How big a change in salinity?

25m of water with salinity 35 psu
grow 1m of ice at 4 psu
- what is the new salinity of the water?

Conserve Mass    (1)     \( \rho_w A_w H_w = \rho_i A_i H_i + \rho_f A_f H_f \)
Conserve Salt    (2)     \( \rho_w A_w H_w S_w = \rho_i A_i H_i S_i + \rho_f A_f H_f S_f \)

\( A_w = \) area of water before freezing, \( A_i = \) area of ice, \( A_f = \) area of water after freezing – these are all the same, as we are considering a column of water
\( H_w = \) depth of water before freezing, \( H_i = \) thickness of ice, \( H_f = \) depth of water remaining after ice has formed
\( S_w = \) salinity of water before freezing, \( S_i = \) salinity of ice, \( S_f = \) salinity of water remaining after ice has formed

\( A \) is all the same, \( \rho \) are all known, \( H_w \) and \( H_i \) are given.
\( H_f \) and \( S_f \) are unknown, want \( S_f \).
So, cancel \( A \), remove \( H_f \), to get:
Rearrange (1) \( \rho_f H_f = (\rho_w H_w - \rho_i H_i) \)
Substitute into (2) \( S_f = (\rho_w H_w S_w - \rho_i H_i S_i) / \rho_f H_f \)
\( S_f = (\rho_w H_w S_w - \rho_i H_i S_i) / (\rho_w H_w - \rho_i H_i) \)
\( = (1023 \times 25 \times 35 - 920 \times 1 \times 4) / (1023 \times 25 - 920 \times 1) \)
\( = 36.16 \text{ psu} \)

DOES THIS SEEM ABOUT RIGHT??
- about the same as removing 1m of fresh water
.. so volume changes ~ 4% .. so we might expect salinity to change about 4% ... 4% of 35 is ... oh around 1 ..

\( \text{i.e., } \sim 1 \text{ psu change} \)
Sea water – heat capacity versus Latent heat

The heat capacity, $c$, of sea water is $\sim 3900 \text{ J Kg}^{-1} \text{ K}^{-1}$

The heat capacity of freshwater is $\sim 4200 \text{ J Kg}^{-1} \text{ K}^{-1}$

The heat capacity of sea-ice is $\sim 2900 \text{ J Kg}^{-1} \text{ K}^{-1}$

The latent heat of fusion, $L$, of sea water is $\sim 330,000 \text{ J K}^{-1}$

Thus:
- to melt one kg of ice, requires $\sim 330,000 \text{ J}$
- the same amount of energy, would raise the temperature of 1 kg of sea-water from 0 deg to $\sim 330,000/3900 \sim 84 \text{ deg}$!

- i.e., it’s a LOT easier to warm water than to melt ice.

So, when we are considering energy, the phase change is much more important than raising/lowering the temperature of ice or water.