# Norwegian coastal hydrodynamics: Insights from observational data

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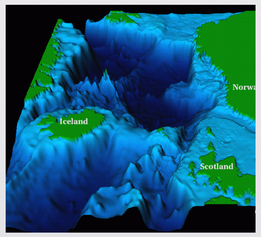
## Why this area?

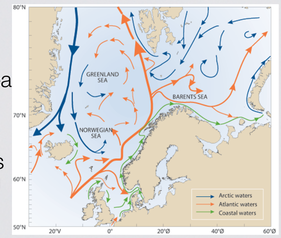



Nordic waters are a dynamic region of intermixing, contrasting water masses.

- Arctic Deep Water
- North Atlantic Water
- Norwegian Coastal Waters

The main currents include:

- Norwegian coastal current bringing freshwater from Baltic sea and coastal sources northwards
- North Atlantic Drift brings warm salty waters north[1]
- East Greenland Current brings cold, fresh waters from Arctic



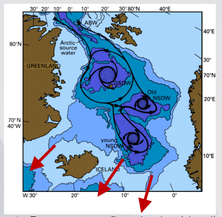




*Figure 1: Deep water flow in the Nordic seas*

- Salinity and temperature impact density and have dynamic effect driving ocean circulation.
- Salinity also acts as tracer, essentially fixed for different water masses (away from surface/boundaries)

- Arctic Deep Water moves through Nordic Seas over the Greenland-Scotland ridge to become Atlantic Deep Water.
- Very important to overall thermohaline circulation which mediates our climate

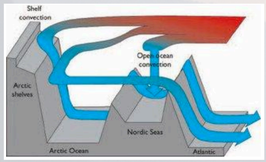
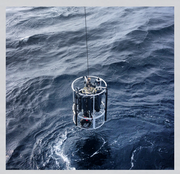



*Figure 2: Journey of Arctic Deep Water through the Nordic seas*

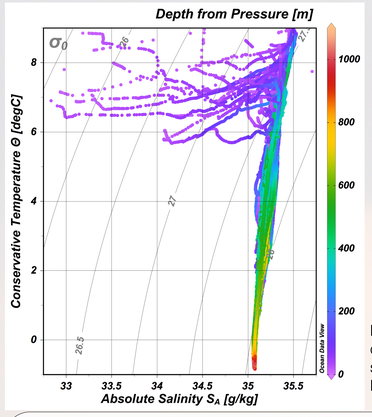
## Methodology



CTD measurements were taken aboard RV. Dana along a north-south transect in May/June 2015.

Data was supplemented with cruise transects from the previous six years

## Tracing the Nordic water masses




*Coastal Waters:*
Have seasonal variability and change year from year.

*Deeper Water Masses:*
Change more slowly and have strong salinity and temperature traces.

Figure 3: T/S diagram demonstrating stability of deep polar waters compared with dynamic surface regions influenced by freshwater from Baltic and Norwegian runoff

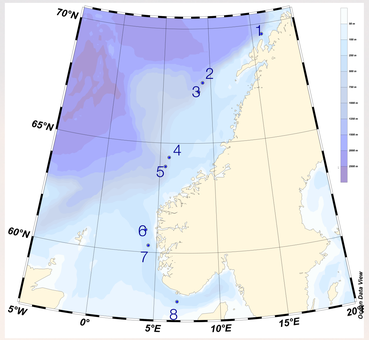



Figure 12: Cruise transect with station numbers

## Winter signal on the shelf

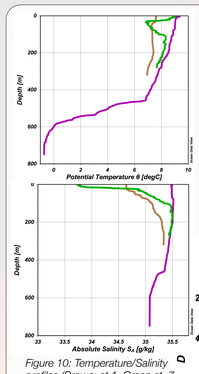



*Figure 10: Temperature/Salinity profiles (Brown: st.1, Green st. 7 (shelf), Purple st. 5 (deep))*

*Shelf station –*
Penetration of winter temperature cools water column → Signal preserved and stable → Fresh top layer stabilises subsurface temperature minimum

*Deep stations –*
Cooling causes instability → Convection
Stability of the water column decreases northward due to mixing between coastal water and Atlantic current

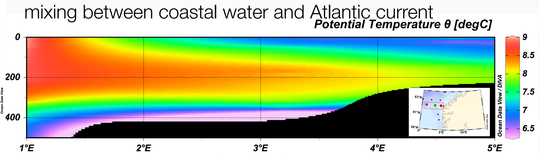



*Figure 11: Temperature section (3rd May) demonstrating coastal wedge with coastal temperature minimum*

## Norwegian Sea Deep Water

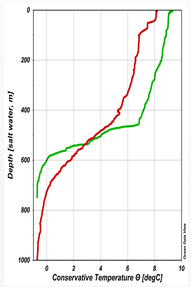



*Figure 4: Temperature-depth profile for Station 2 (red) and 5 (green)*

Cold, dense, deep water was sampled in two stations (Fig 4):

- Station 2 (red):
  - Steady gradient from North Atlantic Intermediate water (NAIW) to deep water
  - 0C at 725 m
  - Old Norwegian Deep Water (NSDW)
- Station 5 (green)
  - Sharper gradient due to warmer NAIW and deeper water
  - 0C at 600 m
  - Colder deep water from 500 m to 750 m
  - New NSDW?

- Depth of density equal to 28 kg/m$^3$ from larger data set (over several years), representative of 0 C, demonstrates very cold water at sea surface on shelf to the north.
- Circulation matches old NSDW literature.

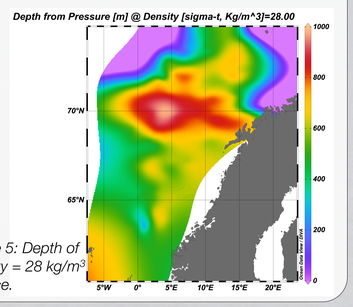



*Figure 5: Depth of density = 28 kg/m$^3$ surface.*

## Atlantic Water

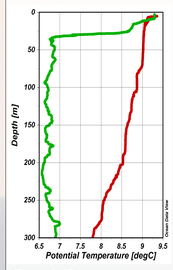



*Figure 6 : Temperature profiles for stations 5 (red) and 8 (green)*

Atlantic water signature is found in the central to northern stations.

- Station 5 (red) - Deep station where the water gets warmer
- Station 8 (green) - Lower water temp due to mixing with Baltic water

*Shallow waters –*
Atlantic water mass occupies all the water column below Norwegian coastal water (Fig 7)

*Deep waters –*
Layer is pushed to the top by the dense NSDW, getting thinner (Fig 7)

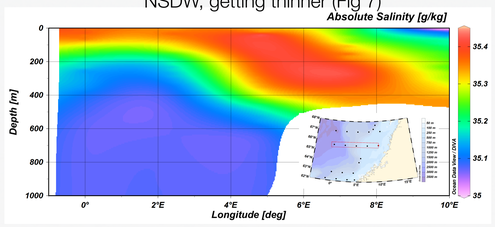



*Figure 7: Salinity along a transect perpendicular to the Norwegian coast*

## Coastal processes

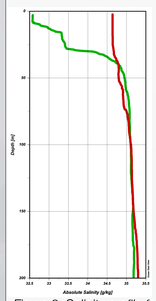



*Figure 8: Salinity profile for northern (red) and southern (green) water column*

Evidence for Norwegian coastal water found along continental shelf.

South –

- Strong influence of Baltic freshwater
- Evidence for freshwater originating from fjords, notably Norway's largest fjord system, Sognefjord (Fig 9).

North –

- Coastal current prevails as a freshwater wedge with a reduced salinity gradient between coastal and Atlantic waters (Fig 8).
- Explained by mixing as dominant Baltic outflow moves northwards.

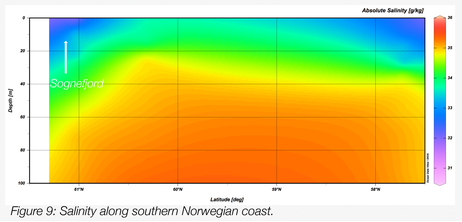



*Figure 9: Salinity along southern Norwegian coast.*

## References

Nilsen, J. E. Ø, 2003
*Sætre, R. and Ljøen, R., 1971*
*Hansen, B. and S. Østerhus, 2000*
*Sætre, R, 2007*

## Acknowledgments

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Photo credit: Randi Hausken