# Baltic Sea water as source of drinking water for cattle

Evaluating Baltic Sea water and strengthening agricultural preparedness

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Swedish University of Agricultural Sciences, SLU
Department of Animal Biosciences
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# Baltic Sea water as source of drinking water for cattle. Evaluating Baltic Sea water and strengthening agricultural preparedness

*Östersjön som dricksvattenkälla för nötkreatur. Utvärdering av vattenkvalitet och möjlig betydelse för stärkt beredskap inom jordbruket.*

Olivia Fröberg

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# Abstract

The aim of the study was to investigate the practical experiences and potential of using water from the Baltic Sea as drinking water for cattle and its immediate effects on health, and growth. Two studies were performed: one farmer survey and one experimental grazing study. Eighteen farmers along the Baltic coast with animals grazing near the Baltic Sea were interviewed about their experiences of having cattle drink from the Baltic Sea. The experimental study lasted 104 days in Swedish summer conditions and included 10 Hereford cows with calves and 10 Angus cows with calves, that were randomised onto Baltic Sea as their only source of drinking water (BALT), or fresh water from a trough (CON). Spatial position and insect discomfort was observed through direct observations, and potential effects of gastrointestinal function were assessed by measuring growth, faecal dry matter content and texture. Sampling also included pasture and water, and the use of a salt lick was quantified. Surveyed farmers reported positive experiences with having animals grazing nearby and drinking water from the Baltic Sea, noting benefits such as cooling, reduced insect pressure, and labour savings, while expressing some concerns about water quality and hygiene. The grazing study, did not find differences in growth performance (BALT 102 ± 28 kg vs CON 110 ± 22 kg; p=0.244), faecal dry matter (calves BALT 0.17 ± 0.02 vs. CON 0.16 ± 0.02 kg; p = 0.13 and cows BALT 0.13 ± 0.01 vs. CON 0.13 ± 0.01 kg; p = 0.11), or average faecal consistency on calves (BALT 4.5 ± 0.7 vs. CON 4.5 ± 0.7; p = 0.5). Faecal consistency was showing significant differences on cows (BALT 2.9 ± 0.9 vs. CON 3.4 ± 1.1; p = 0.04). Heat stress related behaviours showed no significant differences between treatment groups (Tail wagging p = 0.108 and head throwing p = 0.125). Water analyses and literature review indicated that salinity and trace elements remained below thresholds harmful to livestock and in most cases for human consumption. Salt block intake was lower in the BALT group than in the CON (p = 0.02). Based on estimated mineral intake from salt blocks, pasture, and water, BALT group showed lower intake of zinc, manganese, copper, iodine, selenium, and cobalt compared to NASEM recommendations. The CON group displayed a similar pattern for the trace elements, with additionally lower estimated intake of magnesium. Results suggests that Baltic Sea water is at least as safe as supplementary resource for cattle as the water given to CON group. These findings suggest that Baltic Sea water may be a safe supplementary resource for cattle during parts of the year, but further research is required to evaluate long-term safety, optimal management, and mineral supplementation strategies. Threshold values of levels safe for animal consumption should be established to easier evaluate alternative water sources for animals.



*Keywords: Baltic Sea water, cattle, agricultural preparedness, animal health, trace elements, grazing study*

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# Abbreviations

| | |
|---|---|
| ADG | Average Daily weight Gain |
| ADH | Antidiuretic hormone |
| ANP | Atrial natriuretic peptide |
| DM | Dry matter |
| NASEM | Nutrient requirements of beef cattle |
| TDS | Total dissolved solids |
| SLU | Swedish University of Agricultural Sciences |

# 1. Introduction and background

Along the Baltic Sea, coastal areas in Sweden have long been utilized for livestock grazing (County Council Stockholm 2008; County Council Östergötland 2014). According to the County Council Östergötland (2014), approximately 3,000 cattle grazed along the coast of Östergötland, of which around 400 were located on islands in the Baltic Sea. Similarly, the County Council Stockholm (2008) reported that about 600 cattle were grazing on islands within the Stockholm coastline. Rising temperatures caused by climate change have led to fresh water scarcity in parts of Sweden, particularly along the Baltic Sea coastline (Eveborn et al. 2017). Low groundwater levels and ongoing water shortages, due to drought and insufficient groundwater recharge, emphasise the need to identify and evaluate alternative drinking water sources for livestock along the Baltic coastline. Eveborn et al. (2017) state that preventive actions should be taken to secure future water supply and find alternative resources. The current societal discussion is also highlighting the need to maintain robust food and water production in all parts of Sweden (*(Proposition 2024/25:34 s. 136)* n.d.). Global uncertainties and several geopolitical conflicts are playing a bigger role in the societal discussion (Regeringskansliet 2025). Therefore, preparatory actions to ensure the resilience of society systems, including agriculture are important (Livsmedelsföretagen 2023), including solutions for livestock farming along the Baltic coast.

The aim of this study was therefore to investigate the possibility of using water from the Baltic Sea as drinking water for cattle and effects this may have on health, and production, as well as to evaluate the quality of Baltic Sea water regarding content of metals. Animal health was assed using indicators of growth performance and faecal dry matter content to help evaluate both gastrointestinal function and overall well-being. The questions to be answered in this study are the following:

- Can the use of Baltic Sea water as a water source for beef suckler cows and their calves affect animal health and production, evaluated through growth performance and faecal dry matter content?
- How is salt and trace mineral intake from salt-mineral blocks affected by access to the Baltic Sea and are requirements met?
- Is the Baltic Sea water a safe and sustainable water source for cattle during periods of water scarcity, considering levels of heavy metals, trace elements and salinity according to the found literature?
- Do cattle with access to the Baltic Sea use the coastal environment during hot summer days, and are there differences in behaviour related

to heat stress and insect infestation compared to cattle without access to the Baltic Sea?

- Based on interviews, what experiences do farmers have when using the Baltic Sea as drinking water source at pasture?
- What role could Baltic Sea water play in strengthening agricultural preparedness and resilience during future water-related crises?

The thesis focuses on a limited set of research questions, which serves as a delimitation of the broader project (Jansson 2025). This allows for a more focused analysis while still contributing valuable insights to the larger research context. Since the project extends beyond the timeframe of this thesis, participation and results will not be present in all sample collections and analyses that were done in the larger project. This study is therefore reflecting a well-defined and time-bound segment of the larger project.

## 1.1 Water requirements

According to the Swedish Board of Agriculture´s regulations and general advice on cattle farming 5 § states that cattle should have access to water of good quality at least twice a day. In addition to that, in very hot weather the animals should have free access (*SJVFS 2019:18* n.d.). The animal welfare act in Norway is also stating that animals keepers should ensure water of good quality for animals (Ministry of Agriculture and Food 2009-0406). According to 9 CFR § 3.130 in the American Animal Welfare Act animals must be given clean, sanitary water often enough to protect their health and comfort.

The water intake is influenced by many factors. The main aspect influencing water intake is the dry matter content of the feed i.e., how much water the animals get from the feed. By changing the diet from fresh grass/silage to hay/concentrate, the water intake from the feed will decrease, thus the need for water intake increases (Waldo et al. 1965; Murphy et al. 1983; Ammer et al. 2018). Ammer et al. (2017) investigated how diet composition and temperature-humidity index affect water and dry matter intake in dairy cows. The water intake increased with a higher temperature-humidity index. The dry matter intake decreased when the cows were under heat stress, especially cows that were fed high-concentrate diets. The requirement for water increases with the fibre content in the feed (Winchester & Morris 1956; Spörndly 2003). Some fibres are hydrophilic and have low digestibility; water is needed to keep the contents of the intestine moist and moving, therefore, water intake increases. The microbial fermentation of fibres in the rumen generates heat as a by-product. The extra heat increases the animal´s body temperature, and for thermal balance, excess heat evaporates and more water is consumed both to cool the body and to regulate water balance (Sjaastad et al. 2016).

The ambient temperature has shown to have an impact on the daily water intake in finishing cattle in feedlots and in dairy cows under natural conditions (Harbin et al. 1958; Arias & Mader 2011), as well as the minimum temperature and humidity have shown to have an impact on the water intake in beef cattle (Arias & Mader 2011). However, one study found no significant differences between different ambient temperatures and water intake in growing beef cattle (Brew et al. 2011).

Studies have shown that water intake is correlated with growth in cattle (Brew et al. 2011; Bica et al. 2021a). Brew et al. (2011) investigated water consumption in growing beef cattle (7–9 months old) and found that water intake was positively correlated with feed intake and body weight gain. Bica et al. (2021a) also showed that access to water in the right form is crucial for growth. In their study on grazing steers, water from a pond was compared with water from troughs. The results showed that animals with access to troughs had higher daily growth (0.44 vs. 0.34 kg/day) than those that only had access to the pond. In addition, water availability affected the animals' behaviour, with animals with troughs drinking more often and adapting their drinking behaviour over time (Bica et al. 2021a).

The temperature of the drinking water has also shown to influence the intake of water in cattle (Lanham et al. 1986; Huuskonen et al. 2011). Water intake increased in calves during the postweaning period when they were offered warm (16 – 18°C) water rather than cold (6 – 8°C) water (Huuskonen et al. 2011).

An aspect that influences the animal's requirement for water is overfeeding of protein (NASEM 2016; Sjaastad et al. 2016). By increasing the dietary crude protein the protein degradation increases and is excreted with the urine as urea (Colmenero & Broderick 2006; Sjaastad et al. 2016). This process is energy consuming and therefore generates heat that may increase water evaporation from the animals (Muhonen 2008). Protein content therefore has a positive effect on water intake (Winchester & Morris 1956).

Salt (NaCl) and mineral intake also affect the water intake (McDonald 2022; White et al. 2024). When six Angus crossbred heifers (14 months) consumed high levels of salt in the diet their water consumption was higher than when they consumed low levels of salt in the diet (White et al. 2024). Salt and mineral intake plays an important role in regulating water consumption. In early-lactation Holstein cows, each additional gram of sodium in the diet increased water intake by about 50 ml, even after accounting for feed intake and milk yield (Murphy et al. 1983). The effect reflects sodium's role in maintaining osmotic balance (NASEM 2021), highlighting that higher dietary salt supplementation can drive cows to drink more water to support sodium and water balance, metabolic function and milk production.

## 1.2 Water quality

In Sweden and Norway there are no current set limits on water quality for animals other than the Swedish Board of Agriculture´s regulations and the Animal Welfare Act in Norway. However according to a report by the Swedish board of agriculture, water for animals should be of the same quality as that for humans (*Vatten till husdjur* 1999; Olkowski 2009). Several parameters affect water quality, including microbial occurrence, salinity, dissolved salts, trace elements and heavy metals, water temperature, and environmental toxins. This study focuses on water quality in terms of salinity, trace elements, and heavy metals.

Animal water intake can be affected by specific compounds, including sulphate, nitrate, and nitrite, which may alter osmotic balance and metabolic processes. In this context, water quality becomes highly relevant as it can introduce additional factors that influence both intake and animal performance (NASEM 2021). The quality problems on water affecting cattle and production traits includes high concentrations of minerals and salts, trace minerals, bacterial or chemical contamination and growth of blue-green algae (Olkowski 2009). Olkowski (2009) also states that water quality may have a significant impact on the animal's production and health.

An important health parameter is the consistency and faecal DM which can be affected by many factors and has a great impact on the production. Low faecal DM can be a symptom of unhealth, but it does not necessarily indicate a health problem (Sjaastad et al. 2016). Different fibres have different water-binding capacities (Winchester & Morris 1956; Spörndly 2003). Variations in the water content of faeces can also occur naturally. Diarrhoea, on the other hand, occurs when the normal balance between secretion and reabsorption of fluids in the intestines is disturbed. It can be triggered by various factors, including stress, food allergies and infections caused by bacteria or viruses (Sjaastad et al. 2016).

*Salt/salinity/brackish water*

Salinity is defined as the content of salts per litre of water and the salts consist mainly of sodium chloride (NaCl), but also contain amounts of sulphur, magnesium, calcium, potassium and trace elements. Brackish water is ocean water with a salinity level between 0.5- 30 g/l (0.5-30‰) (Nationalencyklopedin 2025). The Baltic Sea is the Earth's biggest brackish water area, and it has variability in salinity both horizontally and vertically. The salinity level is different in different regions of the Baltic Sea (Lehmann et al. 2021). In Kattegat the level is 20 g/l and in the Bay of Bothnian 2 g/l (Müller 2018). Around Skåne it is around 8 g/l  and Gotland has been documented to be <6.5 g/l at the surface, and according to the found literature the level of salinity increases with the depth of the sea (Müller 2018; Lehmann et al. 2021).

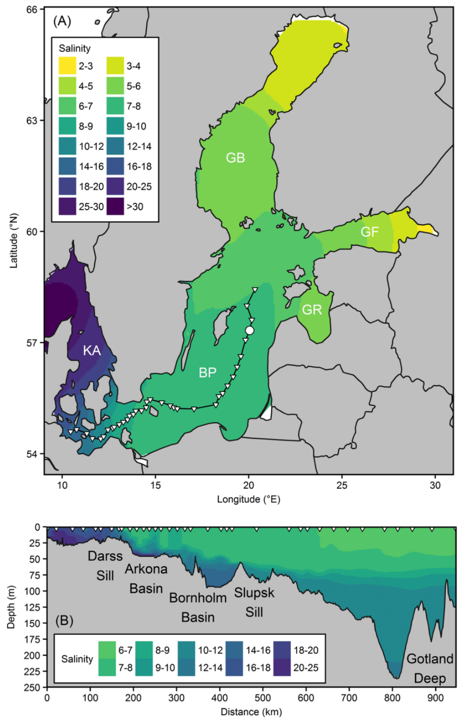


*Figure 1. Salinity of the Baltic Sea. Figure adapted from Müller (2018)*

There are several factors that determine the salinity of the Baltic Sea, including river outflow into the surface layer and inflow of water through the Danish straits from Kattegat to the lower layer of the sea. Also, precipitation over the sea influences the water balance and the salinity of the water (Lehmann et al. 2021).

*Water temperature*

Due to climate change, water temperatures in the Baltic Sea are expected to rise, with the surface water being most affected. Studies indicate an increase between 2.1 and 3.7 °C (Döscher & Meier 2004; Meier 2006). With an increase in water temperature several quality problems including microbial and toxins can affect the water (Störmer 2011; Livsmedelsverket 2018). The risk of algae blooms increases when the temperatures rise, causing the risk of toxic cyanobacteria growth (Wasmund 1997).

Heatwaves during the summer creates good conditions for cyanobacteria to grow in the Baltic Sea. The warmer water increases the stability of the water columns and higher temperatures with reduced wind speeds give the cyanobacteria optimal conditions for growth and blooms (Jöhnk et al. 2008). Longterm consumption of toxins from cyanobacteria can cause liver harm and oxidative stress in cattle, and since the toxins are stored in the bodies it can cause a risk for the consumer of the meat (Bensalem et al. 2025).

*Trace elements and heavy metals*

Mineral elements are naturally occurring in cells of animals and can either be classified as major or trace elements. Tissue of plants and animals contains up to 30 mineral elements and for some, no essential function has been found (NASEM 2016; McDonald 2022). Classification of major elements or trace elements is dependent on the concentration in the animal's body. Some of the major elements are calcium, phosphorus, potassium, sodium, chlorine, sulphur, and magnesium. The trace elements iron, copper, cobalt, iodine, zinc, molybdenum, selenium, fluorine, silicon, chromium, vanadium, nickel, tin, and arsenic, many of which have a toxicity level and can lead to diseases in animals (NASEM 2016). When increasing the dietary sulphur for steers, the feed and water intake decreased (Bolsen et al. 1973) and consumption of water high in sulphate reduced the feed and water intake in Hereford heifers (Weeth & Hunter 1971).

Natural water sources can contain both essential trace elements and potentially harmful heavy metals, either from geological deposits or contamination from human activities (Zhang et al. 2023). Monitoring their concentrations in water is therefore critical to understanding their impact on animal and plant health.

Even though many of the trace elements are toxic at some levels many of which have no current limits or recommendations for cattle. The found limits for cattle have been summarized in Table 5. In some literature the limits for human consumption are used as a guideline (Spörndly 2003). The Food and Agriculture Organization of the United Nations, FAO, has summarized a guideline (Guidelines for levels of toxic substances in livestock drinking water) for upper limits on some toxic substances in livestock drinking water. These guidelines are based on the normally found amounts of toxins in usable drinking water for livestock (Food and Agriculture Organization of the United Nations et al. 1994). In Table 5, the found upper limits on some of the trace elements are summarized along with the results and references. Literature on symptoms in toxicity levels is found; however, levels or limits on the toxicity are in many times not mentioned (McDonald 2022).

Even though there are some guidelines on trace elements and contaminants such as environmental toxins, the National Academies of Sciences (2021) highlight the importance of considering the environmental factors that affect the guidelines and, in some cases, make it impossible to determine precise concentrations of metals and trace elements which causes problems. Trace elements in the Baltic Sea are often measured in the sediment or through bioaccumulation in animals from the

Baltic Sea (Polak-Juszczak 2013; Viklund 2019). Common elements in the Baltic Sea are cadmium, lead, mercury, copper, zinc and arsenic in different levels (Polak-Juszczak 2013). There are also other environmental toxins, like DDT, PCB and PFAS that are present in the Baltic Sea that affect both the quality of the water and the ecosystems in and around the Baltic Sea (Viklund 2019).

## 1.3 Growth of Cattle

The average daily weight gain (ADG) differs between breeds, production type, diet and pasture composition (Bica et al. 2021b; Pitcher et al. 2022). Goldberg and Ravagnolo (2015) modeled the growth of pasture-fed Aberdeen Angus cattle in Uruguay using the Brody equation, which is one of the most widely applied models for describing cattle growth curves. According to their estimates, the predicted birth weight of Angus calves was 44.1 kg, and the average weight at weaning (195.4 days of age) was 162.1 kg. As shown in Figure 1A of their study, the predicted growth curve indicates that Angus calves reach approximately 100 kg live weight at around 100 days of age. The curve further illustrates that the rate of daily weight gain is relatively high during the first 1000 days of life, after which growth gradually slows as the animals approach their mature weight (Goldberg & Ravagnolo 2015). A similar growth pattern has been reported in Hereford calves (1.5 – 4.5 months) with an ADG of 0.8 kg/day for female and 0.9 kg/day for male calves in Patagonia, Argentina. Predicted weights at 100 days of age were about 135 kg (Bruzzone et al. 2022).

In beef steers (15 months), crossbred of Nelore and Hereford, drinking from a pond the ADG was 0.34 kg and steers (15 months) drinking from a water trought had an ADG of 0.44 kg (Bica et al. 2021b). Fall-born Angus steers on grass pasture in Utah, USA had an ADG of 0.43 kg at the age of around 9 months (Pitcher et al. 2022)

## 1.4 Excretion of excessive NaCl intake

In mammals, the ability to cope with water with high sodium content is mainly resdependent on the kidneys capacity to excrete sodium. The regulation of plasma sodium concentration and osmolality differs between species. Animals with high ability to concentrate urine is animals that have good water saving capacity. Animals with unlimited access to water often have the lowest capacity of maximum urine osmolarity. Cows have an maximum urine osmolarity of 1400 mosmol/l and an urine/plasma ratio of 4 (Sjaastad et al. 2016). Under normal conditions, when the osmolarity of the extracellular fluid increases, antidiuretic hormone (ADH) is released. ADH reduces the water excretion in the urine, helping the body to preserve water. At the same time, the sense of thirst occurs, encouraging water intake. The responses together stabilise the osmotic balance (Sjaastad et al. 2016).

When osmolality increases due to animals drinking salt water, ADH secretion increases to retain water. Stretch receptors in the blood vessels detect the rise of blood volume, which has a direct relationship with the amount of sodium in the body, stimulating the release of atrial natriuretic peptide (ANP). ANP promotes sodium excretion by the kidneys, helping to reduce excess sodium. Osmoreceptors in the brain sense high osmolarity and reinforce thirst, encouraging water intake to further stabilize the body's fluid and osmotic balance. (Sjaastad et al. 2016).

In the literature and assessments of water quality, the term total dissolved solids or salinity is sometimes used. Total dissolved solids (TDS) were defined by Morgan (2011) to be all organic and inorganic substances that can pass through a 2-μm filter. The inorganic substances include metals, minerals, and salts, while organic substances include pollutants, hydrocarbons, and pesticides. Salinity, as mentioned above, is defined as the content of salts per litre of water and include therefore all salts.

Previous studies suggest that cattle can tolerate drinking water with moderate salinity (3 – 5 g/l) or brackish water (6 – 7 g/l). Dairy cows given brackish water containing 3574 mg TDS per litre had no negative effects on health or productivity (Bahman et al. 1993). Holstein cows that were given salinity water containing 1 and 5 g/l of TDS showed no changes in feed or water intake, milk yield or composition, body weight, body condition score, or rumen function (Valtorta et al. 2008). However, when haigh-salinity water with 10 g/l of TDS was offered, a significant increase in water intake was shown (Valtorta et al. 2008). On the other hand some studies have shown a decrease in milk production (Jaster et al. 1978; Solomon et al. 1995). Also the sodium level in urine and faeces was higher, as well as the urine chloride when they were given high-salinity water (tap water plus 2500 ppm sodium chloride) than when they were given tap water (196 mg/l TDS) (Jaster et al. 1978).

In many of the found literature the National Academy of Sciences table of guidelines for TDS, Table 1, is used and referred to. Even though the guidelines are from 1974, it seems that this is still widely used.

*Table 1. Expected and/or documented health and performance effects of water with different levels of high-salinity waters according to "A Guide to the use of Haigh-salinity Waters for Livestock and Poultry", (National Academy of Sciences 1974)*

| Total Soluble Salts in water | Expected and/or Documented Health and Performance Effects |
|---|---|

| | |
|---|---|
| <1 g/l<br>fresh water | Acceptable with no reported side effects. |
| 1 - < 3 g/l<br>slightly saline | Few health or performance effects but may cause temporary mild diarrhoea and/or production loss in dairy cows. At 2500 ppm TDS, water intake increased as much as 7% while feed consumption and milk yield was reduced. |
| 3 – < 5 g/l<br>moderately saline | May cause diarrhoea, especially on initial consumption. Young dairy heifers had reduced water intake at TDS drinking water concentration of 3500 ppm. |
| 5 – < 7 g/l<br>saline | Can be used with reasonable safety for adult ruminants; risk is increased if sulphate is a high proportion of the TDS. Generally, should be avoided for pregnant cattle and young milk-fed calves. |
| 7 – < 10 g/l<br>very saline | Avoid if possible; pregnant, lactating, stressed, or young animals can be affected. |
| >10 g/l<br>brine | Unsafe under any conditions. Concentrations of 12,500 ppm caused sodium ion toxicosis in cattle. |

Upper safe limits for salts in water were set to 10 g/l for beef cattle by the Department of Agriculture and the Governmental Chemical Laboratories (1950) of Australia. There is also a recommendation that animals tolerate high salinity best when fed green feeds and are fully grown, and also if they are non-lactating (National Academy of Sciences 1974).

Water with a TDS content of 1 – 3 g/l is classified as salinity at slightly. At these levels, only minor health or performance effects are usually observed, although temporary mild diarrhoea and/or production losses in dairy cows may occur. To evaluate potential health impacts, measuring faecal dry matter (DM) provides a useful indicator, as it helps explain the connection between water quality and animal health.

## 1.5 Voluntary salt intake

Under normal physiological conditions, cattle exhibit an appetite for sodium when intake falls below the metabolic requirements. Salt appetite in mammals is regulated by receptors within the hypothalamic region, which detect alterations in body sodium concentration and extracellular fluid volume (Sjaastad et al. 2016). When blood sodium levels are low, an increase in aldosterone and angiotensin hormones stimulate salt appetite by affecting neurons in the brain (Sjaastad et al. 2016; Grove & Knight 2024). Therefore, the level of dietary salt provided can significantly influence an animal’s voluntary salt intake, as supplementation modifies the physiological stimuli that regulate sodium appetite.

When the sodium content of the diet is low, animals tend to increase their voluntary salt consumption, which may subsequently enhance overall feed intake

(Bell et al. 1981; Little 1987). In a study by Little (1987), mature cows fed hay containing 0.44 g Na/kg dry matter exhibited a 28% increase in voluntary sodium intake compared to those offered higher sodium forage.

## 1.6 Coastal environment and thermoregulation

Rising temperatures can increase heat stress in cattle, affecting both health and productivity (Polsky & von Keyserlingk 2017; Toledo et al. 2022). The thermoneutral zone is the optimal temperature for an animal to maintain body temperature without using more energy than required for metabolic maintenance and for production animals this temperature zone is optimal for maximum production (Sjaastad et al. 2016). The upper critical temperature represents the upper limit of the thermoneutral zone, at which animals must expend more energy on panting and sweating to dispose of excess heat (Sjaastad et al. 2016) and the condition in which the animals have trouble regulating their body temperature is called heat stress. In dairy cows, behavioural changes associated with heat stress have been observed at temperatures ≥ 25 °C. (Veissier et al. 2018). Increasing in standing time (Nordlund et al. 2019), a decrease in rumination (Soriani et al. 2013) along with an increased respiratory rate (Robinson et al. 1986). Toledo et al. (2022) highlighted the need for further research into drinking and eating behaviours related to heat stress.

Common methods used in barns to alleviate the negative effects of heat stress are ventilation and cooling (Collier et al. 2006) along with access to shade (Veissier et al. 2018). In pasture systems, these methods are provided by nature, but this requires a varied pasture (Jose & Dollinger 2019). To minimize heat stress, cattle often use behavioural strategies, like seeking shade or water to cool down (Schütz et al. 2010; Palacio et al. 2015; Veissier et al. 2018). At pasture and at ambient temperatures of ≥ 25 °C (which was considered outside the thermoneutral zone for cattle could be expected), 125 lactating dairy cows without access to shade showed higher respiratory rates, panting scores, rectal temperatures, and milk cortisol concentrations compared with cows that had access to shade (Veissier et al. 2018).

Even though no literature was found to confirm that the coast of the Baltic Sea is used by the animals for thermoregulation, the coast of the Baltic Sea might offer additional relief and has characteristics (e.g., shallow shorelines, vegetation, water) to support thermoregulation.

# 2. Materials and methods

This study includes, an experimental study of beef cows and their calves grazing with or without access to the Baltic Sea, including behaviour observations of the two treatment groups, voluntary salt intake, growth and animal health parameters. A water analysis of the Baltic Sea and freshwater served to the beef cows. Along with a semi-structured interview survey among farms with experience of cattle grazing by the Baltic Sea.

## 2.1 Experimental study

The study included an experimental part to investigate the effects of access to the Baltic Sea on the physiological status and behaviour of beef cattle during the grazing period. Twenty beef cattle cows of the Hereford and Angus breeds, along with their calves, were followed during the grazing period of three months (104 days). The cows had at least five generations of purebred parents. Cows with calves were randomized in two equal groups (based on breed, age and BW of the calves, see Table 2) and the groups were randomly allocated to either access to the shore and water from the Baltic Sea as their only water source during the grazing period (group BALT), or to no access to the shore with freshwater from a water trough (group CON).

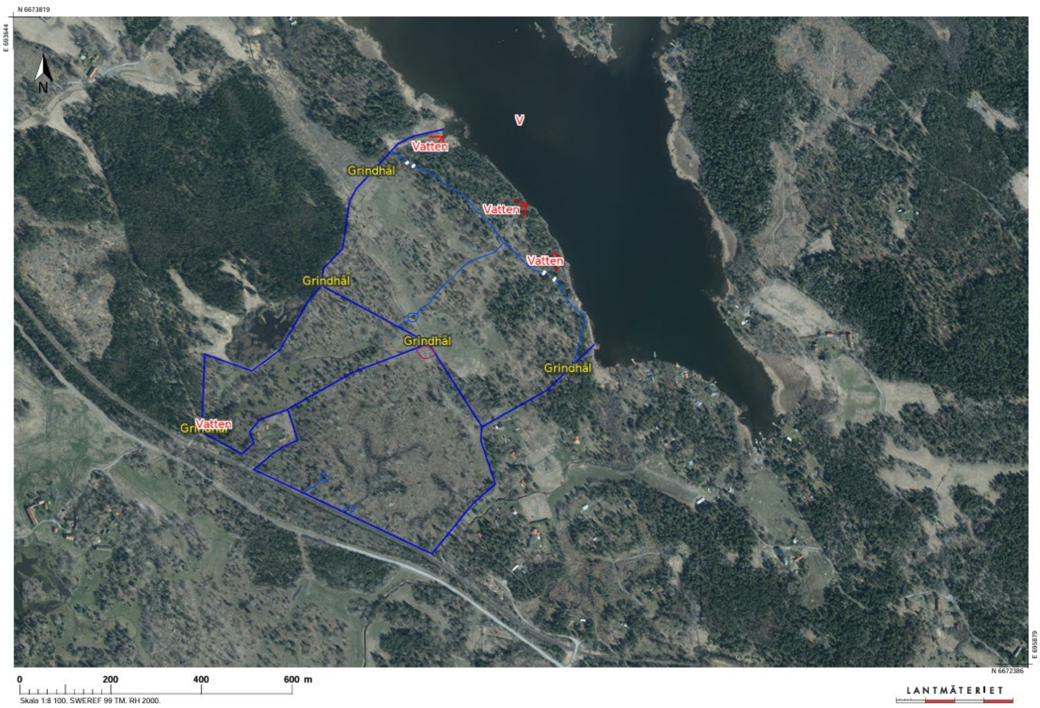


*Figure 2. One large pasture (32 ha) was divided approximately equal into two pastures, to be able to house two treatment groups (10 cows with calves/group) (Modified satellite photo by Lea Managos, original (Lantmäteriet n.d.).*

*Table 2. Division of the Baltic Sea and Control Group*

| Cow ID | Breed | Birth | Calf ID | Sex | Calving date | Group |
|---|---|---|---|---|---|---|
| 1 | Hereford | 2018-10-25 | 1 | ♂ | 2025-03-05 | BALT |
| 2 | Hereford | 2018-03-12 | 2 | ♂ | 2025-03-14 | CON |
| 3 | Hereford | 2015-10-17 | 3 | ♂ | 2025-03-15 | BALT |
| 4 | Hereford | 2017-10-22 | 4 | ♀ | 2025-03-15 | CON |
| 5 | Hereford | 2015-10-26 | 5 | ♂ | 2025-03-17 | BALT |
| 6 | Hereford | 2018-11-15 | 6 | ♂ | 2025-03-25 | CON |
| 7 | Hereford | 2014-03-31 | 7 | ♂ | 2025-03-26 | BALT |
| 8 | Hereford | 2018-03-02 | 8 | ♀ | 2025-04-03 | CON |
| 9 | Hereford | 2018-10-18 | 9 | ♂ | 2025-04-08 | BALT |
| 10 | Hereford | 2017-03-01 | 10 | ♀ | 2025-04-13 | CON |
| 11 | Angus | 2017-10-21 | 11 | ♂ | 2025-03-11 | BALT |
| 12 | Angus | 2014-04-11 | 12 | ♀ | 2025-03-05 | CON |
| 13 | Angus | 2022-10-28 | 13 | ♀ | 2025-03-05 | BALT |
| 14 | Angus | 2018-03-18 | 14 | ♂ | 2025-03-11 | CON |
| 15 | Angus | 2019-10-12 | 15 | ♀ | 2025-03-11 | BALT |
| 16 | Angus | 2020-03-11 | 16 | ♂ | 2025-03-15 | CON |
| 17 | Angus | 2018-10-29 | 17 | ♂ | 2025-03-25 | BALT |
| 18 | Angus | 2017-03-18 | 18 | ♀ | 2025-03-29 | CON |
| 19 | Angus | 2021-12-11 | 19 | ♀ | 2025-04-05 | BALT |
| 20 | Angus | 2020-04-02 | 20 | ♂ | 2025-04-29 | CON |

One of the calves from group CON passed fences 22 days after pasture release and thus switched to group BALT. Several attempts were made to return the calf to its designated group, but these were unsuccessful. As the calf had already begun suckling from cows within the current group, it was allowed to remain there. Also, one of the cows in group CON got lame and was taken back to the barn, along with its calf. It should also be noted that the animals, especially the calves, included in this study exhibited signs of diarrhea prior to being released onto the pasture, a factor that may have influenced the observed outcomes.

To minimize the effects of pasture variability, the groups were rotated three times between two different pastures during the entire grazing period. The two different pastures were originally the same pasture but for the purpose of this study divided into two, both with the possibility to allow or not allow access to the Baltic Sea. Figure 2 shows a satellite photo over the pasture with the blue lines being the fencing.

The Farm involved in the study is located in Roslagen, Uppland Sweden. The production focus on organic, KRAV- certified, beef cattle of the breeds Black Angus and Hereford. The pasture involved in this study was seminatural grazing land with access to the Baltic Sea and had been in regular use by the farm. The pasture was 32 ha in total and was then divided into two smaller pastures, as described above.

The start of the experiment was 13th of May and pasture release took place on the 21ts of May 2025. Pasture rotations were done three times during the experiment, 17th of June 2025 and 15th of July 2026. The grazing and test period were over on 2nd of September 2025. Both groups had free access to a salt and trace mineral block during the whole grazing period (98% NaCl, SP universal, Salinity AB, Sweden, Table 3).

*Table 3. Nutritional declaration per kg for SP universal salt blocks.*

| Component | Content mg/g |
|---|---|
| Sodium | 0,385 |
| Calcium | 0,02 |
| Magnesium | 0,01 |
| Zinc | 0,3 |
| Manganese | 0,2 |
| Copper | 0,08 |
| Iodine | 0,05 |
| Selenium | 0,02 |
| Cobalt | 0,012 |

*Data collections*

For pasture rotation and data collection (Table 4), all animals were gathered with the assistance of both project stakeholders and employees at the farm. The two treatment groups were each housed in separate pens during the data collection, both with direct access to a gate that connected to two different pasture areas. A handling cage including a scale (W110, Gallagher, New Zealand) was positioned within a larger pen, centrally located to allow access to both pens and making pasture rotation available (Figure 4.). One by one, animals were guided into the handling cage (PM 2400 Standard, BS Agro, Sweden, 2.), where measurements and body weights were recorded. After handling, each animal was released back into the collection pen. Animal handling was carried out with great care to minimise stress and ensure the well-being of

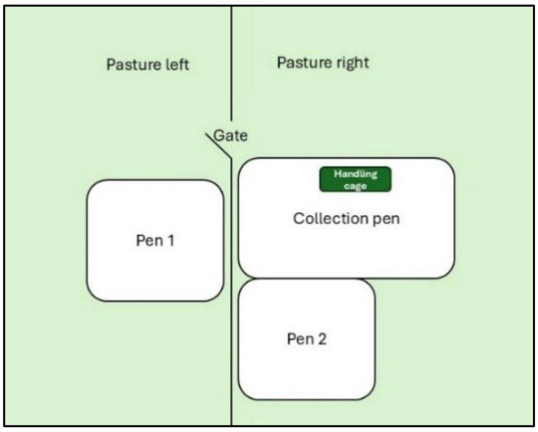


*Figure 2. Illustration of pens for sample and data collection, as well as and pasture rotation.*

both the animals and the handlers. All procedures were conducted in accordance with established risk assessment.

Faeces were collected either from spontaneous defecation or rectally by the handlers using individual sample plastic bags. Each sample was labelled with the corresponding animals identification number. For safety reasons, most of the samples were collected while the handlers remained outside the pens. However, due to the proximity required for accurate collection, this was not feasible in all cases. In some cases, samples were collected while the animal was restrained in the handling cage.

*Table 4. Date of sample and data collections during the test period.*

| Date | Faeces | Weight of salt lick | Body measurements calves and cows | Water analysis | Behaviour study |
|---|---|---|---|---|---|
| 2025-05-21 | | X | | | |
| 2025-05-26 | | | | X | |
| 2025-06-17 | X | X | X | | |
| 2025-07-15 | X | X | X | | |
| 2025-07-18 | | | | | X |
| 2025-07-22 | | | | | X |
| 2025-08-21 | | | | | X |
| 2025-08-25 | | | | | X |
| 2025-09-02 | X | X | X | | |

Throughout the study, biological and environmental data were collected, see Table 4. Dry matter content in faeces was analysed by placing 12.5-50 grams of faeces in tin foil trays and drying them at 103 degrees for at least 24 hours. The trays were cooled down to room temperature before weighing (PJ6000, Mettler, Switzerland, 0.1 g) to determine the DM.

The faecal samples were also subjectively analysed and estimated for consistency to evaluate diarrhoea (Renaud et al. 2020). To minimise variation, all samples were evaluated by the same person, in accordance with both *Manureology 101* by Hutjens (2010) and *Score Sheet for the assessment of wellbeing in cattle* by the University of Queensland (n.d), both of which provided structured scales for faecal consistency regarding parameters such as; firmness, shape, presence of liquid separation and texture.

Voluntary salt/mineral intake was documented by weighing the salt stones placed in each pasture. The lick blocks were placed in a mineral crib equipped with a rubber roof, which the animals had to lift in order to reach the salt stones. This setup prevented the salt stones from being degraded by rainfall, and potentially also by the use by other animals, including the calves. The lick blocks were weighed three times during the grazing period, and the total amount of salt/mineral intake was then calculated and divided per cow.

*Water analysis*

Samples for the water analysis of heavy metals and trace elements were collected in small glass bottles provided by Eurofins Environment Testing Sweden AB, from the surface water. The samples from the Baltic Sea were collected approximately 2 m from the shoreline, at a spot where the animals were observed drinking. The samples were analysed by Eurofins in an accredited laboratory (ISO/IEC 17025:2017, SWEDAC 1125) using standardized methods. Lithium (Li), phosphorus (P), sulphur (S), and titanium (Ti) were analysed by determination of selected elements by inductively coupled plasma atomic emission spectrometry (ICP-AES) (ISO 11885:2007). Mercury (Hg) was analysed by determination of mercury by atomic fluorescence spectrometry (ISO 17852:2006). The following elements were analysed by determination by inductively coupled plasma and mass spectrometry (ICP-MS) (ISO 17294-2:2023): sodium (Na), potassium (K), calcium (Ca), iron (Fe), magnesium (Mg), manganese (Mn), aluminium (Al), antimony (Sb), arsenic (As), barium (Ba), beryllium (Be), lead (Pb), boron (B), cadmium (Cd), silicon (Si), cobalt (Co), copper (Cu), chromium (Cr), molybdenum (Mo), nickel (Ni), selenium (Se), silver (Ag), strontium (Sr), thallium (Tl), tin (Sn), uranium (U), vanadium (V), and zinc (Zn).

*Behaviour studies*

Behavioural observations were done to assess if cattle with access to the Baltic Sea use the coastal environment during hot summer days, and if there are differences in behaviour related to acute heat stress and insect activity compared to cattle without access to the Baltic. Observations were carried out during four days with varying ambient temperature during the grazing period, 18$^{th}$ of July (24 °C), 22$^{nd}$ of July (26 °C), 21$^{st}$ of August (19 °C) and 25$^{th}$ of August (18 °C). The study was designed to evaluate both thermoregulatory behaviour and environmental preferences under hot and sunny conditions, as well as to detect possible signs of heat stress. The temperature and weather, type of environment, and sunlight conditions along with frequencies of observed behaviours were documented in a protocol (see Appendix 3).

At first the location preferences were documented and evaluated to determine if all animals were placed in shade or in direct sunlight. Furthermore, any additional notable behaviours were recorded, including drinking, signs of visible sweating, or any other activities that could indicate attempts at thermoregulation or discomfort. Respiratory rates were wanted to be observed; however, it could not be done. Both because of the distance that had to be kept to not disturb the animals, and due to that some of the animals were too fat to see their respiratory rate from a distance. Each individual was then observed for a 20-second period, during which the frequency of the following behaviours was recorded: tail wagging above the horizontal plane (used as an indicator of fly avoidance), head tossing or jerking movements, typically performed to dislodge flies and self-licking behaviour.

All observations were conducted from a distance (>5 m) that did not interfere with the animals' natural behaviour, and care was taken to ensure consistency in observation timing and recording. Also, time was spent just standing still near the groups to make them comfortable with the observer before the actual observation began. The combination of interval-based group assessments and short individual-focused observations provided a comprehensive picture of how animals responded behaviourally to heat and insect disturbance in their environment.

## 2.2 Survey among farmers

This study involves a qualitative research design to explore farmers perspectives on using the Baltic Sea as a water source for cattle. Semi-structured interviews were chosen as the primary method of data collection to allow for insight into the participants experiences and practices. In total 18 interviews were included in the analysis, and two persons were conducted during all interviews. Two of the interviews were conducted by the author and one of the supervisors, while the remaining interviews were provided by the supervisors. The interviews were originally collected as part of the research project (Jansson 2025) and were intended to explore the possibility of doing the experimental part of the study. The interviews are used with permission and in compliance with GDPR. No contact details were stored.

Interviewees were recruited through a combination of outreach efforts. An open call for participation was published on the website of Växa Sweden in 2023 (*Östersjön som vattenkälla vid bete* 2023). Some contacts were provided by Växa Sweden. In addition, previously interviewed farmers were asked about neighbouring farms with animals grazing near the Baltic Sea that might be willing to participate. The recruitment efforts focused primarily on farmers located in southern Sweden, on Gotland, Öland, and in the Kalmar region, where water scarcity is an ongoing concern. The interviews done by the author, had participants who had contacted the project leader, Anna Jansson, after reading the projects trials in agricultural media, including ATL and *Husdjur*. The broader media attention helped raise awareness of the study and indirectly supported recruitment.

The interviews conducted by the supervisors took place via Zoom, Teams, and phone calls between July and September 2023. One of the interviews done by the supervisors took place on a farm. The interviews lasted between 30-60 minutes and were done in Swedish. All farmers were informed about the area of application and consent was obtained from all participants. The supervisor-provided interviews were anonymised prior the analyses by the author.

A semi-structured interview survey was used to ensure consistency across the interviews while allowing flexibility and discussion to explore individual experiences in depth. The survey was provided by the supervisors and developed by Lea Managos, to ensure information about cattle having access to the Baltic Sea and their experiences. The full interview survey (original in Swedish and translated into English) is included in Appendix 1.

## 2.3 Statistical design and analysis

All statistical analyses, except differences between days with behaviour observations, were performed in Microsoft Excel (version 2508, Microsoft Corp., Redmond, USA). Weight gain, faecal dry matter (DM), faecal consistency, and voluntary salt intake were evaluated to compare differences between the two treatment groups. For each variable, mean values and standard errors were calculated using built-in statistical functions. Independent samples t-tests were then applied to assess whether differences between treatment groups were statistically significant. For weight gain on calves, the average total weight gain was calculated for each treatment group prior to statistical testing. Faecal DM and consistency were analysed by first calculating the mean for each sample, followed by the mean per individual across the test period, after which group means were compared using t-tests. A scatter plot was created to show the growth over the test period for the 19 calves in the study. Voluntary salt intake was analysed by calculating the mean intake per treatment group, estimating the standard error, and subsequently applying an independent samples t-test to determine group differences.

Differences in behaviours related to heat stress on hot and less hot observation days were analysed using SAS 9.4. Tail wagging observations indicated normal distribution and were analysed using a general linear model (GLM) with treatment group, breed, observation date, and treatment group x breed interactions as fixed effects. Comparisons of least-square means (LSMeans) were performed to compare individual dates. Head movement observations did not show a normal distributionand contained many zeros, indicating overdispersion. A negative binomial regression was therefore applied with the same fixed effects, and pairwise comparisons were performed to evaluate differences. All comparisons with p-values $< 0.05$ were considered statistically significant.

# 3. Results

The result from this study is categorised into results from growth, faecal dry matter and faecal scoring, voluntary salt intake and behavioural observations, water quality and the farmers survey.

## 3.1 Growth, faecal dry matter and faecal scoring

The body weight of the calves increased significantly from May to September ($p<0.01$ Figure 6). There was no difference in growth performance evaluated by weight gain during the experimental period between calves in group BALT and CON (102 ± 28 vs 110 ± 22 kg; $p=0.24$). ADG during the test period was 0.92 kg BALT and 0.99 kg in CON.

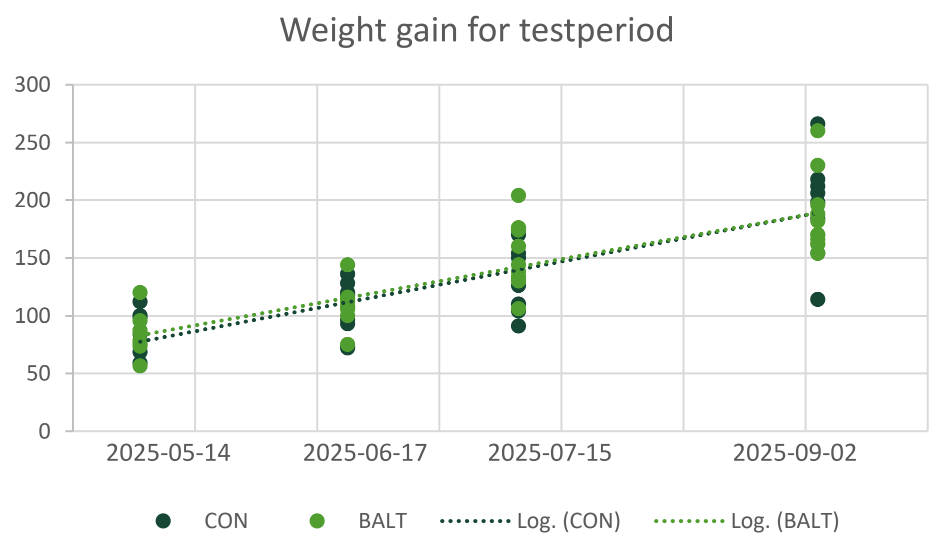


*Figure 3. Weight gain in calves of the breeds Hereford and Angus kept on pasture from May to September (with their dams) either with access to the Baltic Sea (BALT, n=11) or without access to the Baltic Sea (CON, n=8).*

There was no difference in faecal DM between the calves (BALT 0.17 ± 0.02 vs. CON 0.16 ± 0.02 kg; $p = 0.13$), nor the cows (BALT 0.13 ± 0.01 vs. CON 0.13 ± 0.01 kg; $p = 0.11$) and no difference in faecal consistency between the calves (BALT 4.5 ± 0.7 vs. CON 4.5 ± 0.7; $p = 0.5$). Statistically significant difference was found on faecal consistency for the cows (BALT 2.9 ± 0.9 vs. CON 3.4 ± 1.1; $p = 0.04$).

## 3.2 Water quality

*Metals and trace elements*

The results from the water analysis are presented in Table 5 (for all results of metals, see Table 7., Appendix 3). The most pronounced difference between the freshwater and the Baltic Sea water sample was observed for sodium (Na), with concentrations of 22 mg/l in freshwater and 1700 mg/l in Baltic Sea water (corresponding to 0.06 and 4.33 g/l of NaCl). Potassium (K) and magnesium (Mg) also showed substantial variations, with concentrations of 3.3 mg/l and 4.8 mg/l, respectively, in freshwater, compared to 55 mg/l and 160 mg/l in Baltic Sea water. Silicon (Si) was found in higher concentrations in the freshwater sample than in the Baltic Sea water. Sulphur (S) levels differed markedly as well, with 5.4 mg/l in freshwater and 140 mg/l in Baltic Sea water. Zinc (Zn) concentrations were lower in the Baltic Sea water compared to the freshwater sample.

*Table 5. Results from water analysis and found upper limits for different species*

| Substance | Freshwater (mg/l) | Baltic Sea (mg/l) | Literature data on the upper limit (mg/l) | Species |
|---|---|---|---|---|
| Sodium | 22 | 1700 | 1000 | Cattle[4] |
| | | | 200 | Human[1] |
| Potassium | 3.3 | 55 | 12 | Human[1] |
| Calcium | 77 | 89 | 1000 | Cattle[4] |
| | | | 100 | Human[1] |
| Iron | 0.86 | 0.39 | 0.5 | Human[1] |
| Magnesium | 4.8 | 160 | 30 | Human[1] |
| Manganese | 0.10 | 0.032 | 0.3 | Human[1] |
| Silicon | 5.4 | 0.68 | not found | |
| Cobalt | < 0.000050 | 0.00019 | 1 | Cattle[2] |
| Copper | 0.0029 | 0.0014 | 0.2 | Human[1] |
| | | | 1 | Cattle[2] |
| Selenium | < 0.0030 | < 0.0030 | 0.02 | Human[1] |
| | | | 0.05 | Catlle[2] |
| Sulphur | 5.4 | 140 | 2500 | Cattle[4] |
| | | | 5000 | Cattle[3] |
| Zinc | 0.013 | < 0.050 | 5 | Cattle[2] |

*1 The Swedish Food Agency (2024)*

*2 National Academies of Sciences (2021)*

*3 National Research Council (US) Subcommittee on Beef Cattle Nutrition (1996)*

*4 Livestock Water Quality | NDSU Agriculture (2015)*

*Voluntary salt intake*

Voluntary salt intake from the salt blocks was lower in group BALT than in group CON (10.5 ± 3.3 vs 27.8 ± 7.7 g day/cow; p=0.02). This was also associated with differences in trace mineral intake from the blocks (Table 3). In Table 6 estimation of trace mineral daily intake per cow during the grazing period is calculated along with recommended intake. Both treatments BALT and CON showed reduced estimated intakes for several trace minerals: zinc, manganese, copper, iodine, selenium and cobalt, with the CON group additionally showing a lower intake of magnesium compared to requirements,

*Table 6. Estimated trace mineral intakes mg per cow during a grazing period of 104 days in two groups of beef cattle grazing with (BALT) and without (CON) access to drinking water from the Baltic Sea compared to NASEM (2016) requirements.*

| | Estimated intake saltblock[1] | Estimated intake water source[2] | Estimated intake pasture[3] | Estimated total daily intake in NASEM unit | Requirements NASEM (2016) |
|---|---|---|---|---|---|
| BALT | | | | | |
| Iron | - | 30 | 10 190 | 236 mg/kg diet | 50 mg/kg diet |
| Sodium | 4039 | 130 220 | 0.1 | 1.12% of DM | 0.10% of DM |
| Calcium | 21 | 6 817 | 139 200 | 145 751 mg | 30000 mg |
| Magnesium | 11 | 12 256 | 194 40 | 0.26% of DM | 0.2 % of DM |
| Zinc | 3.2 | 3.8 | 520 | 12 mg/kg diet | 30 mg/kg diet |
| Manganese | 2.1 | 2.5 | 951 | 22 mg/kg diet | 40 mg/kg diet |
| Copper | 0.8 | 0.1 | 107 | 3 mg/kg diet | 10 mg/kg diet |
| Iodine | 0.5 | - | - | 0.01 mg/kg diet | 0.5 mg/kg diet |
| Selenium | 0.2 | 0.2 | - | 0.01 mg/kg diet | 0.1 mg/kg diet |
| Cobalt | 0.1 | 0.01 | - | 0.003 ng/kg diet | 0.1 mg/kg diet |
| CON | | | | | |
| Iron | - | 55 | 10 190 | 236 mg/kg diet | 50 mg/kg diet |
| Sodium | 1070 | 1408 | 0.1 | 0.10% of DM | 0.10% of DM |
| Calcium | 56 | 211 | 139 200 | 139 412 mg | 30000 mg |
| Magnesium | 28 | 307 | 194 40 | 0.16% of DM | 0.2 % of DM |
| Zinc | 8.3 | 0.8 | 520 | 12 mg/kg diet | 30 mg/kg diet |
| Manganese | 5.6 | 6.4 | 951 | 22 mg/kg diet | 40 mg/kg diet |
| Copper | 2.2 | 0.2 | 107 | 3 mg/kg diet | 10 mg/kg diet |
| Iodine | 1.4 | - | - | 0.03 mg/kg diet | 0.5 mg/kg diet |
| Selenium | 0.6 | 0.2 | - | 0.02 mg/kg diet | 0.1 mg/kg diet |
| Cobalt | 0.3 | 0.00 | - | 0.01 mg/kg diet | 0.1 mg/kg diet |

*1 10.5 and 27.8 g salt block per cow and day in BALT and CON respectively, calculated from salt block consumption for the whole group divided by days and the number of cows in each group and the trace mineral content of the salt block (SP universal, Salinity AB, Sweden).*

*2 Calculated from estimated daily water intake in beef cattle cows (64 kg and ambient temperature 21°C, (Winchester & Morris 1956)with a correlation (+12.6 kg) in BALT for expected higher intake on water containing 4g of NaCl/kg (Managos et al., unpublished)and analyses of* *the Baltic Sea water and fresh water used.*

*3 12 kg DM, calculated from estimated daily pasture intake in beef cattle cows (Bruckental et al. 1987; NASEM 2016) and results from pasture trace mineral analyses,*

## 3.3 Behavioural observations

There were no significant differences in behaviour between the two treatment groups (BALT and CON) regarding tail wagging (p = 0.11) or head throwing (p = 0.12). Similarly, no effect of breed was observed (tail wagging: p = 0.12; head throwing: p = 0.13). In Table 7 the results from the behaviour observations are shown. The BALT group was observed approximately 100 meters from the shoreline during the observation on 22 July. No other time were the group near the shore during the observations. A clear difference was also observed between hot and cooler days: during the first two (warmer) observations, no animals were standing in direct sunlight, whereas during later (cooler) observations, animals were more frequently observed in exposed areas.

*Table 7. Observations of positions and behaviour during four days with different ambient temperatures in two groups of beef cows with calves with (BALT, n=21), or without (CON, n=17) access to the Baltic Sea. Numbers are shown as median and range. LSMean frequency of behaviours associated with heat stress and insect infestation during four days with different ambient temperatures in a group of beef cows with calves. Different superscripts within rows indicate significant differences between days (p<0.05).*

| | 18 July 33°C | 22 July 26°C | 22 August 19°C | 25 August 18°C |
|---|---|---|---|---|
| Standing in shade | | | | |
| CON | All | - | Non | Non |
| BALT | All | All | Non | Non |
| Tail wagging | | | | |
| CON | 5 (15-0) | - | 1 (4-0) | 0 (4-0) |
| BALT | 7 (23-0) | 4 (11-0) | 0 (5-0) | 0 (2-0) |
| LSMean | $6.88^{a}$ | $3.99^{b}$ | $1.33^{c}$ | $0.45^{c}$ |
| Head throw | | | | |
| CON | 1 (3-0) | - | 0 (0-0) | 0 (0-0) |
| BALT | 0 (4-0) | 0 (4-0) | 0 (0-0) | 0 (0-0) |
| LSMean | $0.99^{a}$ | $0.72^{a}$ | $-0.00^{b}$ | $-0.00^{b}$ |

a,b,c Different superscripts within rows indicate significant differences between days (p < 0.05)

When looking at the tail variable in Table 7, significant differences were found between all dates except between 22 August and 25 August (p = 0.26). The highest least squares mean was observed on 18 July (6.89) and the lowest on 25 August (0.435). For the variable head in Table 7, a similar pattern was observed. However, in this case, no significant differences were found between 18 July (date 1) and 22 July (date 2) (p = 0.23), as well as between 22 August (date 3) and

25 August (date 4) ($p = 1.00$). The least squares mean also decreased over time, with higher values in July and lower values in August.

## 3.4 Survey among farmers

A total of 18 farmers along the Baltic Coast participated in the survey, approximately one-third of whom operated under organic production systems. Most respondents (n=17) had prior experience grazing livestock in coastal areas, with grazing periods ranging from three to seven months. Grazing livestock near the Baltic Sea were predominantly young cattle, although in some cases (n=5) all age groups were represented, and this was often when the farms had small herds. No farmer had lactating dairy cows grazing by the Baltic Sea.

All farmers, except one, reported that their animals entered the Baltic Sea to some extent, ranging from knee-deep wading to immersion up to the topline. Seabed conditions were identified as a factor influencing how far animals went out into the water, and one farmer described cows swimming alongside their calves. Regarding water preference, five farmers believed cattle favoured freshwater, two believed they preferred Baltic Sea water, and the remainder were uncertain. One of the farmers said that the animals more often drank from the Baltic Sea than from the water trough.

When asked about their experiences on grazing near the Baltic Sea, the farmers highlighted time savings when animals could drink directly from the Baltic Sea, the reliability of water availability, and reduced labour demands for water provision. However, some expressed concerns about water quality, algae growth, and animals defecating in the same water they drank from (n=3). Challenges included long travel distances to pastures, fencing maintenance, and, in some cases, lower pasture quality, causing poor growth or difficulties maintaining body condition. Several farmers valued the scenic and open landscapes associated with coastal grazing. The overall experience was predominantly positive: 11 farmers were either positive or fairly positive, none were negative, and the remainder were neutral.

Ten farmers reported reduced use of lick blocks during coastal grazing. The rest either did not provide lick blocks or did not notice any change in usage. Eleven farmers reported no differences in perceived animal growth compared to other grazing systems. Others noted differences, which they attributed to pasture characteristics, lower forage quality, or practical challenges such as fencing. Two farmers reported reproductive issues (abortions and reduced conception rates). While these could be due to other factors, the potential influence of water quality was not excluded. None of the farmers had analysed Baltic Sea water, and only a few (n=5) had analysed freshwater sources. Ten farmers had experienced health issues in livestock grazing near the Baltic Sea. Reported conditions included actinomycosis, blackleg, liver fluke infestation, problems with ticks and flies, occasional mastitis, and, in one case, the loss of a heifer.

All farmers reported that livestock used the Baltic Sea for cooling in some way, either from animals entering the water during hot days or standing at the coastline to have access to the breeze. The coastal breeze was reported to reduce fly and mosquito presence. During the 2018 Swedish heatwave, one farmer observed all animals standing in the sea to cool down.

# 4. Discussion

The results from this study indicate no significant differences between the two treatment groups in calf growth performance, faecal dry matter, or consistency. This suggests that the treatments had limited influence on these parameters under the conditions tested. The trace mineral analysis revealed no concerning levels of metals in the Baltic Sea, indicating minimal risk of adverse health effects from environmental contamination. However, a notable difference in salt/mineral intake from salt blocks was observed. Estimated mineral intake from salt blocks, pasture, and water indicated lover intake than recommendations for several essential minerals compared with established cattle requirements, which could have consequences for long-term health and productivity.

## 4.1 Animal health and production

Animal health was evaluated through growth performance on beef calves, faecal dry matter content along with faecal consistency on both calves and cows. When farmers were asked about the observed growth performance in calves four farmers reported lower performance when animals were grazing near and drinking from the Baltic Sea. The results show no significant differences in either of the evaluated health parameters. The growth performance was evaluated by looking at the live weight of the calves over the grazing period of 104 days during summer. The ages of the calves were around two months (54.5 ± 7.8 days) when the first weighing occurred. When looking at the growth curve data by Goldberg & Ravagnolo (2015) the estimated weight for Angus calves during that age is calculated to be about 85 kg. This is consistent with this study's results (49 – 112 kg) and by comparing the two curves, at around 200 days the weights of the observed calves of Goldberg & Ravagnolo (2015) ranged between 100 – 270kg which also is consistent with this study's results (75 – 144kg). No difference between the treatments groups was also observed, which indicate that the growth performance of calves is not affected by drinking from the Baltic Sea. It also indicates that the growth of the calves along the Baltic Sea has an expected growth performance according to the Brady model done by Goldberg & Ravagnolo (2015). The found ADG for the calves in this study (BALT 0.93 kg/day and CON 0.99 kg/day) were also consistent with the found literature of 0.8 kg/day for female and 0.9 kg/day for male Hereford calves (Bruzzone et al. 2022).

The faecal DM content of the animals in this study did not differ significantly between the treatment groups. Similarly, no significant differences were found in average faecal consistency. Faecal DM and faecal consistency are widely used indicators of animal health (Hutjens 2010; The University of Queensland n.d.), since diarrhoea is often a sign of some health problems and can be caused by various factors (Sjaastad et al. 2016). The National Academy of Sciences (1975) notes that diarrhoea is a symptom associated with saline water intake. In this study, the average consistency scores were approximately 4.5 for calves and 3 for cows, which fall within the normal range reported by Hutjens (n.d.). Based on these findings, the animals consuming saline water from the Baltic Sea did not show signs of diarrhoea, which indicate that the digestion system and fluid losses is not affected by the consumption of Baltic Sea water. This is also consistent with the interviewed farmers observations, that none of the farmers' had observed and reported diarrhoea as a health problem.

During the experimental period, several health and welfare-related observations were recorded. Numerous animals exhibited signs of fly irritation, and some carried substantial tick infestations. Dermal lesions were present for certain lesions, with flies congregating around the affected areas. While animals were restrained in the treatment cage, technicians administered an antiseptic spray to these lesions to reduce further fly activity and to facilitate wound healing.

Four farmers answered that lower growth performance in calves was observed when animals were drinking and grazing near the Baltic Sea. The results in this study indicate that this is not an effect of the Baltic Sea water, but rather an effect of environmental factors. One observation that was made during data collection was the number of ticks and blood-sucking flies that attacked the animals. Some of the cows had big wounds caused by the flies and many of the calves had many ticks. This was also mentioned by one farmer, that the parasitic load in animals was mentioned as a health problem. Farmers also expressed concern regarding the growth performance of calves grazing near and drinking from the Baltic Sea. It can be hypothesized that growth performance may be influenced by a correlation with tick-borne and fly-borne infections, which warrants further investigation. Tick-borne infections have previously been shown to negatively affect production in dairy cows (Al-Shammari et al. 2025), and a similar association could be considered in this context, that production could be affected.

## 4.2 Water quality and salt/mineral intake

The salinity level along the Baltic coast is around 6 – 8 g/l (Müller 2018), and according to *A Guide to the use of Saline Waters for Livestock and Poultry* of the National Academy of Sciences, this could be a questionable amount in drinking water for cattle. A depression in milk yield and persistency of milk production were associated with the consumption of saline water in high producing Holstein cows (Solomon et al. 1995). The results from this study show on the other hand no difference in growth production for beef cattle calves which may indicate that there was no difference in milk production between the two groups.

Eight of 16 farmers who offered salt/mineral stone on pasture, reported that the animals have a reduced intake from salt/mineral stone when having access to the Baltic Sea. These observations are in accordance with the results of the field study, where BALT had lower intake than CON. Trace element intake was estimated and the estimated daily intake of minerals was compared with requirements for beef cattle according to NASEM (2016). The numerical comparison indicates that both treatment groups had lower mineral intake than recommendations. The data for iodine, selenium, and cobalt are incomplete, as these elements were not included in both analytical datasets. Thereby limiting the ability to draw definitive conclusions for these elements. The BALT group showed no deficiency in magnesium due to the higher concentration in Baltic Sea water. The results from this estimation could indicate that both groups showed lower than recommended mineral intakes for zinc, manganese, and copper, potentially due to limited minerals and trace element content in the pasture. This is also pointed out by one farmer that pasture quality near the Baltic Sea may affect performance. Results also show that drinking from the Baltic Sea could have a positive impact on mineral intake during pasture season for beef cattle cows because cows drinking from the Baltic Sea show fewer mineral deficiencies than cows drinking fresh water when grazing near the Baltic Sea.

There are no current set limits on water quality for animals other than the Swedish Board of Agriculture´s regulations. However, according to the Swedish Veterinary Agency, water to animals should be of the same quality as for humans (Olkowski 2009). However, this can be hard to implement on pastures and recommendations and limits on water quality should be investigated further. Even though the results from this study indicate that water from the Baltic Sea is of sufficient quality for cattle, based on the analyses that were done in, many considerations must be taken when determining water quality (Valtorta et al. 2008). Further research should evaluate the Baltic Sea water for more parameters that those done in this study.

Due to the lack of information on trace elements and heavy metals for animals the results from the water analysis will mostly be compared with human guidelines for water quality. On the 5$^{th}$ of December 2024 the Swedish Food Agency published the lates version of the Analyses parameters and reference values for drinking water analysis (The Swedish Food Agency 2025). These guidelines are used when no limits or guidelines were found for cattle. When comparing the results with the found guidelines on both animals and humans many of the found substances in the Baltic Sea are within the guidelines for both humans and for the found guidelines for cattle. However, some values could be of concern.

The sodium concentration was measured at 1700 mg/l in the Baltic Sea and 22 mg/l in the freshwater well. When estimating the NaCl concentration, the Baltic Sea contains about 4.33 g/l of NaCl, while freshwater contains about 0.06 g/l, assuming that all sodium is bound as NaCl. These results are consistent with the higher salinity level of the Baltic Sea of 0.5-30 g/l. For drinking water, however, the upper limit is set at 0.1 g/l, primarily due to aesthetic and technical reasons for human consumption (The Swedish Food Agency 2024a). The Swedish Food Agency (2024) does not, however, establish a threshold for when water becomes unfit for consumption. The ability to excrete sodium/osmotic particles through the kidneys is a limitation that differs between species, with cows maximum urine osmolarity being 1400 mosmol/l and humans 1200 mosmol/l and the same urine/plasma ratio being set to 4 (Sjaastad et al. 2016). This could argue for that threshold values for cattle should be about the same as for human consumption.

Potassium levels were also higher in the Baltic Sea compared to the guidelines for human consumption. According to the Swedish Food Agency, the recommended upper limit for potassium in drinking water is 12 mg/l. Similar to sodium, no threshold value is defined for when water is considered unfit for human consumption. However, potassium is typically present in high concentrations in grasses and other forage plants, to which ruminants are well adapted due to their natural dietary habits, making the levels of potassium found in drinking water generally not a cause for concern for cattle consumption.

Iron concentrations (0.86 mg/l) in the freshwater well were higher than in the Baltic Sea (0.39 mg/l) and exceeded the potable level with reservations for drinking water for human consumption, which is 0.5 mg/l according to the Swedish Food Agency (2024a). This may be due to water pipes oxidation due to low pH in the water, or that surface water leaks into the freshwater. Iron is also naturally occurring in the bedrock (The Swedish Food Agency 2024b). Again, no limit is set by the Swedish Food Agency for when iron levels make water unsuitable for human consumption and in regular households the measures are taken to reduce the level due to reservations that could be smell and taste (The Swedish Food Agency 2024a). For cattle, an increased dietary copper intake is recommended to prevent copper deficiency when drinking water contains high levels of iron (NASEM 2016). In the present study, the estimated copper intake in both groups was below the recommended requirements, which may adversely affect immune function, enzyme activity, and other physiological processes.

Magnesium levels in the Baltic Sea were 160 mg/l, which is considerably higher than the recommended upper limit for human consumption of 30 mg/L. Magnesium toxicity is not a common condition for cattle (NASEM 2016). High levels of dietary magnesium have on the other hand been associated with the development of diarrhoea in calves and steers (Gentry et al. 1978; Chester-Jones et al. 1990). However, according to the results from the present study no difference in faecal DM or average faecal consistency was found between the two treatment groups. According to the estimated magnesium intake, the BALT group had an intake approximately equal to the recommended level, suggesting that the magnesium concentration was not at a toxic level.

Sulphur concentrations in the Baltic Sea (140 mg/l) were elevated compared with freshwater values (5.4 mg/l). Previous research by Weeth and Hunter (1971) demonstrated that excessive sulfur in drinking water can restrict both feed and water intake in Hereford cattle. However, the concentrations applied in their study (5,000 mg/l) greatly exceeded those observed here. According to Managos (2025), dairy cattle drinking saline water had a greater water intake than those drinking freshwater which shows the opposite. No difference was found between growth performance of calves, and this could indicate that the level of sulfur found in the Baltic Sea does not affect the feed intake.

Because of the lack of analytical data on mineral content, there remains a risk that water from the Baltic Sea may contain harmful levels of certain minerals or metals. Iodine, for example, was not included in the water nor the pasture analysis, and iodine consumption by the animals is therefore unknown. A maximum tolerable level of iodine has however been set to 50 mg/kg diet (National Research Council, 1980). It is, however, noted that it is of low concern for animal health in Mineral Tolerance of Animals (2005). The level of Iodine isotopes is monitored and are in different levels in surface water and sediment, and is found to have correlations with salinity level of the water (Daraoui et al. 2016). Elevated levels of iodine isotopes in the Baltic Sea have been associated with discharges from nuclear reprocessing plants (Daraoui et al. 2016). This emphasises the need of conducting specialized water analyses that consider the concentrations found in the Baltic Sea, local conditions, and the threshold levels of metals harmful to animals, to obtain a clearer understanding of tolerable levels. The risk of cyanobacterial growth in the Baltic Sea (Jöhnk et al. 2008) with the increasing water temperatures, and their risk for consumer of the meat (Bensalem et al. 2025) also highlights the need for repeated water analyses where the animals drink from the Baltic Sea. Although farmers report that animals generally avoid water contaminated with algal blooms, it cannot be excluded that they may still drink it, which would not comply with the Swedish Board of Agricultures standards for water quality.

## 4.3 Coastal environment

To assess if cattle with access to the Baltic Sea use the coastal environment during hot summer days, and if there are differences in behavior related to heat stress and insect activity compared to cattle without access to the Baltic. The only significant difference in behavior was found between the dates in July and August. During the first two observation times, the ambient temperature was 33 °C for the BALT group and 24 °C for the CON group, with the difference likely due to the CON group being in the forest. On the second observation, the temperature for the BALT group was 26 °C. In the last two observation periods the ambient temperatures were lower (19°C vs 18°C). According to the literature the thermoneutral zone for lactating dairy cattle is ≥ 25 °C (Veissier et al. 2018). This could indicate that the animals were under heat stress on the first two dates of observation. However, the behavior observed is performed to keep insects away, which could also just indicate that more insects were active during hot days.

Veissier et al. (2018) highlighted the need for shaded areas in the pasture for animals to reduce heat stress and according to the observations, during the hot days (first two observations) all the animals were in shaded areas. On the second observation, the BALT group was even seen near (100m from the shoreline) the Baltic Sea. During the interviews all farmers also reported that livestock use the Baltic Sea for cooling in some way. All except one also reported that they have seen the animals enter the Baltic from knee-deep to swimming. The coastal breeze was reported to reduce fly and mosquito presence which could explain the results from the second observation of the BALT group. However, the observation study is too limited to draw any conclusions about this. No literature was found to confirm that the coast of the Baltic Sea is used by the animals for thermoregulation. The results from the interviews could on the other hand reinforce the hypothesis that the Baltic Sea is used by the animals for thermoregulation. The coast of the Baltic Sea might offer additional relief and has characteristics (e.g. shallow shorelines, vegetation) to support thermoregulation. However, the results and number of observations are not enough to make any conclusions. For further research, to assess whether the Baltic Sea is used for thermoregulation, the animals GPS locations need to be correlated with temperature data over several days.

## 4.4 Agricultural preparedness

Six farmers participating in the survey answered that it felt safe to have animals drinking from the Baltic Sea because they always have access to water and one even brought up the safety of having good water for the animals during a crisis. Based on the results from this study, no difference in either faecal dry matter, consistency, or growth performance of the calves was found, and it could be argued that the Baltic Sea water is safe to use for cattle during times of water scarcity. By having the animals drink from the Baltic Sea farms along the coastline, take actions to maintain robust food and water production in Sweden which is accordingly with the Proposition (2024/25:34 s. 136).

When comparing different production systems for different production animals, reindeer in Sweden face similar challenges with water quality. During the grazing period, the reindeer often drink from natural water sources or eat snow for water. There are pointed out that the quality of the water could be questionable and that is important to evaluate the water resources (Swedish Sami Association n.d.). However, no systematic water analyses are carried out for reindeer during the grazing period (Skarin 2025). It could be argued that the reindeer industry experiences the same type of problem with water quality as cattle do when drinking from the Baltic Sea. That the Swedish board of agriculture's regulations are hard to implement when having extensive animal grazing systems. This highlights a more fundamental challenge confronting multiple animal production systems and emphasizes the need for further investigation in the matter. As a part of actions to maintain a robust food and water production in Sweden threshold values of levels safe for animal consumption should be established to more easily evaluate alternative water sources for animals.

To ensure a resilient, sustainable and robust food and water production system in Sweden, it is essential to establish threshold values for water quality that define levels safe for animal consumption. Such reference values would facilitate the evaluation and comparison of alternative water sources for livestock, particularly during periods of water scarcity under changing climatic conditions or geopolitical crises.

## 4.5 Limitations

This study has several limitations. The recruitment of farmers for the survey could be discussed. It is important to note that participation in the survey was based on farmers themselves contacting the supervisors to take part. It could therefore be argued that the farmers participating were the ones that have a positive experience due to the voluntary participation. This entails a risk of selection bias, as those who chose to participate may differ from those who declined. The results may therefore to some extent reflect the experiences and opinions of a particular group of farmers rather than the entire population. However, it can on the other hand be argued that farmers who have had problems with animals drinking from the Baltic Sea and are therefore participating in the study because they want to know the cause of the problem.

The behavioral data in the study provided insights into how cattle respond to heat and insect activity under natural grazing conditions. A strength of the method is that direct observations in the field allow animals to be studied in an undisturbed environment. The use of clearly defined behavior's and short individual observation periods is consistent with established approaches in behavioral research (Dawkins 2007). The method has, however, several limitations that must be acknowledged. Because each animal was observed briefly, behaviours that occur infrequently or vary over the day may have been overlooked. The limited observation windows may not fully capture variability in the animals behavioural due to diurnal patterns (Iqbal et al. 2023). Furthermore, the absence of physiological measurements, such as respiration rate, restricts the ability to directly link observed behaviours to heat stress. Observer distance and reliance on visual assessment may also introduce subjectivity, although efforts were made to standardise observation conditions. Despite these limitations, the behavioural data still contribute meaningful information. Future studies would benefit from combining direct observations with continuous monitoring methods or physiological indicators to enhance precision and repeatability (Dawkins 2007).

One limitation is the geographic placement of the farm and pasture. For knowledge of the study the pasture is placed in a larger bay with several outruns of freshwater, which could influence both the salinity and the metal analysis of the water. There are also several summer houses and many boats nearby which could contaminate the water. A bit north of the bay there is placed a sawmill, which may affect water quality and the amount of metal in the water. A sawmill is also classified as an environmentally hazardous activity which could influence water quality.

The method used to evaluate faecal consistency should also be discussed. The method that was used was based on scoring systems from two different established documents. One notable strength of this method is that it allows for rapid assessment without the need for specialized equipment. The use of subjective evaluation is also common within animal science, for instance, the body condition scoring relies on the observer's judgement and is considered a well-established method (Roche et al. 2009). This demonstrates that subjective methods can be scientifically valid when applied consistently. However, the reliance on subjective evaluation introduces some limitations, particularly regarding precision and repeatability. Variation in observers' experience or interpretation may influence the results (Vasseur et al. 2013). Additionally, the consistency of faeces is affected by factors such as fibre composition, as different types of fibre possess varying water-retaining capacities. Consequently, samples with similar moisture content may present different consistencies due to their fibre characteristics, adding another source of variability.

To ensure accuracy in future studies, a standardized and objective measurement could be explored. A procedure inspired by egg-yolk quality testing could be adapted, measuring the height, deformation, or spread characteristics of a standardized faecal portion may offer a more objective method. Alternatively, a predefined amount of faecal material is released from a fixed height and the diameter of the resulting spread on a standard surface is measured. This would provide a quantifiable parameter less susceptible to observer bias. Developing such methods, grounded in measurable physical properties, would likely improve both the scientific accuracy and the repeatability of faecal consistency assessments.

Another limitation concerns the seminatural pasture used in this study, which likely has a lower nutritional value compared to the farm’s conventional pastures. This difference could have influenced the production traits observed in the study and has likely affected the estimated intake of minerals done in Table 6.

Furthermore, there is a lack of comprehensive literature on toxic threshold levels of trace elements and metals in water for cattle, which limited the theoretical framework of this research. While known environmental contaminants such as PFAS, PCBs, and DDT are recognized for their potential to impact animal health, these substances were not analyzed in this study. Considering the pasture’s proximity to a potentially hazardous industrial activity, this represents an important area for future investigation.

Overall, the findings of this study should be interpreted with caution, as a complete analysis of water quality was not performed. The results also highlight the need for further research on water quality in the Baltic Sea, as well as the development of clearer guidelines regarding acceptable water quality standards for production animals.

# 5. Conclusion

This study investigated the use of Baltic Sea water for cattle and its effects on health, growth, and production, as well as the water's quality. The results showed no significant differences in growth performance, fecal dry matter, or fecal consistency for calves. No differences in heat stress-related behaviors between animals having access to Baltic Sea water and those in the control group; however a significant difference between the observation dates was found, which could indicate that the animals were over the thermoneutral zone during the hot observation days. A significant difference in salt block intake was observed, suggesting adjustments may be needed to compensate for mineral intake. Farmers generally viewed access to Baltic Sea water positively, noting benefits such as time and labor savings, reduced insect pressure, and improved animal comfort. Concerns were raised by farmers regarding water quality, algae blooms, and hygiene. Water analyses on metals and literature indicate that the Baltic Sea does not exceed critical thresholds for salinity, heavy metals, or trace elements, supporting its potential as a safe water source during times of water scarcity.

Overall, while the findings suggest Baltic Sea water does not have severe impact on animal health or production traits on healthy cattle and their calves, multiple parameters must be carefully evaluated. To maintain a robust food and water production in Sweden threshold values of levels safe for animal consumption should be established to more easily evaluate alternative drinking water sources for animals. And further research is needed to assess long-term safety, evaluation of environmental toxins, optimal management strategies, and potential adjustments to mineral supplementation.

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# Popular science summary

Rising temperatures caused by climate change have led to water scarcity in many parts of Sweden, particularly along the Baltic Sea coastline, where cattle farming is common. Low groundwater levels and ongoing water shortages, due to drought and insufficient groundwater recharge, emphasizes the need to identify and evaluate alternative drinking water sources for livestock. The current societal discussion is also highlighting the need to maintain robust food production in all parts of Sweden, due to global uncertainties like geopolitical conflicts. Therefore, preparatory actions to ensure the resilience of society systems including agriculture are important, including solutions for livestock farming along the Baltic coast. The aim of this study was therefore to investigate the possibility of using water from the Baltic Sea on cattle along with their calves and its effects on health, and production, as well as to evaluate the quality of Baltic Sea water considering trace mineral levels. To do this, the study consists of an experiment with grazing cows and their calves of the breeds Hereford and Angus, behavioral observations during warm summer days, and interviews with 18 coastal farmers. Calves given Baltic Sea water grew just as well as those drinking freshwater, and their digestion appeared normal. The animals also showed no differences in heat-related or insect-avoidance behaviors depending on the water source. Instead, behavior varied mainly with temperature, suggesting heat stress, not water type, influenced their actions. Water analyses showed that Baltic Sea salinity, about 4.3 grams of salt per liter, fell within safe limits for cattle, and tested metals and trace elements stayed below harmful thresholds according to found literature. Animals drinking Baltic Sea water consumed less salt from mineral blocks, though total mineral intake was somewhat low in both groups, highlighting the need for further research. Based on interviews farmers described Baltic Sea water use as convenient and labor-saving but expressed concerns about water quality, toxins, and pollution. Overall, the study found no negative effects on cattle health, growth, or behavior and suggests that Baltic Sea water could serve as a valuable backup water source. However, the findings of this study should be interpreted with caution, as a complete analysis of water quality was not performed. The results also highlight the need for further research on water quality in the Baltic Sea, as well as the development of clearer guidelines regarding acceptable water quality standards for production animals.

# Appendix 1 – Survey

**Survey – The Baltic Sea as a Water Source for Cattle**

1. **Main production of the farm (what generates the most income):**
- Beef
- Milk
- Breeding
- Other
2. **Type of production system on the farm?**
- Conventional
- EU Organic
- EU Organic and KRAV
- Other
3. **Types of animals in the herd (cows, replacement heifers, growing slaughter animals)?**
4. **Which breeds are in the herd?**
5. **How long is the grazing period?**
6. **Do the animals have access to Baltic Sea water during the grazing period? (Number of animals that do)**
   NO YES: Number ..............................................
7. **How many years have you had cows grazing along the Baltic Sea?**
8. **Which animals graze along the Baltic Sea? (young stock, pregnant, lactating, cow with calf, etc.)**
9. **If you have pastures along the Baltic Sea but don't use them for grazing – what are the reasons?**
10. **Is it your perception that the animals drink water from the Baltic Sea?**
    YES NO
11. **If you have a salt lick/mineral block on pasture with access to Baltic Sea water, do you feel that the animals use it more or less?**
12. **Do you feel that the animals prefer water from the Baltic Sea over freshwater?**
13. **Do the animals prefer to go into the water to drink, or drink from the shoreline?**
14. **How would you describe your overall experience with grazing animals having access to water from the Baltic Sea?**
- Positive
- Quite positive
- Neutral
- Quite negative
- Negative

15. **Can you briefly describe why you answered as above?**
16. **Do you experience that growth is affected by grazing along the Baltic Sea?**
    YES NO
17. **Do you experience that different breeds perform better or worse on pasture along the Baltic Sea?**
    NO YES
    If YES, please elaborate:
18. **Have you ever had health problems that you suspect may have been caused by animals drinking from the Baltic Sea?**
19. **Have you ever had reproductive problems that you suspect may have been caused (directly/indirectly) by animals drinking from the Baltic Sea?**
20. **Have you ever tested the water quality? Either from the Baltic Sea or available drinking water (municipal or private well)?**
21. **Do you perceive that the animals sometimes use the Baltic Sea to cool off?**
    YES NO
22. **Do you have a well with brackish water on your farm?**
    YES NO

**Enkät - Östersjön som vattenkälla till nötkreatur**

1. **Gårdens huvudproduktion (vad omsätter mest pengar):**
   - kött
   - mjölk
   - avel
   - annat
2. **Gårdens produktionssätt?**
   - konventionell
   - EU ekologisk
   - EU ekologisk samt KRAV
   - annat
3. **Typ av djur i besättningen (kor, rekryteringskvigor, växande slaktdjur)?**
4. **Vilka raser finns i besättningen?**
5. **Hur lång är betesperioden?**
6. **Har djuren tillgång till Östersjövatten under betesperioden? (Antal djur som har)**
   NEJ JA: antal…………………………………………
7. **Hur många år har du haft kor på bete längs Östersjön?**

8. **Vilka djur går på bete längs Östersjön? (ungdjur, dräktiga, digivande, ko med kalv…)**
9. **Om du har betesmarker längs med Östersjön men inte betar dem – vilka är orsakerna?**
10. **Är din uppfattning att djuren dricker vatten från Östersjön?**
    JA NEJ
11. **Om du har en saltsten/slicksten/mineral på bete med tillgång till Östersjövatten upplever du att djur använder den mer eller mindre?**
12. **Upplever du att djuren föredrar vatten från Östersjön framför färskvatten?**
13. **Föredrar djuren att gå ut i vattnet för att dricka eller från strandkanten?**
14. **Hur vill du översiktligt beskriva din erfarenhet av att ha betesdjur som kan dricka från Östersjön?**

- positiv
- ganska positiv
- neutral
- ganska negativ
- negativ

15. **Kan du kort beskriva varför du svarat som ovan?**
16. **Upplever du att tillväxten påverkas av bete längs Östersjön?**
    JA NEJ
17. **Upplever du att olika raser fungerar bättre eller sämre på bete längs Östersjön?**
    NEJ JA
    Om JA, utveckla:
18. **Har du någon gång haft hälsoproblem som du misstänker kan ha varit orsakat av att djuren druckit ur Östersjön?**
19. **Har du någon gång haft reproduktionsproblem som du misstänker kan ha varit orsakat (direkt/indirekt) av att djuren druckit ur Östersjön?**
20. **Har du kontrollerat vattenkvalitén någon gång? Vattenkvaliteten från Östersjön eller tillgängligt dricksvatten (kommunalt eller egen brunn)?**
21. **Har du uppfattningen att djuren ibland använder Östersjön för svalka?**
    JA NEJ
22. **Har du brunn med bräckt vatten på din gård?**
    JA NEJ

# Appendix 2 – Protocol for behaviour studies

**Datum:** ___________________

**Observatör(er):** ___________________

**Väder:** ___________________________

**Temperatur:** ______ °C

**Vind:** ___________________________

**Plats:** ☐ Östersjön ☐ Kontroll

**Tid för observation:**

Start:

Slut:

Platsbeskrivning där flest djur befinner sig

**Typ av miljö:**

☐ Öppet landskap/gräsmark

☐ Skog

☐ Strand

☐ I vatten

**Ljusförhållanden:**

☐ Sol

☐ Skugga

☐ Varierat

| **T1** | **Per 20e min** | | | | | **20 sek / individ** | | | Notera |
|---|---|---|---|---|---|---|---|---|---|
| ID | Står i solen | Står / ligger | Betar | Idisslar | Hjässning? (öppen mun) ja/nej | Andningsfrekvens | Svansviftningar antal | Antal bakåtkast med huvud | dricker? Synligt svett |
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# Appendix 3 – Table of results from water analysis and found upper limits for different species.

*Table 7. Table of results from water analysis and found upper limits for different species.*

| Substance | Freshwater (mg/l) | Baltic Sea (mg/l) | Literature data on upper limit (mg/l) | Species | Ref. |
|---|---|---|---|---|---|
| Sodium (Na) | 22 | 1700 | 1000 | Cattle | 5 |
| | | | 200 | Human | 1 |
| Potassium (K) | 3.3 | 55 | 12 | Human | 1 |
| Calcium (Ca) | 77 | 89 | 1000 | Cattle | 5 |
| | | | 100 | Human | 1 |
| Iron (Fe) | 0.86 | 0.39 | 0.5 | Human | 1 |
| Magnesium (Mg) | 4.8 | 160 | 30 | Human | 1 |
| Manganese (Mn) | 0.10 | 0.032 | 0.3 | Human | 1 |
| Aluminium (Al) | < 0.010 | 0.23 | 0.5 | Cattle | 2 |
| Antimony (Sb) | < 0.00020 | < 0.00020 | 5 | Dairy Cow | 3 |
| Arsenic (As) | 0.00053 | 0.00085 | 0.005 | Human | 1 |
| | | | 0.05 | Cattle | 2 |
| Barium (Ba) | 0.061 | 0.023 | 300 | Dairy Cow | 3 |
| | | | 10 | Cattle | 5 |
| Beryllium (Be) | < 0.00050 | < 0.00050 | 0.1 | Cattle | 3 |
| Lead (Pb) | < 0.00050 | < 0.00050 | 0.005 | Human | 1 |
| | | | 0.015 | Cattle | 2 |
| Boron (B) | 0.021 | 0.56 | 5 | Cattle | 2 |
| Phosphorus (P) | < 0.30 | < 0.30 | no found | | |
| Cadmium (Cd) | < 0.00010 | < 0.00010 | 0.0005 | Human | 1 |
| | | | 0.005 | Cattle | 2 |
| Silicium (Si) | 5.4 | 0.68 | no found | | |
| Cobalt (Co) | < 0.000050 | 0.00019 | 1 | Cattle | 2 |
| Copper (Cu) | 0.0029 | 0.0014 | 0.2 | Human | 1 |
| | | | 1 | Cattle | 2 |
| Chromium (Cr) | < 0.00050 | < 0.00050 | 0.05 | Human | 1 |
| | | | 0.1 | Catlle | 2 |
| Mercury (Hg) | < 0.00010 | < 0.00010 | 0.001 | Human | 1 |
| | | | 0.01 | Catlle | 2 |

| | | | | | |
|---|---|---|---|---|---|
| Lithium (Li) | < 0.050 | < 0.050 | 5 | Human | 6 |
| Molybdenum (Mo) | 0.00088 | 0.0018 | 0.5 | Cattle | 5 |
| Nickel (Ni) | 0.0010 | 0.0012 | 0.02 | Human | 1 |
| | | | 0.25 | Catlle | 2 |
| Selenium (Se) | < 0.0030 | < 0.0030 | 0.02 | Human | 1 |
| | | | 0.05 | Catlle | 2 |
| Silver (Ag) | < 0.000050 | < 0.000050 | 200 | Chicken | 7 |
| Strontium (Sr) | 0.14 | 1.3 | 5000 | Chicken | 6 |
| Sulphur (S) | 5.4 | 140 | 2.500 | Cattle | 5 |
| | | | 5000 | Cattle | 4 |
| Thallium (Tl) | < 0.00010 | < 0.00010 | 12,5 | Rats | 8 |
| Tin (Sn) | < 0.00050 | < 0.00050 | 5 | Dairy cow | 3 |
| Titanium (Ti) | < 0.050 | 0.0013 | 5 | Dairy cow | 3 |
| Uranium (U) | 0.00062 | 0.00069 | 0.03 | Human | 1 |
| | | | 0.2 | Dairy Cow | 3 |
| Vanadium (V) | 0.00028 | 0.0031 | 0.1 | Cattle | 2 |
| Zinc (Zn) | 0.013 | < 0.050 | 5 | Cattle | 2 |

*1 The Swedish Food Agency (2024)*
*2 National Academies of Sciences (2021)*
*3 Eadie (2021)*
*4 National Research Council (US) Subcommittee on Beef Cattle Nutrition (1996)*
*5 Livestock Water Quality | NDSU Agriculture (2015)*
*6 National Academy of Sciences (1974)*
*8 Shipkowski et al. (2023)*

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