried out by Bigot de Morogues were, according to himself, a success, as he had "dried out the hold in less than half an hour" on each attempt. The analysis of the machine's effects was based above all on a sensory evaluation by the ship's officers:

> Having made the Officers of the ship go down, & those of the crew who were curious about it, they all admitted, as I experienced it myself, that after this time they did not smell any bad smell; moreover, they found that they breathed a fresh air, although the thermometer of the hold had risen to a few degrees higher than it was before the experiment.[102]

In addition to renewing the air, Hales's ventilator could be used to effectively perfume the interior of a vessel. Bigot de Morogues used it for this purpose, circulating fumes of tar, sulphur, and gunpowder soaked in vinegar throughout the hold. The use of the machine was not limited to the hold, and he advised sending steam into the steerage,

102 Bigot de Morogues (1750, p. 409).



Source gallica.bnf.fr / Bibliothèque nationale de France

Figure 2. Ventilators and bellows. "Figure 5" shows Hales's ventilator. From *Moyens de conserver la santé aux equipages des vaisseaux* (planche II, p. 214), by H.-L. Duhamel du Monceau, 1759, Paris: H. L. Guerin & L. F. Delatour. Accessed via the Bibliothèque Nationale de France (gallica.bnf.fr).

emphasising the beneficial effect these fumes had on the hammocks used as beds by the crew. In his *Treatise on the Diseases of Seafarers* (1767), Antoine Poissonnier-Desperrières praised the benefits of using the ventilator. He then attacked those who accused the machine of being too cumbersome, at the same time that pens and cages holding animals intended for the officers' mess overloaded the steerage:

> It would be very surprising if such frivolous reasons could be put in the balance with the salvation of the Seamen. What difficulty, what embarrassment is there in moving and transporting bellows built in this way? It is certainly not because of their weight or their volume. The removal of two poultry cages will leave sufficient space to place them. As for the manoeuvre, it will not be so much an extra workload as a healthy exercise for the crews.[103]

In this passage, the physician also responded to the objection that men were needed to operate the bellows, pointing out the lack of exercise that sometimes characterised sea life and asserting that physical activity could only help to balance the diet of

103 Poissonnier-Desperrières (1767, p. 369).

seafarers. The size of the machines and the need to mobilise men to operate them were nevertheless the main reasons why ventilators were not effectively implemented on board ships in the 18th century, either in France or Britain.[104] These criticisms, often expressed by ships' captains, emphasised the impossibility of reproducing experiments carried out in very different conditions, such as in marine hospitals. According to Paul E. Sampson, the rejection of ventilators also highlights "a growing disconnect between the ideology of environmental improvement and the lived experience of captains and crews stationed in the far corners of the newly expanded [British] empire."[105] This applies to France's overseas empire too, where the most influential actors in the field of naval hygiene, such as Antoine Poissonnier-Desperrière, paid little attention to the criticisms of ventilators' effectiveness and the practical difficulties of using them at sea for long voyages.

Comparison with Britain was an important part of the discourse on naval hygiene in France. The French Navy's lack of resources compared to the British Royal Navy is often stressed in the correspondence of the Minister of the Navy, as well as in the literature relating to seamen's health. Encouraging the use of ventilators, Bigot de Morogues recalled that "its excellence is already known among our neighbours."[106] The integration of technical devices from Britain was thus a powerful driving force for innovation in mid-18th-century France. However, France sought not only to imitate its rivals but also to supplant them. As early as 1752, Mr. Pommier, "King's Engineer for Roads and Bridges," submitted to the *Académie Royale des Sciences* a "New ventilator rectified according to that of Mr. Hallés."[107]

Among the many proposals received by the Secretary of State for the Navy, a number put forward new ventilators. In 1780, one machine particularly attracted the minister's attention, the ventilator designed by Henri Weulersse. This ventilator, invented by a Navy mechanic (a job Weulersse had held since 1778), is an example well attested in the archives.[108] A file in the French National Archives preserves several related documents from the period between 1780 and 1800. In addition, there are some documents in the archives of the port of Rochefort relating to Weulersse's ventilator.

Henri Weulersse likely began designing his machine shortly after the promulgation of the "Regulations concerning the Cleanliness of Vessels, & the Preservation of Crews" on January 15, 1780. This is perhaps not unrelated, as Article XXX of this regulation ordered that "Ventilators shall be taken on board all Her Majesty's ships, and as much use as possible shall be made of them."[109] Though it is impossible to state that the marine mechanic only started to work on his project following

104 Sampson (2021, p. 6).
105 Sampson (2021, p. 15).
106 Bigot de Morogues (1750, p. 410).
107 A machine that was approved by the Académie Royale des Sciences since it appears in *Machines et inventions approuvées par l'Académie royale des sciences* (1777, Vol. 7, pp. 413–422).
108 MAR G119/3/20–65, AN MAR. On Weulersse's career, see Henrat (1990, p. 393).
109 "Règlement concernant la propreté des vaisseaux, & la conservation des équipages" (1780, Jan. 15), p. 10, AEMN.

the promulgation of the regulation, it is nevertheless perfectly clear that the actual equipment of ships with ventilators was still illusory at that time. The vast majority of ships were certainly not equipped with ventilators due to the lack of available machines and technicians able to design and install them. Through his initiative, Henri Weulersse was thus responding to a desire expressed by the Crown. It was, of course, also an opportunity for him to be noticed and to expect a reward, such as a pension or the advancement of his career.

The oldest document concerning Henri Weulersse's ventilator dates to June 14, 1780. It is a letter written in Brest by Pierre-Isaac Poissonnier (principal advisor to the Minister for naval hygiene and brother of Antoine Poissonnier-Desperrières) to Antoine de Sartine, the Minister of the Navy. In it, the physician informed him that he had attended the trial of a new ventilator on the frigate *La Cibelle*.[110] Considering it a success, he stated that the machine "did not cause any embarrassment" and "seemed to renew the air with the greatest ease."[111] His conclusions were, however, somewhat hasty. The experiments, which were supposed to continue at sea, were not completed because the machine was damaged before departure.[112] The archives are incomplete for the remainder of 1781. In any case, on January 24 1782, after having apparently been approved by the Académie Royale des Sciences, the French Navy entered into a contract with Weulersse, engaging him to supply 123 ventilators for the king's ships.[113]

A document dated June 1782 details the state of the orders and deliveries in progress. At that date, of the 60 machines intended for Brest, the inventor had already sent 29. However, only 2 of the 36 machines intended for Toulon and 4 of the 24 promised to Rochefort had been delivered. The total cost, estimated at 240,000 livres, was approved by the Minister of the Navy in the summer of 1782.[114] This unprecedented investment in preventive efforts highlights the French state's involvement in the development of naval hygiene at the end of the 18th century. The aim was, of course, to reduce the number of deaths and to preserve the health of men essential to France's maritime strength. It is also worth noting the obvious temporal overlap between moments of investment in seafarers' health and the wars in which the Navy was involved during the second half of the century: the Seven Years' War (1756–1763) and the American War of Independence (1775–1783, in which France was engaged after 1778).[115] This investment can also be explained in part by the positive reputation that Henri Weulersse's ventilator quickly acquired, offering the

110 On the role of demonstrations in the validation (or rejection) of inventions in the 18th century, see Hilaire-Pérez (2000b). For a case study regarding innovation in the French navy, concerning food preparation and transformation for long-distance travel, see also Spary (2009).

111 P.-I. Poissonnier to A. de Sartine [Letter] (1780, Jun. 14), fol. 1, MAR G119/3/20, AN MAR.

112 M. A. N. G. de Clugny to C. E. G. de La Croix de Castries [Letter] (1781, May 14), fol. 1, MAR G119/3/21, AN MAR.

113 "Ventilateurs pour les vaisseaux, fregates et batiments du Roi" (1782, [May or Jun.]), MAR G119/3/22, AN MAR; Minutes of the Conseil de Marine (1789, Feb. 13), MAR G119/3/33, AN MAR.

114 "Ventilateurs pour les vaisseaux, fregates et batiments du Roi" (1782, [May or Jun.]), MAR G119/3/22, AN MAR.

115 Regarding the relationship between war and health, see Charters (2014); Hudson (2007); Tortosa (2021a).

possibility of competing with the British Royal Navy in the field of naval hygiene. On June 19, 1782, a trial was organised in the port of Rochefort, where eight devices were shipped for the occasion. Designed to be used not only on ships but also in hospitals and prisons, the ventilators were approved by the commission created for the occasion:

> We would have put them in four different rooms of the hospital; and after having used [the ventilators] for a sufficient time, we would have found that they are very suitable not only for renewing the air in a short time, but also for perfuming it; and we would have recognized that the use of them can only be very advantageous for the healthiness of the air on board the King's ships and in the hospitals and prisons.[116]

Those present at a trial carried out in Brest in November of the same year shared the opinion that "this machine fulfils the purpose for which it was proposed."[117] However, the official report raised doubts about the durability of the leather from which the ventilator was made and questioned whether it would deteriorate during long journeys: "We believe that it will be difficult to guarantee the leather from rats and, in hot countries, from insects." This was potentially a significant weakness for a tool designed to sail across the colonial empire.

Despite these positive assessments, ventilators were rarely installed on board ships. From the mid-1780s onwards, critics increasingly focused on the device's limitations, principally the space it occupied and the manual force required to operate it. Captains were reluctant to add further difficulties to those already inherent in transoceanic travel. A commission appointed by the Conseil de Marine judged that the ventilator was not very different from Hales' machine and shared its main defects. Above all, the commission noted a problem with the very use of the ventilator at sea in this period:

> its effects are momentary, and that no advantage can be taken of it during the night, a time when the air is absolutely stagnant and during which the patients are immersed in the emanations produced by the perspiration of each individual.[118]

Finally, the commission requested that an expert investigation on "air quality" be carried out over several months by physicians in naval hospitals in order to establish the influence of the ventilator's use "on the state of the patients." Weulersse worked to improve his machine and proposed visiting all the arsenals to install it himself on the King's ships and in the marine hospitals; this is what he did from 1787 onward, following instruction from the Minister of the Navy.[119] Nevertheless, in 1789, a

116 "Procès-verbal de visite et d'épreuve de huit ventilateurs, de l'invention du Sr. Weulersse, pour le service des vaisseaux et des hôpitaux et prisons, suivant son marché du 24 janvier 1782" (1782, Jun. 19), SHD Rochefort 2F1/22/2, Service historique de la Défense, Rochefort, France.

117 "Procès-verbal d'un ventilateur" (1782, Nov. 30), MAR G119/3/23, AN MAR.

118 "Rapport de la commission nommée par le Conseil de Marine pour examiner les effets et l'utilité du ventilateur du S. Veulers" (1786, Nov. 26), MAR G119/3/25, AN MAR.

119 C. E. G. de La Croix de Castries to H. Weulersse [Letter] (1787, Aug. 4), MAR G119/3/28, AN MAR.

document relating to the February 13 session of the Conseil de Marine assessed the situation as poor:

> These ventilators were rarely used at sea, in spite of repeated orders to embark them on all ships that were armed, either because of the inconvenience they could cause on the vessels, or because their volume did not allow them to be installed on board of small ships. The result is that these machines, although recognised as being very useful for the preservation of men and supplies, have fallen into disuse, and are likely to be damaged in the warehouses.[120]

During the French Revolution, Henri Weulersse continued to improve his ventilators. New trials were held in 1790, and the commission responsible for evaluating them recommended (once again) that the machines be installed on board Navy vessels.[121] It must, however, be noted that significant changes had been made to the ventilator: the redesign halved its size (from 4 to 2 feet), limiting the required space and allowing it to be installed on smaller ships.[122] The intense political tensions in Europe during the French Revolution may also partly explain the renewed interest in Weulersse's ventilator.

Henri Weulersse's ventilator implementation in the French Navy was a failure. Conceived as an efficient solution to the problems of scurvy and epidemic hazards, it never managed to convince the main stakeholders: naval officers and crews. The significant sums invested and the adoption of a regulation that imposed the use of the ventilator in the King's ships were made in a context in which the colonial future of France depended on its maritime power. An interesting parallel can be drawn with Britain, where Paul E. Sampson has shown that a similar failure took place. Although an order was given to install a Hales's ventilator on all Royal Navy ships in 1756, very few were taken to sea. According to Sampson, the lack of interest in Hales's machine was also part of a growing pessimism about the process of acclimatisation in the late 18th century. Such a connection cannot be made in the case of France, where the implementation of ventilators on board was not seriously considered until the 1780s. It seems that the failure was predominantly due to the practical limitations of installing and maintaining the ventilator, as well as the impossibility of proving its efficiency and its capacity to be used for long voyages in hot climates.

Conclusion: Pathogenic Environment and Stigmatisation

With France's growing overseas ambitions, seamen's health became a crucial issue in the second half of the early modern era. The ideas, practices, and regulations developed in this context greatly influenced the debates on air quality and health during this period. Naval hygiene reshaped the understanding of the marine environment

120 Minutes of the Conseil de Marine (1789, Feb. 13), MAR G119/3/33, AN MAR.
121 Minutes of the Conseil de Marine (1790, May 8), MAR G119/3/42, AN MAR.
122 Minutes of the Conseil de Marine (1790, Sep. 7), MAR G119/3/49, AN MAR.

and its influence on human beings, and more broadly of "pathogenic environments," in which foul air was seen as the main cause of disease. However, although there were substantial changes in theoretical thinking and in the medicalisation of the vocabulary used in the 18th century, the ways in which the causes of illnesses were identified and the methods used to combat them remained relatively constant throughout this period. It is clear that the "chemical revolution" and meteorology led to an increased interest in the analysis and study of the air from the mid-18th century onwards, as reflected in discourses and practices. However, even among authors such as Antoine Poissonnier-Desperrières who more pessimistically attributed the causes of scurvy to the very qualities of the sea air, health prevention strategies consisted of renewing the air and rectifying its qualities, mainly by ventilating and perfuming the steerage and the hold of ships. The development of technical devices, such as bellows or ventilators, aligned with existing practices such as opening the gunports and perfuming ships' interiors, but constitute a new tool aligned with growing overseas and commercial ambitions of France in the 18th century. The need to defend the colonial empire became clear after the Seven Years war and then with the American War of Independence, which emphasised the crucial importance of hygiene on board ships. However, implementation of technical solutions remained rare and often inefficient. As discussed above, although widely praised since Stephen Hales and included in the regulations of the 1780s, the ventilators intended to equip the ships of the French Royal Navy usually languished in port warehouses.

What influence did this technical disillusionment have on the developments of the following century, which emphasised the role of filth rather than foetid air in the origin of diseases?[123] This shift can be observed in French naval hygiene texts as early as the 1780s, when physicians such as Sabathier and Lebeschu de La Bastays highlighted the importance of seamen's individual hygiene and the cleanliness of everyday objects. The question of personal hygiene was of course not new, as it is also mentioned in 17th-century documents, but it took on increased prominence in medical prescriptions and regulations of the late 18th century. For example, in his 1786 dissertation, Sabathier dedicated six pages to bodily cleanliness. The retention of perspiration, which causes illness, is not presented as a consequence of humidity, but of the filth that covered seamen's bodies:

> all the parts of the human body are pierced with an infinite number of pores; if we do not take care to keep the skin clean, it is covered with filth, which, by blocking the pores, creates an obstacle for the humours, which seek to escape, that they cannot overcome.[124]

In 1788, Lebeschu de La Bastays also devoted a chapter to this issue in his book, in which he distinguished four forms of "uncleanliness": the dirtiness of the ship and particularly the steerage room; the dirtiness of seamen's clothes; the uncleanliness of

123 Brown (2008).

124 Sabathier (1786), Mémoire sur la santé des équipages [Dissertation], SRM 201, d9, no. 1, fols. 19–24, Archives de la Société royale de Médecine, BAM.

the bedding (he described mattresses full of "filth and dirt"); and, finally and most originally for the time, the state of the copper or iron crockery, for which rusting and clogging "become a continual cause of uncleanliness" that altered the men's food quality and health.[125]

Finally, one last point remained significant throughout the second half of the early modern period: the stigmatisation of seafarers. In various forms, the main victims of poor sanitary conditions at sea (except in the case of slave ships) were constantly blamed for this state of affairs. Their alleged uncleanliness and negligence, towards both themselves and the ship, was a cliché common in both the archives of the Ministry of the Navy and scholarly literature dedicated to seafarers' health. Their poverty, which in particular meant that they had few changes of clothing, is also often mentioned.[126] The increased attention to dirtiness at the end of the 18th century only reinforced this idea. Stating that seafarers "push uncleanliness to the last degree," by which he meant that filth and vermin covered them, Sabathier considered it necessary to impose strict bodily hygiene requirements. Similar language had already been used in the 1780 regulations. This disciplinary aspect was an essential element of naval hygiene in the 18th century, especially for scurvy prevention in imperial contexts, as Lawrence highlighted for British Royal Navy.[127] Moreover, the failure of some preventive measures taken at sea was also attributed to sailors. For example, in 1757, Duhamel du Monceau, in a letter to the French Navy Minister, wrote: "Nothing is so important as to renew the air in the hold and steerage of ships, there is no lack of means to do this, but the seamen are inexcusably negligent in this respect."[128] In the end, the ship at sea, or more precisely its steerage, was conceived in the 18th century as a pathogenic environment. This led to the stigmatisation of a population, the seafarers, whose poverty and lifestyle were deemed partly responsible for the occurrence and spread of the very diseases that afflicted them.

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125 Lebeschu de La Bastays (1788, pp. 40–50).
126 "Tableau de la vie du matelot au service du Roy" [Dissertation] (ca. 1760), MAR G179/50, AN MAR.
127 Lawrence (1996); Caputo (2022).
128 H. L. Duhamel du Monceau to F. M. P. de Mauras [Letter] (1757, Oct. 1), MAR G119/1/7, AN MAR.

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