Cooling of North Sea – 1939 (2_16)

Introduction

Coming as a surprise!

The North Sea is the principal factor in the climatology of Western Europe. On the one hand, the North Sea is part of the North Atlantic Ocean and is like a big bight. On the other hand, it curves into the landmasses of the European continent. Climatic conditions are therefore transitory. Its climate is neither maritime nor continental. Nevertheless, due to its geographical location, prevailing westerly winds travelling through the hemisphere within a zone of 2,500 kilometres breadth, usually ensure a temperate humid climate.

Suddenly the war winter of 1939/40 was different. The winter turned to arctic conditions from Southern England to Stockholm. That was unexpected and sudden. A.J. Drummond, a scientist from Kew Observatory at Richmond, expressed surprise at this unusual phenomenon in 1943[1] when he wrote: "The present century has been marked by such a wide-spread tendency towards mild winters that the "old–fashioned winters", of which one has heard so much, seemed to have disappeared for ever. The sudden arrival at the end of 1939 of what was considered to be the beginning of a series of cold winters was therefore all the more surprising. Since the winters of 1878-79, 1879-80 and 1880-81, there have never been such severe winters, three in succession, as those of 1939-40, 1940-41 and 1941-42."

The North Sea has a significant role only as a transitional area, as long as it is able to sustain the west-wind-drift. (A) Further, the North Sea is a maritime contributor as long as its water masses can contribute to humidity. For this

[1] Drummond

purpose, the sea needs a positive heat budget. If the heat is lost, the maritime role is diminished or gone and the sea turns continental.

Further details: (A) Lost west wind drift, 2_12.

In September 1939 when the German Fuehrer Adolf Hitler dragged the European powers into World War Two (WWII), the North Sea became a battleground. The sea was stirred and mixed from bottom to top at many places, day after day. This is like cooling soup by stirring it with a spoon. Cooling the sea inevitably means inviting continental conditions. Suddenly, arctic weather conditions penetrated into Northern Europe in the winter of 1939/40. Was it surprising?

The theme

The North Sea, being a semi-enclosed sea, may hold the key to understanding reasons for the arctic winter in Northern Europe in 1939/40 and other meteorological changes that started in late 1939. The war machinery that overran Poland in September 1939, the war activities along the French Maginot or German Westwall (A), the churning of Baltic Sea water (B), and the Russian – Finnish war at the Arctic Circle in December 1939 (C), etc may have contributed to returning Europe back into the 'ice age'. The North Sea's role in this phenomenon was prominent. It can therefore be fairly concluded that the North Sea, together with the Baltic Sea, played the central role in the emergence of severe winter conditions in Northern Europe in 1939/40, a condition not experienced in more than100 years.

Further details: (A) Rain-Making, 2_31; (B) Baltic Sea cooling, 2_17; (C) Russian-Finnish war, 2_41.

North Sea's climatic features

A principal contributor

There are certainly a number of factors relating to the North Sea that usually contribute to prevent Northern Europe from experiencing arctic winter conditions. The following two factors are particularly relevant.

The first factor relates to water conditions that enable Atlantic cyclones to enter the Euro-Asian continent in the middle of Western Europe, via Britain, the North Sea and Central Europe, a corridor called the West-drift by German weather services in early last century. (A) The second factor, certainly closely related to the first one, is the impact any excessive "stir and shake" of the water body has on heat storage in autumn and subsequently on the conditions of the successive winter. Usually, this is mainly achieved by the wind. A two-day storm can advance or delay the heat status of a season by many days, or for one or two weeks. Can a mighty war machine plough the sea as effectively as the wind? (B)

> Further details: (A) Lost west wind drift, 2_12; (B) Naval activities in late 1939, 2_13, 2_14, and 2_15.

Seasonal heat storage

Next to the Atlantic Gulf Current, the North Sea (Baltic Sea is discussed in the next chapter) plays a key role in determining the winter weather conditions in Northern Europe. The reason is simple. As long as these seas are warm, they help sustain the supremacy of maritime weather conditions. If their heat capacity turns negative, their feature turns 'continental', giving high air pressure bodies an easy opportunity to reign, i.e. to come with cold and dry air. Once that happens, access of warm Atlantic air is severely hampered or even prevented from moving eastwards freely. This is a particularly serious matter during winter, when the effect of the sun's radiation to weather processing is comparatively low.

From the above, it is clear that the most critical months are those when the sea experiences greater heat output than heat intake. By the end of August, the North Sea would have accumulated its highest level of heat intake. An important question pertaining to 'weather' is how long the sea body is capable of retaining this accumulated heat. This can also be expressed in a more practical way: how long can the sea serve as a central heat reservoir to help provide Northern Europe moderate winters? In fact, the North Sea can and will contribute to this climatic effect, as long as it is not frozen and the surface layer of water has positive temperatures. Even during a longer cold weather period, supply of heat continues, as long as the 'heat reservoir' at lower water levels is not exhausted. But while the Atlantic has, during a winter season, an unlimited quantity of retained heat at hand, due to the Gulf Current, the North Sea, which is comparatively small with just an average depth of 60 metres, can store heat during summer at a very limited capacity only. From the peak heat in late August, water loses more heat than it absorbs. At the same time the North Sea holds a considerable quantity of heat to spend. It however reaches its lowest level to spend only in subsequent March, i.e. seven months after the water heat balance turns from receiving to delivering.

Autumn season and the war

While the status of North Sea water is important for the weather in Western Europe throughout the year, three to four months comprising autumn are of considerable importance for processing the build-up of heat for the coming winter months and for sustaining a maritime-based winter. Using this sea area for war activities during this time of the year is hardly a good idea as it may result in a cooler winter. When thousands and thousands of exploding bombs, mines and shells turn the water upside down and when hundreds and hundreds of naval vessels criss-cross the sea day and night ‘stirring’ the sea surface from one to 10 metres or more, increased release of heat is inevitable. Every depth charge could have shaken the sea body down to 50 metres or more. Every sea mine could have …and so on. Every shell could have; etc; etc.

The rule is the same as applied to a hot soup. The more the soup is ‘stirred’, the quicker it cools down to the level of the surrounding air. Similarly, the stirring of seawater took place everywhere and excessively within the North Sea realms, after major European powers were at war since the 3rd September 1939. Apart from this, any sinking ship or underwater explosion or any other military activities, whatsoever, could have turned a lot of water ‘upside down’.

Further elaboration

This ‘cooling process’ needs further explanation, which will be given in the next section. Thereafter, one section will deal with seawater temperature measurements at the Helgoland observation station in late 1939. These data prove that a ‘stir’ and consequent ‘squeeze-out’ of sea heat took place. Temperatures decreased more rapidly than ever during October and November 1939 since measurements were taken. This had consequences. Along the coast from Jutland to Holland ice formed as early as mid December. A general summary will then highlight the main developments, which took place in the North Sea in late 1939. Finally a number of incidents indicating a ‘breakdown’ in the common temperature structure by the early arrival of winter in the North Sea area are listed in the section ‘Events’.

Temperature Structure in autumn

Sea temperatures vary depending upon their depth and also in accordance with the seasons. The water depth in the North Sea can be roughly divided into two sections.

The southern section comprises a plateau from Dover to the Hanstholm/Jutland – Dogger Bank - Hull/England line that is mostly less than 40 m deep. The northern section is a triangle between Hanstholm – Hull – Shetland Islands with a water depth generally ranging between 60 and 120 m (the deepest place is 263 m), and the submarine valley along the Norwegian coast with depths ranging between 240 to 350 metres, although the Skagerrak, south and east of Kristiansand, is 500 – 700 m deep. Inflow of warm water from the Atlantic Gulf current enters the sea from the north and is influencing the current system from the surface to the bottom in the northern part only. The 40 m deep southern plateau is hardly affected by the northern water, but receives some Atlantic water via the Strait of Dover and freshwater from rivers. Thus the North Sea is rich with different water masses, which vary seasonally and fluctuate annually. As all coastlines are subject to marked tidal forces, considerable water masses actually vary on a daily basis.

In March the annual lowest mean minimum surface temperatures range between 7°C in the northwest (Atlantic water) and 4.5° in the southeast (Dutch coast). The highest mean surface temperatures at the end of August range correspondingly (NW and SE) from 13° to 17.5° in the Helgoland Bight. But these few data reveal very little. What counts climatically during the important autumn period is the whole water column.

During the period December to May the water body has a homogeneous temperature structure (from surface to bottom), with a decrease in temperatures in December (8-9°); January (7.5-6°); February (6.5-5°); March (6-4.5°), April (4.5-6.5°). Water very close to the coastlines has lower temperatures during the winter season.

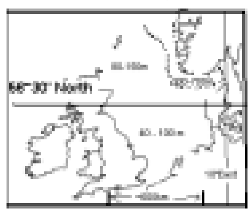
From May to August a horizontal thermocline builds up but declines during the autumn months.
It is worth noting that while the temperature level increases at lower water levels (e.g. 20 m, 40 m) in autumn, it decreases at the bottom (60 m). It is therefore possible that the whole water body might be warmer in September than in August. While the calculation of 'monthly averages' is an approximate figure, it nevertheless gives an indication that the monthly decrease in temperature (or energy release) takes place in small quantities

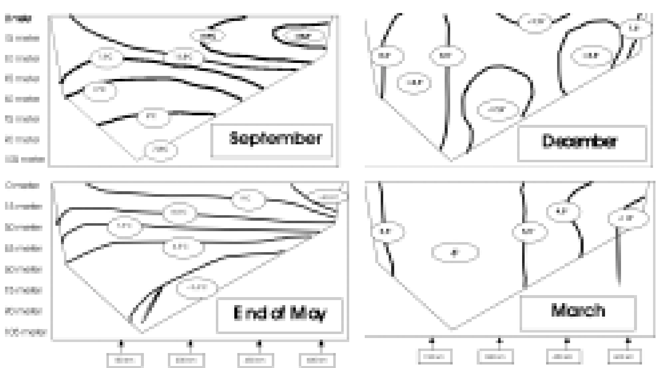
only, from 11°C in August to 4.5°C in March, i.e. on an average it could be as little as just one degree per month. A more realistic figure would be somewhere between 1°C and 1.5°C.

Conditions from August to November (without coastal waters) are as follows:

	August	September	October	November
Surface	14.5 °C	14 °C	12 °C	10 °C
20 m	13.5 °C	13.5 °C	12 °C	10 °C
40 m	9 °C	9.5 °C	10 °C	9,5 °C
60 m bottom	7 °C	7.5 °C	8 °C	8,5 °C
Sum total	44	44.5	42	42
Monthly av.	11°C	11.1°C	10.5°C	10.5°C

Based on the work of Tomezaqk & Goedecke[2] data relating to two concerned locations is briefly summarized as follows:



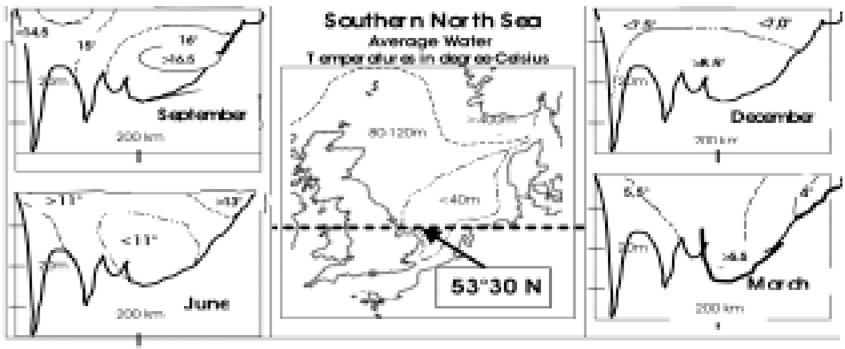


Location: Scotland to Jutland, 56° 30’ North, distance ca. 650 kilometres, average depth ca. 65 m; maximum depth 120 m; belonging to the northern part of the North Sea (water body mixed with water from the Atlantic) and integrated in a current system.

Location: Borkum (Island) – Hull/England, 53° 30’ North, distance ca. 400 kilometres,
Average depth ca. 15 m; maximum depth ca 35 m;

[2] Tomezaqk & Goedecke

Due to the shallowness and tidal forces, temperature structure of the water body is homogeneous (from surface to the bottom) with small variations, as the average temperatures indicate; Dec (8.5°); Jan (6.5-7°); Feb (5.5°); Mar (5°), Apr (6.5°), suggesting that water very close to the coasts has lower temperatures during the winter season. The variations are negligible and can be ignored.



From May to August temperatures increase from 8.5° to 14.5°/17°C and decrease as follows:

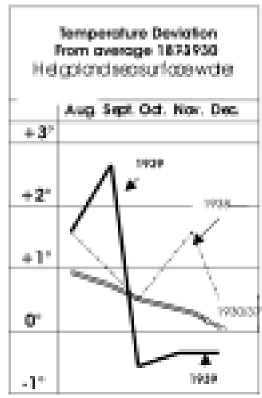
Depth	August	September	October	November
Surface, West-East	14.5-17 °C	14-16 °C	12-13.5 °C	09°- (mid) 11.5°-10°
20 m, West-East	14-16 °C	15-16.5 °C	13.5-14 °C	9.5-11 °C

Fairly homogeneous figures for the water body with 15°/16° at peak time and the lowest in March (5°), indicate that the water body experiences an average decrease in temperature of about two degrees per month.

The annual approximate temperature variation data in the three sections of the North Sea is as follows: (Source: Tomezaqk & Goedecke)

	Area in the North Sea		
	Southern section West/East	Middle section West/East	Northern section West/East
Water depth		Temperature °C	
Surface	10/12.5 °C	8/15 °C	6/10 °C
7.5 m	11/13 °C	8/15 °C	5.5/10 °C
20 m	11/13 °C	7/13 °C	5.5/8.5 °C
30 m	11 °C	6.5/12 °C	5/7.5 °C
40 m	-	6/11 °C	4.5/6 °C
60 m	-	4.4 °C	4.5/3.5 °C
80 m	-	3.5°C	4.5/1.5°C
100 m	-	-	4/1.5°C

Water Temperatures recorded at Helgoland Station in autumn 1939



It is well recorded that a positive seawater temperature series in the Helgoland Bight from 1930-39 at the Helgoland station with WWII commencing suddenly came to an end. Goedecke dates this end at 1940-1942[3]. Nearby light vessel “Elbe 4” on the mouth of the river Elbe records the annual anomalies as: 1939 (+0.9); 1940 (-0.7); 1941 (-0.7); and 1942 (-0.2). At both stations seawater temperatures increased again after 1942. Goedecke attributed this increase in temperatures until 1940 and after 1942 to “the secular climatic changes in the Northern Hemisphere”[4], resulting “primarily from the warming of the polar and sub polar atmosphere”[5].

This paper’s next step is to look in detail at the figures available for 1939, showing an average annual seawater temperature increase of 0.9°C. The starting line will be August 1939 to prove that the war at sea, during its initial months, i.e. September to December 1939 made its clear contribution in ushering in the arctic winter of 1939/40 in Europe.

Figures from Helgoland station showing deviations from average temperatures during the autumn season of 1939:

Average temperature 1901-30	August 16.34°	September 15.60°	October 13.15°	Nov. 9.68°	Dec. 6.48°
Deviation: 1930-37	+1.05	+0.85	+0.55	+0.3	+0.5
Deviation: 1938	+1.6	+1.0	+0.6	+1.7	+0.6
Deviation: 1939	**+1.7**	**+2.6**	**-0.6**	**-0.4**	**-0.3**

Source: Goedecke, Verhalten, p.7

Deviations of seawater temperatures from the mean (1901-30) at Helgoland Station in early 1940 are:

	January	February	March	April
Diff.: 1940	**-1.6**	**-3.5**	**-3.0**	**-2.3**

Source: Goedecke, Verhalten; p.7

Even if one is fully aware that the water masses of the German Bight (Helgoland Station) do not represent the North Sea as a whole, the

[3] Goedecke, Ergebnisse [4] Goedecke, Ergebnisse [5] Goecke, Verherhalten p.28

differences are remarkable. The first hard fact is that August 1939 figures of water conditions had been in the normal range. A high figure for a corresponding period as in September 1939 had been recorded only once before, i.e. in September 1875. The September 1939 figure is most likely so high because of extraordinary naval ship movements and military activities that took place, 'shovelling' lower and warmer water up to the surface. Once warmer water reached the surface, evaporation increased and subsequently seawater cooled more quickly.

This becomes evident in two ways; firstly by the difference in temperature between September and October, and secondly by the high deviation in temperature from the previous decade by one degree in each of the months of October, November and December 1939, showing a very spontaneous and significant deviation from the sea climatology of the Helgoland Bight.

If one can rely on the figures given by Goedecke, it can be fairly assumed that military activities were a key contributor in the arrival of the arctic winter of 1939/40. 'Normal' monthly seawater temperature decrease recorded at Helgoland Station is 2.5°C from September to October, with a minor deviation (<0.4°C) over the decade since 1930. In 1939 water temperature decreased within a period of one month from September-October by 5.7°C (normal 2.5°C; plus 3.2°C in 1939). Therefore this big drop requires an explanation. Further, the negative figures observed for the period October – December would certainly have contributed to the surprising arrival of the cold winter. These events of 'temperature changes' at a place where the German navy was very active, by laying thousands of mines in close by areas and the bombardment by British aeroplanes cannot be ignored by climate watchers. Links of these events to ensuing winter conditions are quite obvious.

Early, severe and long lasting icing conditions

Icing along the Danish, German and Dutch coasts started early (see below: Events), and sea ice conditions lasted longer than in dozens of previous years. On the other hand, the main features of the 1939/40 icing are not 'completely' out of question. For example, in December 1938, ice formation started early due to a sudden cold spell, but it lasted only for two to three weeks. The winter of 1938/39 is listed as a quite moderate one, in fact, the warmest for decades. Also the post war winter of 1946/47 could, in some respects, be regarded as an even icier winter than the first war winter of 1939-40, at least with regard to the North Sea, but the winter of 1946/47 was of a totally different nature than the winter of 1939/40. (A)

Further details: (A) Late winter 1946-47, 4_21.

The importance of the winter of 1939/40 as proof of the impact created by war at sea on climatic changes since 1939 remains valid in every respect. Circumstantial evidences throwing light to the war winter of 1939/40 are manifold and include following facts concerning sea ice:

- seawater temperature data at Helgoland in autumn of 1939;
- suddenness with which icing started;
- early start and longer stay of ice;
- severity of icing;
- long duration of the icy period caused by two cold waves, one in January and another in February 1940.

Changed factors

Interchange air - water

During the first four months of war no quadrant of the North Sea would have seen the same war activities as any other location might have. Considering the very basic factors, it seems reasonable to concentrate on the southern plateau section, south of the line Hanstholm/Jutland – Dogger Bank - Hull/England and the section north of this line. The southern part with its low depth and nearly homogeneous water body condition round the year, saw, by far the most aggressive military activities during the early days of the war, such as 20-50,000 mines along the "Westwall" in the middle of the North Sea over a length of 1,000 kms, 10,000 mines along the Dutch and English coast, hundreds of naval ship movements, depth charging and bombing, etc. every day. (A) However, the northern part saw certainly less activity, but due to the temperature structure depending on water depths, the water body would often react quite differently than in the southern part section and with a long-term effect.

Further details: (A) Sea mines, 2_14; and Depth charges, 2_15.

A few words concerning the dynamics of seawater evaporation and seawater cooling: Water vapour escapes into the atmosphere only from water surfaces. The intensity of this process depends on the temperature difference between the media, and also whether a certain amount of water vapour is in equilibrium with the water surface. If it is less, seawater will vaporise; if it is higher, the vapour in the air will condense and transform into clouds, rain, fog etc. In each system (water – atmosphere) the level of temperature is important. A rise in air temperature from 0°C to 10°C doubles the amount of water in the atmosphere at equilibrium.

Evaporation cools a water surface by removing heat from it. As water cools, the equilibrium decreases and the evaporation rate will decrease. Cold and salty water increases vertical convection (water movements by sinking); warm and low salty water tends to sink less.

However, in this investigation only two rules will be considered:

> The warmer the water, the more evaporation;
> The more evaporation, the more the water cools.

For the atmosphere this means: Adding water vapour to the atmosphere makes it less dense and causes vertical air movements. In the case of the North Sea, when air rises from a surface water layer, air thus lifted upwards must be replaced by air that is surrounding the location of evaporation, whereby dry air, presumably continental air, may try hardest to fill this space. Back in 1939 the German weather analyst wondered, when the usual wind from South-West turned to North-East. (A)

> Further details: (A) Lost west wind drift, 2_12, see: "End of October 1939", or Seewarte, 02 November 1939.

Climatic conditions in Northern Europe had been regarded as 'normal' during the first eight months of 1939 until the end of August. Based on this assumption, the chain of causes in forcing a deviation in mean conditions during the winter of 1939/40 could have worked as follows:

- stirring of sea waters increased evaporation;
- this blocked the west-wind, caused continental air to move in (N-E winds) and increase the barrier;
- colder continental wind and high evaporation rate cooled seawater;
- while the cooling effect was not very pronounced early, due to the fact that 'stirring' of the sea continued bringing warmer water to the surface thus delaying the 'typical' winter effect (e.g. icing);
- this is clearly reflected by strong temperature deviation from January – April 1940, and particularly by a long duration of the ice period (see below: Events).

Southern North Sea: Due to low water depth (max 40 m) and tidal forces, the 'mixing', whether by natural dynamics or military activities, will occur fairly quickly throughout the whole water body. Correspondingly, the chain reaction affecting evaporation, change of wind direction and cooling, etc will set in motion:

- if, at the peak time of high surface temperature, this water is mixed with colder water at deeper levels, the total heat capacity will rise and the evaporation process will be reduced at the surface for some time;

- if the stirring process continues or even increases, warm water from lower levels is exposed to the evaporation process at a higher frequency, thus accelerating the cooling of the surface and forcing wind to replace rising vapour;
- the emergence of the first visible sign of cooled down seawater (icing) can be delayed by the continuation of the 'mixing' of water.

All these criteria are clearly reflected in the sea surface data from Helgoland for the winter period of 1939/40. These main results can be fully applied for all of the southern part of the North Sea, south of the Hanstholm/Jutland – Dogger Bank - Hull/England line, even taking into account, that the Helgoland Bight particularly had been highly exposed to naval activities.

Northern North Sea: The forced 'stirring and mixing' situation of the water body in the northern part is much more diverse and intense than in the southern part during autumn. A naval activity that may force the cooling of the sea surface layer in September may, by similar activity increase evaporation in December, or may be doing both actions at the same time. On the other hand, a stirring and mixing within the upper water layer down to 10 or 20 metres in early autumn will, just as it does in the southern section, actively support an accelerated evaporation process in September and October. But speaking in general terms, a military activity-forced mixing in autumn will move warm water to a greater depth, thereby extending the retention of the amount of stored heat by weeks or even months. It should not be regarded as too big a surprise, if the northern section of the North Sea may have even contributed with a release of more heat into the air during the later part of the winter of 1939/40 than during other years.

Heat matters

Since the day the Second World War had started naval activities moved and turned the water in the North Sea at surface and lower levels at 5, 10, 20 or 30 metres or deeper on a scale that was possibly dozens of times higher than any comparable other external activity over a similar time period before. Presumably only World War One could be named in comparison. The combatants arrived on the scene when the volume of heat from the sun had reached its annual peak. Impacts on temperatures and icing are listed in the last section: 'Events' (see below). The following circumstantial evidences help conclude with a high degree of certainty that the North Sea contributed to the arctic war winter of 1939/40.

Meteorological 'West Wall'– Wind Drift blocked

Excessive evaporation from the first day of September until November 1939 could be evidenced by a decrease in water temperature at Helgoland Station, Rising air (vapour) instead of attracting Atlantic cyclones to move into the North Sea area to travel east, in fact assisted in blocking their movement. Presumably, this aspect alone would not have changed the situation very much. But the rising air certainly forced inflow of continental air from East and North. This air, flowing almost in the opposite direction to the West drift, necessarily prevented or reduced the movement of Atlantic cyclone systems to travel on common routes. Daily weather analysis of the Seewarte wondered a number of times where the West Drift had gone. Excessive heat release as illustrated in previous paragraphs was the most likely cause for blocking Atlantic cyclones from reaching and passing Western Europe as was usually expected. In December, high pressure took full control in Europe and the North Sea, leaving cyclones the only opportunity to storm east either via the Barents Sea, or crash through the Iberian Peninsula into the Mediterranean Sea. (A) Others turned north and passed the battlefields in the Arctic Circle in the Russian – Finnish war. (B)

Further details: (A) Violent weather, 2_52; (B) Russian-Finnish war (2_41.

More Evaporation – more wind, rain, cooling

Water, among all solids and liquids, has the highest heat capacity except liquid ammonia. If water within a water body remained stationary and did not move (which is what it does abundantly and often forcefully for a number of reasons), the upper most water surface layer would, to a very high percentage, almost stop the transfer of any heat from a water body to the atmosphere. However, temperature and salt are the biggest internal dynamic factors and they make the water move permanently. The question as to how much the ocean can transfer heat to the surface depends on how warm the surface water is relative to atmospheric air. Of no lesser importance is the question, as to how quickly


Battleships with escort plough through North Sea

and by what quantities cooled-down surface water is replaced by warmer water from sub-surface level. Atmospheric factors responsible for exposing quickly new water masses at the sea surface are wind, cyclones and hurricanes. Another ‘effective’ way to replace surface water is to stir the water body itself. Naval activities are just doing this.

On the basis of sea surface temperature record at Helgoland Station and subsequent air temperature, developments provide strong indication that the evaporation rate was high. This is confirmed by the following impacts observed:

More wind: As the rate of evaporation over the North Sea has not been measured and recorded, it seems there is little chance to prove that more vapour moved upwards during autumn 1939 than usual. What can be proved is that the direction of the inflow of wind had changed from the usually most prevailing SW winds, to winds from the N to E, predominantly from the East. At Kew Observatory (London) general wind direction recorded was north-easterly only three times during 155 winter years; i.e. in 1814, 1841 and 1940[6]. This continental wind could have significantly contributed to the following phenomena of 1939: ‘The Western Front rain’ (next paragraph).

More rain: One of the most immediate indicators of evaporation is the excessive rain in an area stretching from Southern England to Saxony, Silesia and Switzerland. Southern Baltic Sea together with Poland and Northern Germany were clearly separated from the generally wet weather conditions only three to four hundred kilometres further south. A demonstration of the dominant weather situation occurred in late October, when a rain section (supplied from Libya) south of the line Middle Germany, Hungary and Rumania was completely separated from the rain section at Hamburg – Southern Baltic[7]. Plentiful rain from England to Silesia/Germany and to Switzerland may have been caused by military activities as follows:

A north-easterly wind pushes humid air (partly generated by naval war in North Sea and Baltic Sea) southwards, while the coldness of the pushing air and abundant supply of condensation nuclei, by shelling, bombing etc., intensify cloud formation and condensation further, thus forcing and sustaining rain over a longer period of time. (A)

Further details: (A) Rain-Making, 2_ 31.

More cooling: Further, cooling observed from December 1939 onwards can be linked to war activities in two ways. The most immediate effect, as has been explained (above), is the direct result from any excessive evaporation

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[6] Drummond [7] Seewarte

process. The second (at least for the establishment of global conditions in the first war winter) is the deprivation of the Northern atmosphere of its usual amount of water masses, circulating the globe as humidity. The less moist air is circulating the globe south of the Arctic, the more easily cold polar air can travel south. A good piece of evidence is the record lack of rain in the USA from October – December 1939 (A), followed by a colder than average January 1940, a long period of low water temperatures in the North Sea from October-March (see above) and the 'sudden' fall of air temperatures to record low in Northern Europe.

Climatic conditions in the North Sea in autumn 1939, together with those of the Baltic Sea (B), played a key contributory role in sustaining the coldest winter in Northern Europe for more than 100 years.

> Further details: (A) USA dried out, 2_32; (B) Baltic Sea cooling, 2_17.

Events: Temperatures or Serious Icing in the North Sea Winter of 1939/40

The following list does not give a full picture of events but only points to some major events, places and impacts reported.

11 December 1939; Helgoland reported frost on December 11 and December 13-19 (from December 14-18 mean temperature of -1,6°C; December 15, mean temp. -3,6°C; lowest December 16, – 4,5°C; and frost from December 26-31[8].

16 December 1939; Ice on river Elbe, (e.g. Glückstadt, Hamburg), remained continuously for more than 90 days until mid March, 1940[9].

17 December 1939; Tönning (near Husum) reported first ice, which remained for 100 days[10]. Note: Before icing commences along the German North Sea coast, the air temperature needs to be below zero for about 4 to 5 days[11].

17-21 December 1939; Almost all observation stations along the German coast from Nordstrand (island south of Sylt and Amrum) to Borkum report the emergence of sea ice, its stay in the south ca. for 60 to 70 days, and further north of Cuxhaven for 70 to 102 days[12]. North of Husum (Amrum, Sylt) ice remained from early January for approx. 60 days.

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[8] Witterungsbericht [9] DHI_Eisbeobachtungen [10] DHI-Eisbeobachtungen
[11] Nusser, Gebiete

29-30 December 1939; During the night of 29/30 a strong southwest storm swept through Helgoland Bight (Helgoland up to 11 Beaufort)[13]. At the same time in far East Germany (East Prussia) very cold air of more than -20°C, had been blowing from the North and pushing further south[14].

1 January 1940; Monthly mean air temperatures for January 1940 for Westerland, Helgoland, Emden[15] :

Location	Month	Mean air temp.	Deviation from average	Lowest/day
Westerland	January 1940	- 4.2°C	- 5.3°C	-13.5°C/Jan.19
Helgoland	January 1940	- 3.2°C	- 5.1°C	-12.4°C/Jan.31
Emden	January 1940	- 7.0°C	- 8.1°C	-17.9°C/Jan.10

2 January 1940; Esbjerg – soft or new ice, navigation not hindered, Danish light buoys were withdrawn over the next 10 days[16].

6 January 1940; Drift ice in the East Scheldt. Ameland temporarily cut off from the mainland by ice. river Maas is frozen over from Woudrichem to Heusden[17].

14 January 1940; Drift ice on river Scheldt reported to have torn buoys from their mooring[18]. Frankcom made the following comment just a few days later: “in these nine days conditions have deteriorated very rapidly and one sees the first real indication of somewhat abnormal conditions, most particular is freezing of rivers Scheldt and Maas”.

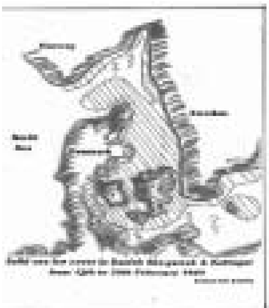
17 January 1940; Ice reported in the North Sea off Jutland for the first time in many years, up to 2 miles from the coast. Fjord in Jutland frozen over. Ice three metres thick reported from western end of Limfjord. Minus 23° F reported during the night in Denmark[19]

20 January 1940; Difficulties due to ice reported in the river Scheldt[20].

21 January 1940; Heavy ice drift reported on the west Scheldt [21].

[12] DHI-Eisbeobachtungen [13] Seewart [14]Witterungsberichte
[15] Witterungsberichte [16] Frankcom [17]Frankcom
[18]Frankcom [19] Frankcom [20] Frankcom [21] Frankcom

23 January 1940; More difficulties due to ice reported on river Scheldt. Many small vessels bound for Antwerp were put into Flushing because of ice. Navigation to Brussels was closed by ice. Fast ice reported at Lobith, on the river Rhine[22]. Frankcom concludes in his report dated January 23, 1940, noting: "…the spread of ice out into the North Sea itself is a definite indication of unusually severe weather. It is particularly unusual for shipping to be held up in the river Scheldt." [23]



27 January 1940; Helgoland had ice for 10 days between January 27 and February 23[24]; duration of ice formation in Helgoland is 11 days[25].

28 January 1940; In the close vicinity of London river Thames had been frozen for the first time since 1814. (Neue Zürcher Zeitung, 29 January 1940).

1 February 1940; Given below are monthly mean air temperatures for February 1940 in respect of Westerland, Helgoland and Emden[26]:

Location	Month	Mean air temp.	Deviation from average	Lowest/day
Westerland	Feb. 1940	- 6.1°C	- 6.9°C	-13.5°C/Jan.19
Helgoland	Feb. 1940	- 4.1°C	- 5.7°C	-12.4°C/Jan.31
Emden	Feb. 1940	- 3.7°C	- 5.3°C	-17.9°C/Jan.10

Remark: It should be noted that January was colder in Emden than in Westerland, which ranks first in February, a fact that could support the thesis that war activities in the northern section of the North Sea, delayed cooling of the sea (see previous chapter).

From February until March 1940 general winter conditions remained very severe. While investigating causes for the harsh winter, weather conditions observed in the month of February are considered important as a second cold spell pushed the winter to record low level. (A)

Further details: (A) Winter 1939/40, 2_11.

[22] Frankcom [23] Frankcom
[24] DHI - Eisbeobachtungen [25] Nusser, Gebiete [26] Witterungsberichte