

Evidence essay · Sea ice and ocean

The warmth beneath the Arctic surface

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ABSTRACT

Subsurface Arctic warmth is examined through the density structure that separates a heat reservoir from the ice above it. The essay explains how salinity can keep warmer Atlantic-origin water beneath a colder, fresher surface layer and uses contrasting hypothetical columns to distinguish stored energy from access to that energy. Heat content, horizontal transport, and upward flux are treated as separate quantities requiring different observations. Published Atlantification evidence supplies regional contrasts rather than a claim that the entire Arctic has lost its stratification. The discussion connects upward heat transfer with reduced winter ice growth and potentially changed nutrient supply, without prescribing one ecological outcome. Temperature, salinity, velocity, mixing, depth, and position are therefore needed to follow the mechanism from incoming water to a measured effect at the surface.

Keywords: Atlantification · halocline · ocean heat transport · upward heat flux · stratification

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Water can be warm enough to melt sea ice yet remain separated from it by a cold surface layer. The Arctic Ocean is not a well-stirred bath. To understand ocean heat and ice loss, a temperature number needs a vertical address and a route by which its heat can reach the ice.

The NOAA Arctic Report Card assessment of Atlantification describes Atlantic-origin water flowing beneath a fresher upper ocean. Historically, a strong halocline, a layer with a marked salinity gradient, has helped insulate the surface from that deeper warmth. Changes in the strength and depth of this layering can matter as much as the temperature of the warm water itself.

Why warmer water does not simply rise

Density depends on salinity as well as temperature. Warm, salty water can be denser than colder, fresher water above it. In the cold Arctic environment, salinity is particularly important to that balance. A stable density structure resists vertical mixing, so a reservoir of heat can remain below near-freezing surface water.

Imagine two deliberately simplified columns containing equally warm Atlantic-origin water at depth. One has a strong fresh cap; the other has weaker density separation. The amount of stored warmth may be similar, while the ease of transferring it upwards differs. This is an analytical contrast, not a forecast for two named locations. It shows why a map of subsurface temperature alone cannot supply the rate of heat delivered to ice.

A reservoir, a transport, and a flux

Three quantities are often folded into the phrase 'ocean heat'. Heat content concerns energy stored in a volume of water. Horizontal heat transport concerns moving that energy through a section, which requires information about currents and the water's temperature relative to a stated reference. Upward heat flux concerns energy crossing a surface per unit area and time. A rise in one does not automatically establish an equal rise in the others.

For example, warmer water moving more slowly through a gateway need not transport more heat than cooler water moving rapidly. Likewise, increased heat arriving at depth does not guarantee an immediate increase at the ice base if the intervening layers remain strongly stratified. Observations of temperature, salinity, velocity, and mixing constrain different parts of this chain.

The distinction matters in winter. Ocean heat reaching the surface can reduce the rate of ice formation, even without producing a dramatic patch of summer open water. A thinner starting cover can then be more vulnerable in the following melt season. Our [sea-ice overview](#) connects growth, melt, and deformation rather than treating September extent as the whole annual story.

The Arctic does not have one lid

NOAA's assessment describes contrasting stratification histories in the Eurasian and Amerasian basins. In parts of the Eurasian Basin, weakening separation has allowed greater upward transfer of Atlantic Water heat. Freshening has strengthened stratification elsewhere. A result from one sector should not be stretched into a claim that every part of the Arctic has lost its protective layering.

The report also separates preconditioning from deep ventilation. A warm layer becoming shallower can bring the system closer to a change in mixing without proving that heat is already being released upwards at the same rate as in a neighbouring region. That distinction makes repeated observations valuable: a vertical arrangement is a state, while the movement of heat through it is a process.

How would we recognise the mechanism?

A useful investigation would compare profiles through the seasons, establish where the water masses and density gradients sit, and examine currents and evidence of mixing. It would keep instrument depths and positions attached to each record. A warm anomaly crossing a

mooring could reflect a displaced current or layer, so nearby observations and the wider circulation matter.

The physical change also has biological consequences, but not a single guaranteed outcome. Mixing can alter nutrient supply and the depth at which sufficient light and nutrients meet. The NOAA productivity assessment explains why regional increases in algal production are not equivalent to a universal improvement in ecosystem health. Habitat and seasonal timing remain important.

A careful account therefore follows the heat step by step: where it entered, where it is stored, what limits its movement, and which transfer was actually measured. Arctic change in 2025 places the regional assessment in a wider evidence record. 'Warmer ocean' is a beginning; the density structure tells us which questions must come next.

References

1. NOAA Arctic Report Card assessment of Atlantification (arctic.noaa.gov)
2. NOAA productivity assessment (arctic.noaa.gov)