AUV-based acoustic observations of the summer distribution and patchiness of zooplankton in Spitsbergen

To be submitted to L&O

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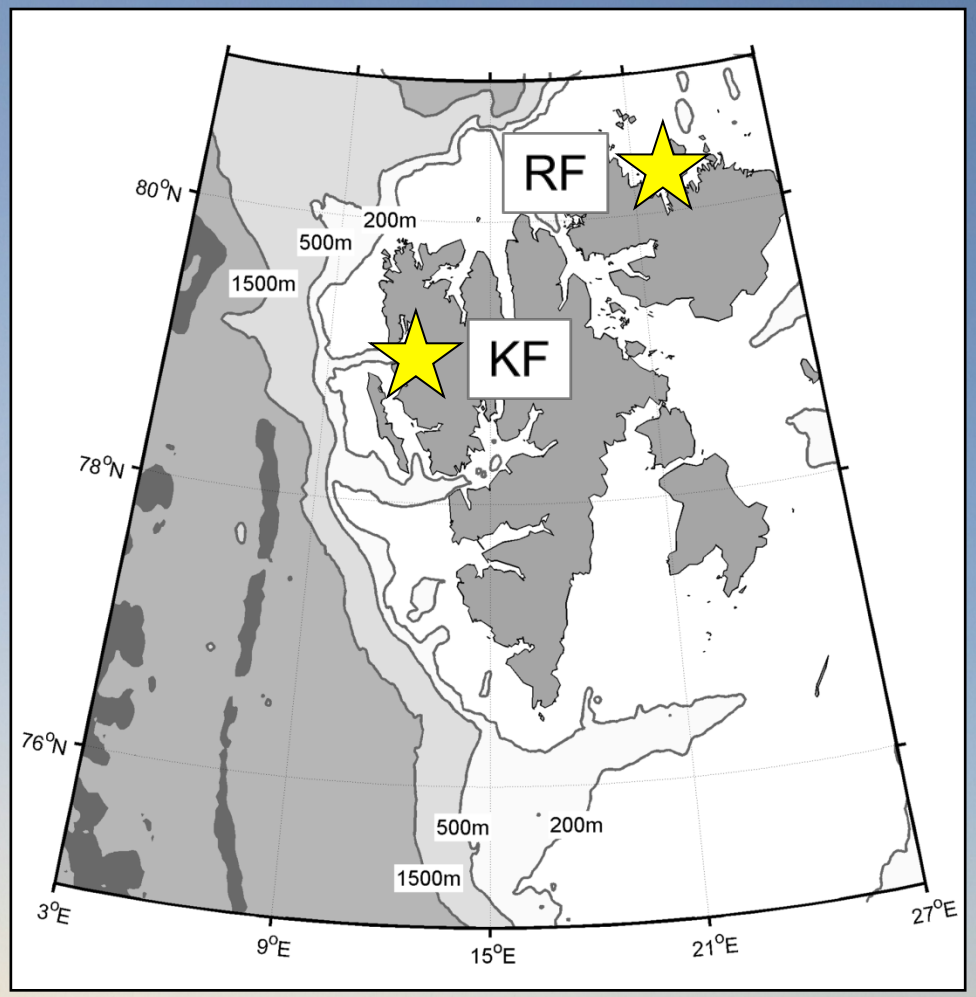
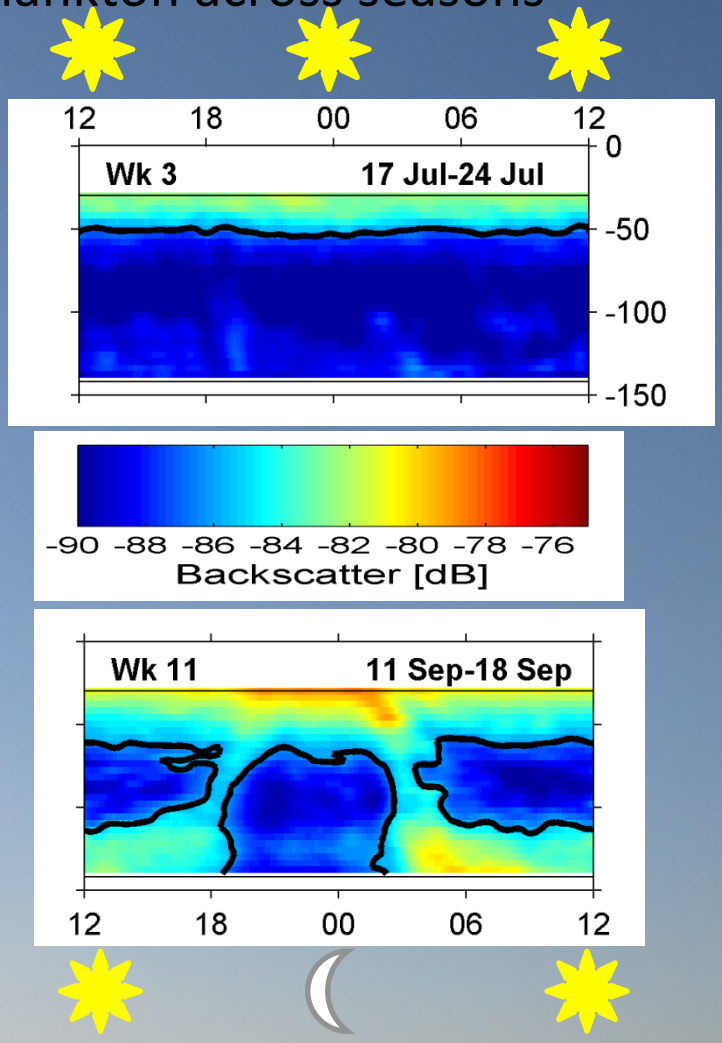
Arctic Zooplankton Studies

- Previous studies have documented the vertical distribution and Diel-Vertical-Migrations (DVMs) of zooplankton across seasons





Cottier et al 2006

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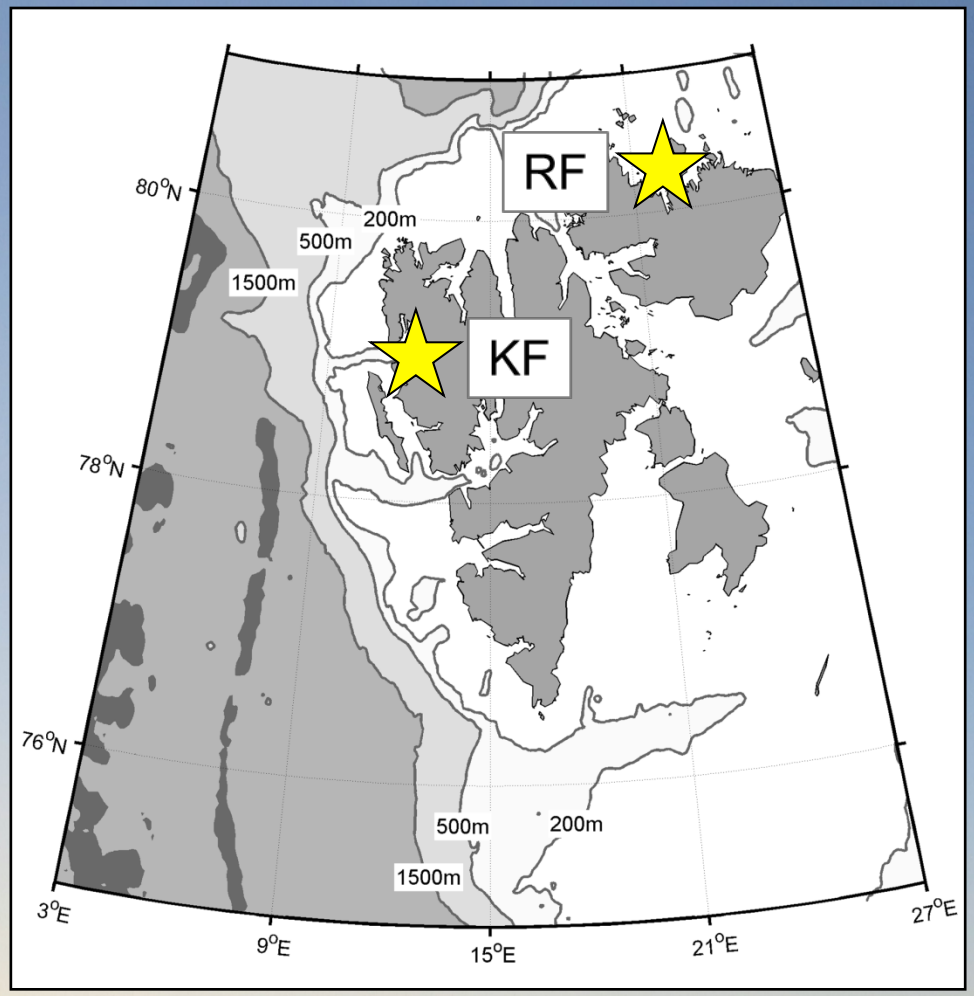

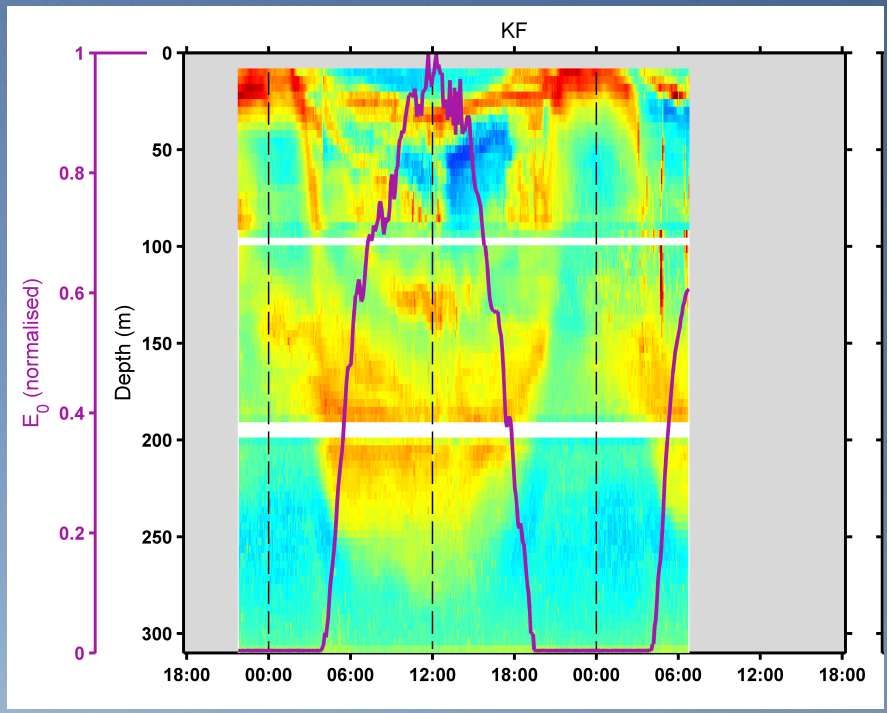

Berge et al 2014

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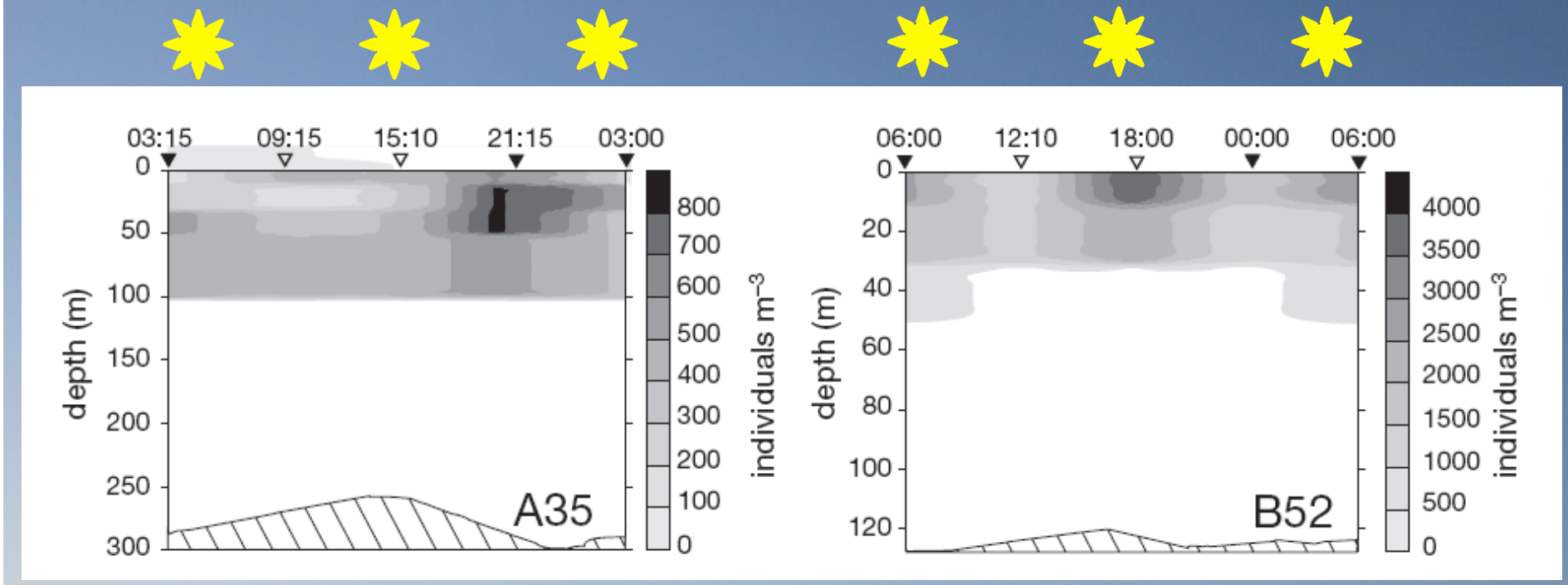


Blachowiak-Samolyk et al 2006

All studies generally lack spatial resolution

AUV-based Study

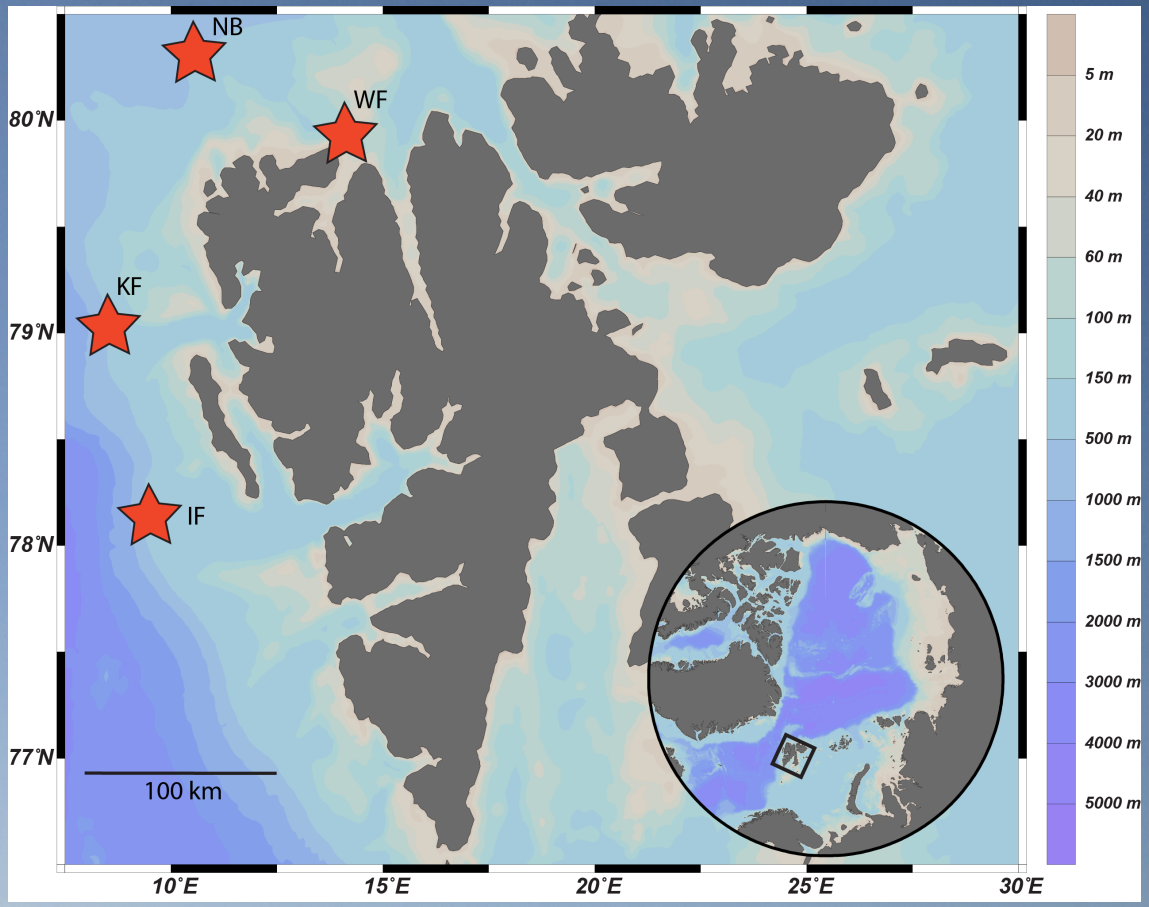
- Cruise on RRS *James Clark Ross* between June 13 and July 22 2010
- Period of continuous daylight
- REMUS 600 AUV specified to measure turbulence (Steele *et al*., 2012)
- Also equipped with up- and down- looking 600 kHz ADCPs

Objectives of Study

1) **Verify if AUV-mounted ADCPs can be used for biological studies.**
2) **Document the vertical distribution of zooplankton over larger spatial scales than previous studies.**
3) **Document the patchiness of zooplankton.**

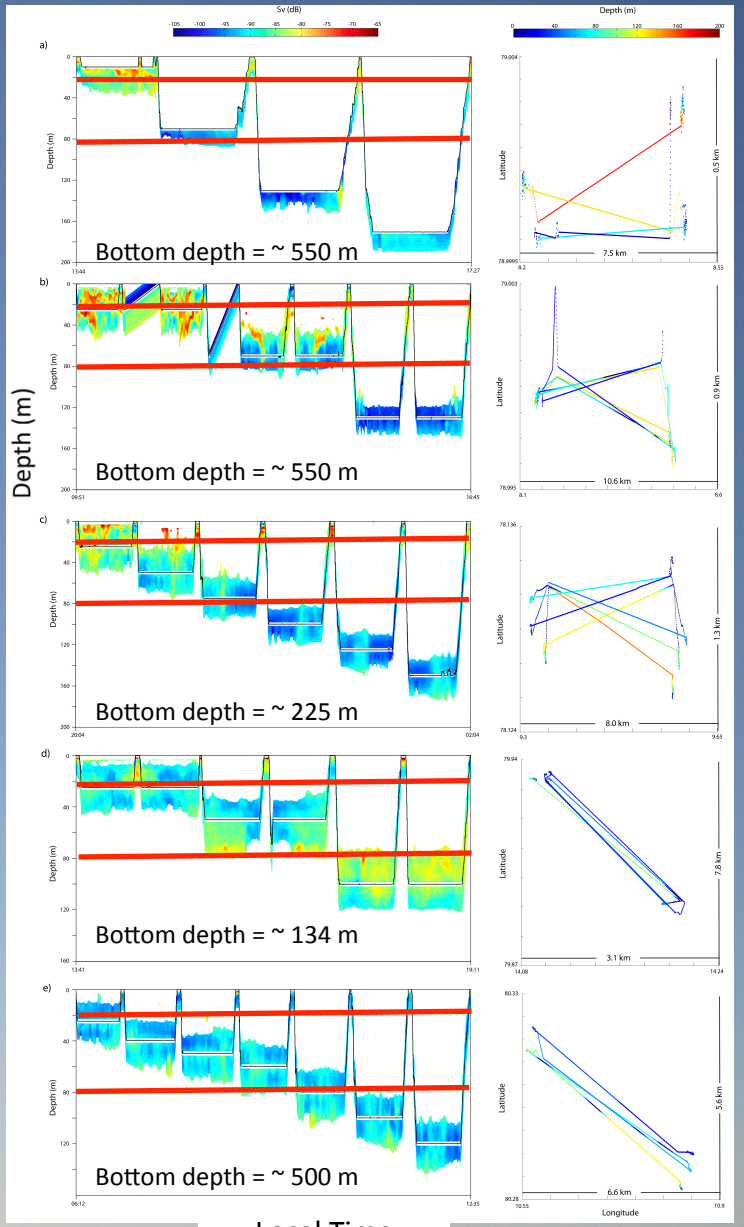
Study Area

- Kongsfjordbanken
  - 2 deployments
  - July 6 and July 12
  - Centered on midday
  - 10.75 hours mission time
- Isfjordbanken
  - 1 deployment
  - July 20
  - Centered on midnight
  - 6 hours mission time
- Woodfjorden
  - 1 deployment
  - July 16
  - Centered on midday
  - 5.5 hours mission time
- Norskebanken
  - 1 deployment
  - July 18
  - Centered on midday
  - 6.33 hours mission time

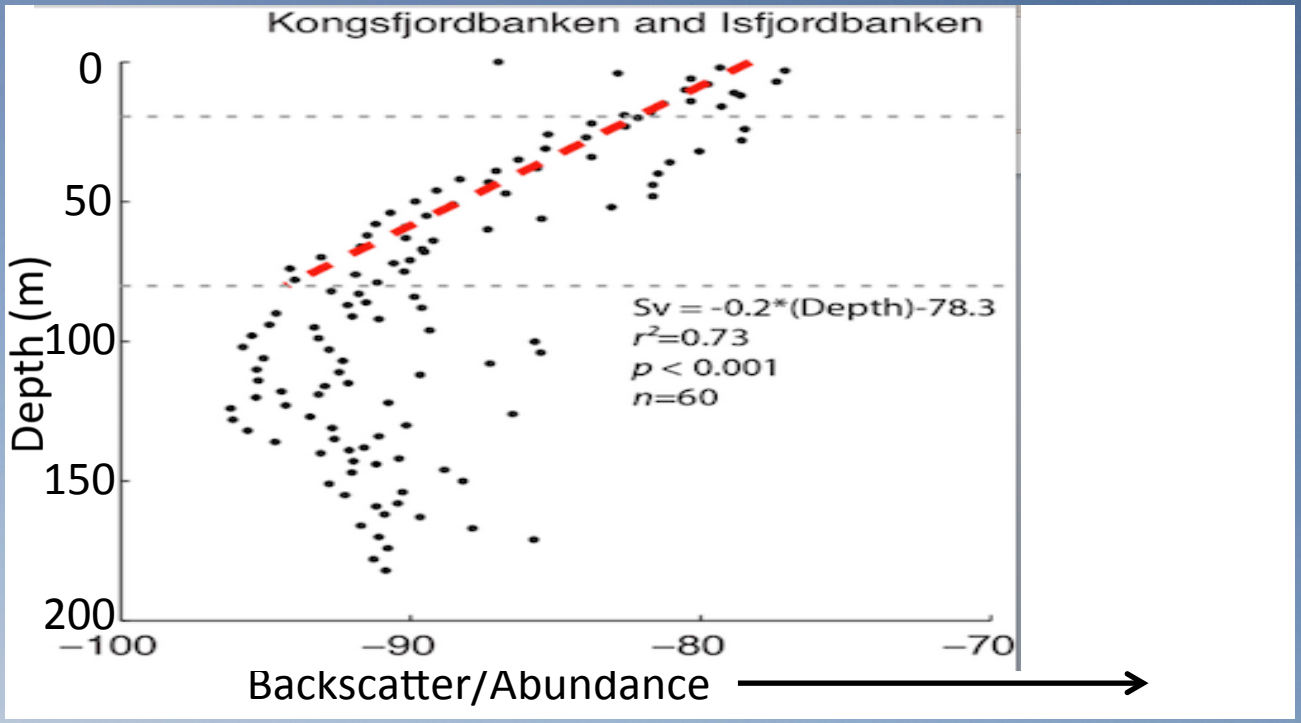


Methods: Processing AUV-mounted ADCP

- Backscatter transformed using the SONAR equation for moored ADCPs (Deines, 1999).
- Adapted to a moving platform using the algorithm for current measurements from AUV-mounted ADCPs.
- Vertical resolution of 4 m.
- Inclusion of a Time-Varied-Threshold of -142 dB at 1 m to remove noise amplification with range.
- Acoustic backscatter at 600 kHz can be related to zooplankton abundance
- No data recorded below 200 m

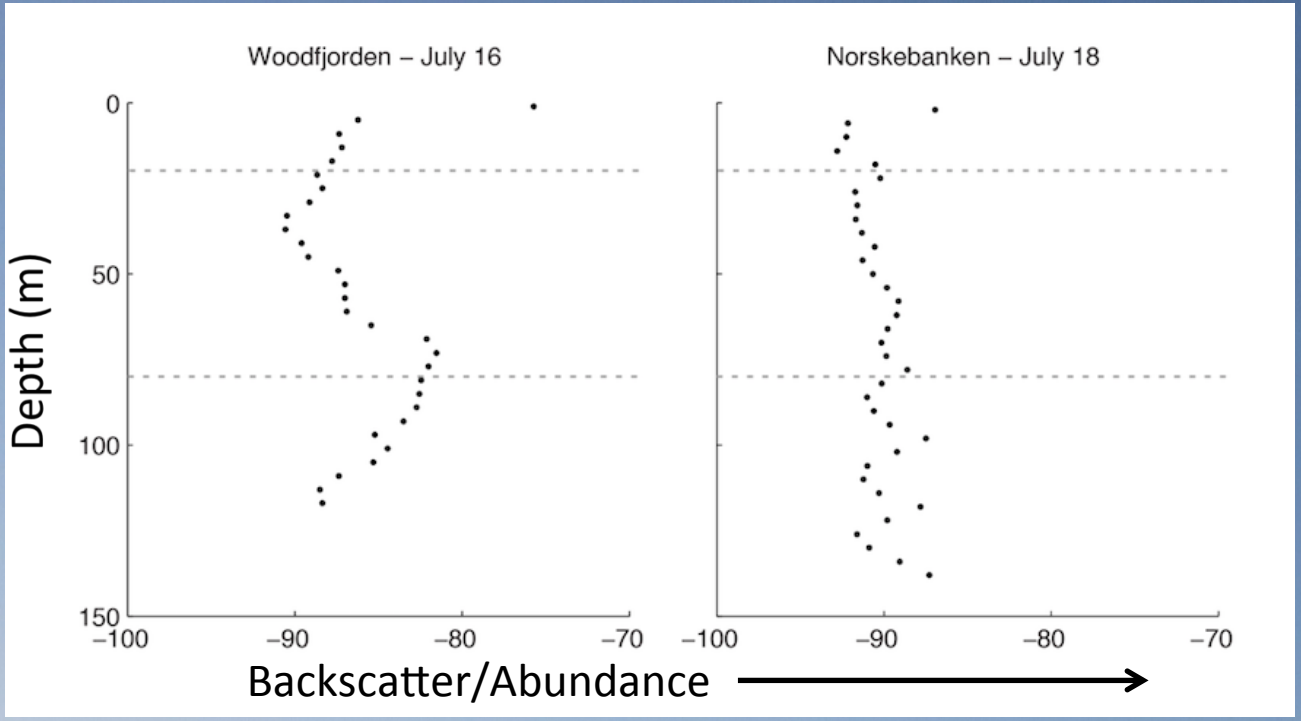


Results: Vertical Distribution



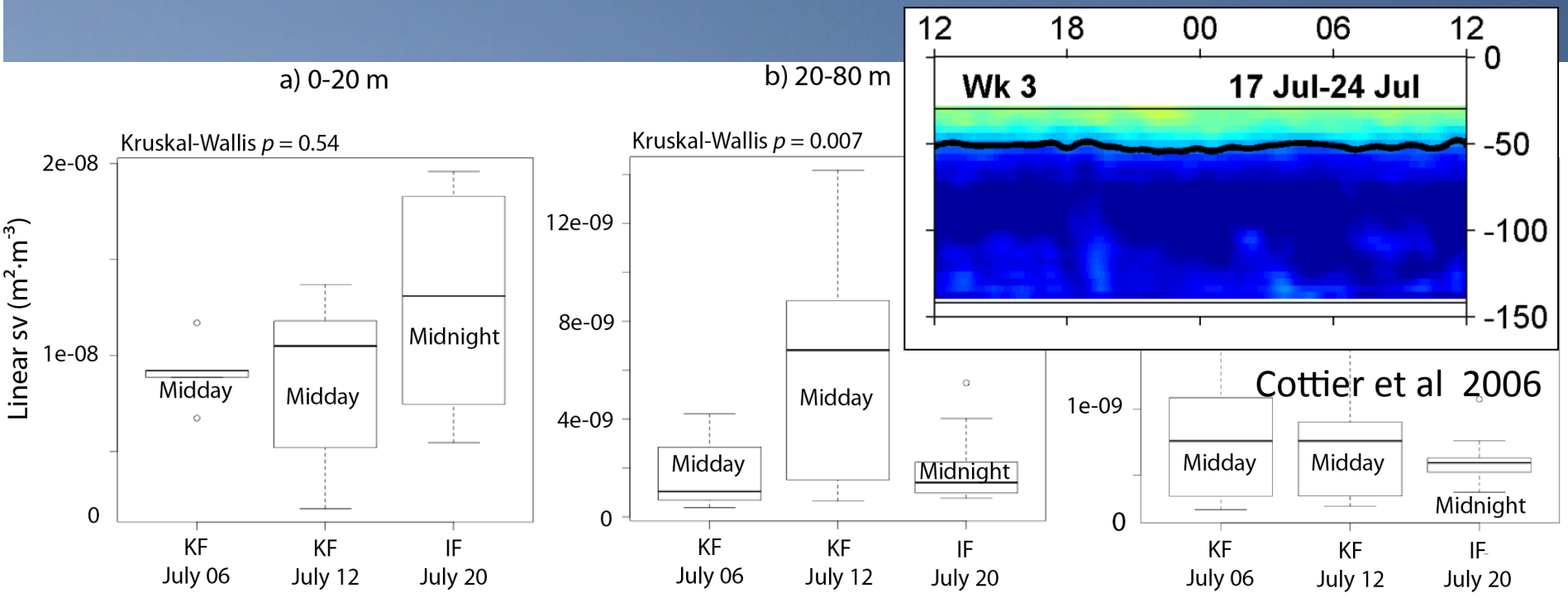
- Vertical distribution of zooplankton is similar at both survey sites
- Maximum zooplankton abundance near the surface. Significantly higher in surface layer

Results: Vertical Distribution



- Less stratification of the zooplankton distribution
- Low backscatter at Norskebanken

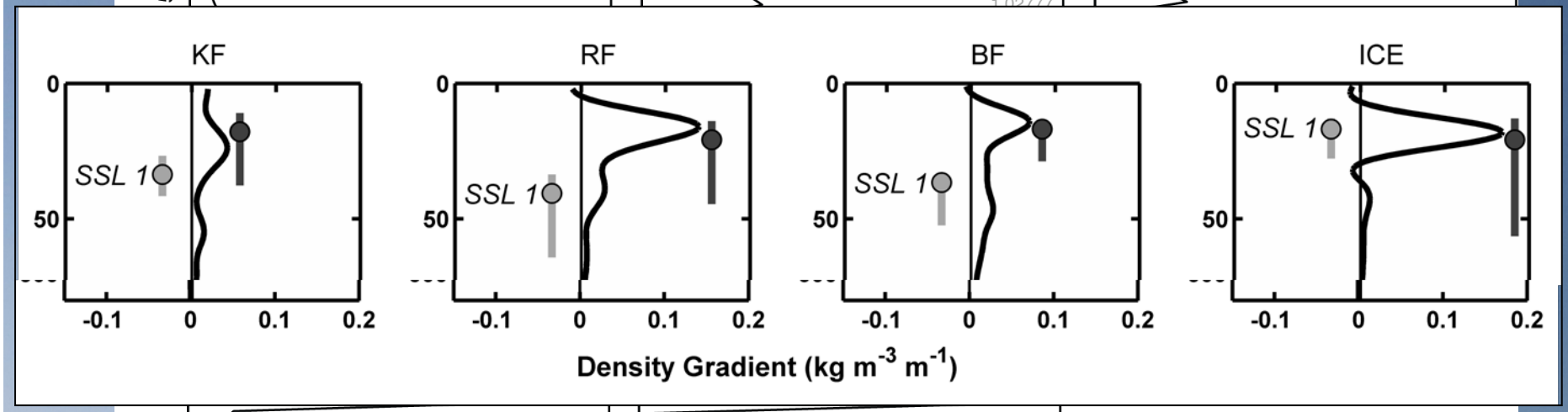
Results: Absence of DVMs



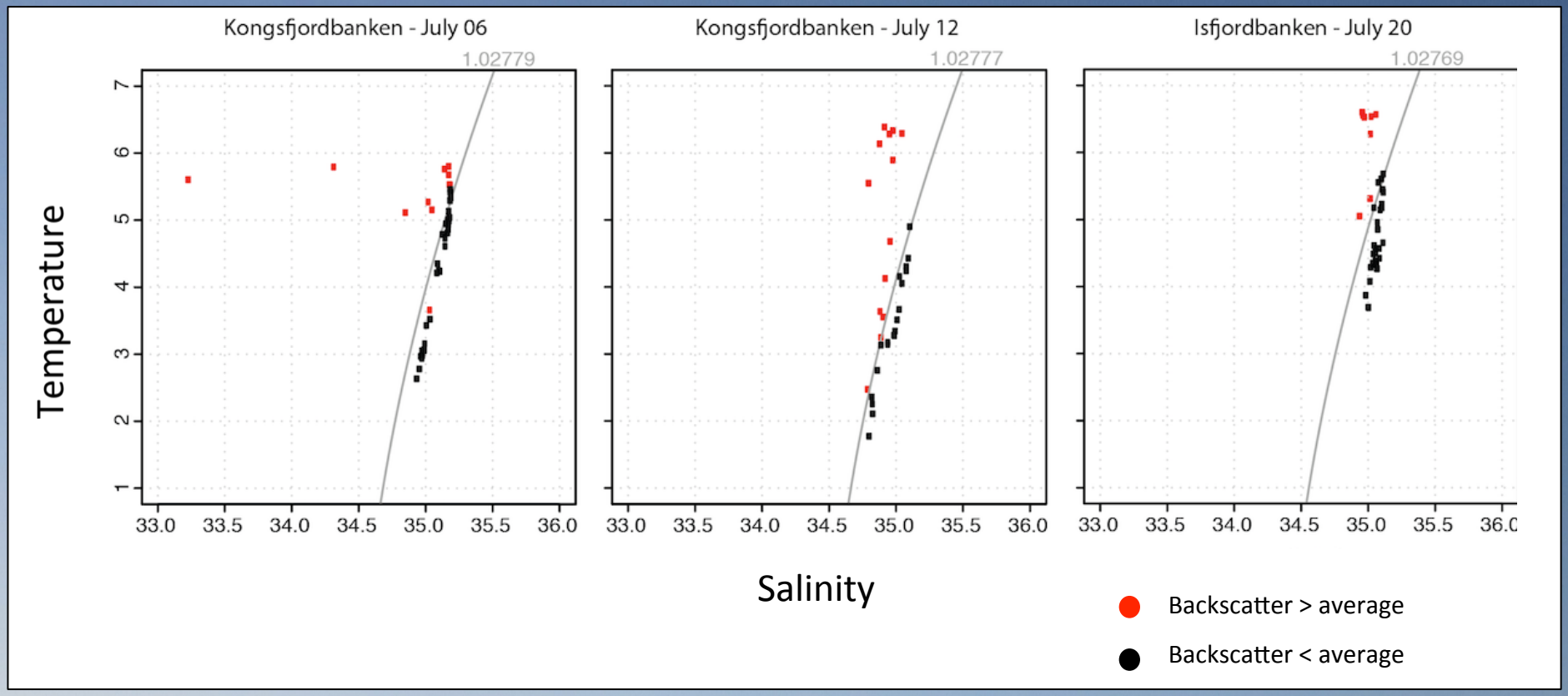
- No significant difference between day and night distributions
- Suggests most zooplankton remain in the surface layer at night and that there is no large-scale synchronized DVM during summer supporting the early observations of Cottier *et al*. (2006) and Blachowiak-Samolyk et al (2006)

Results: Vertical Distribution

- In autumn, Berge *et al*. (2014) observed that the abundance of zooplankton was higher above the Base of the Pycnocline (BOP).

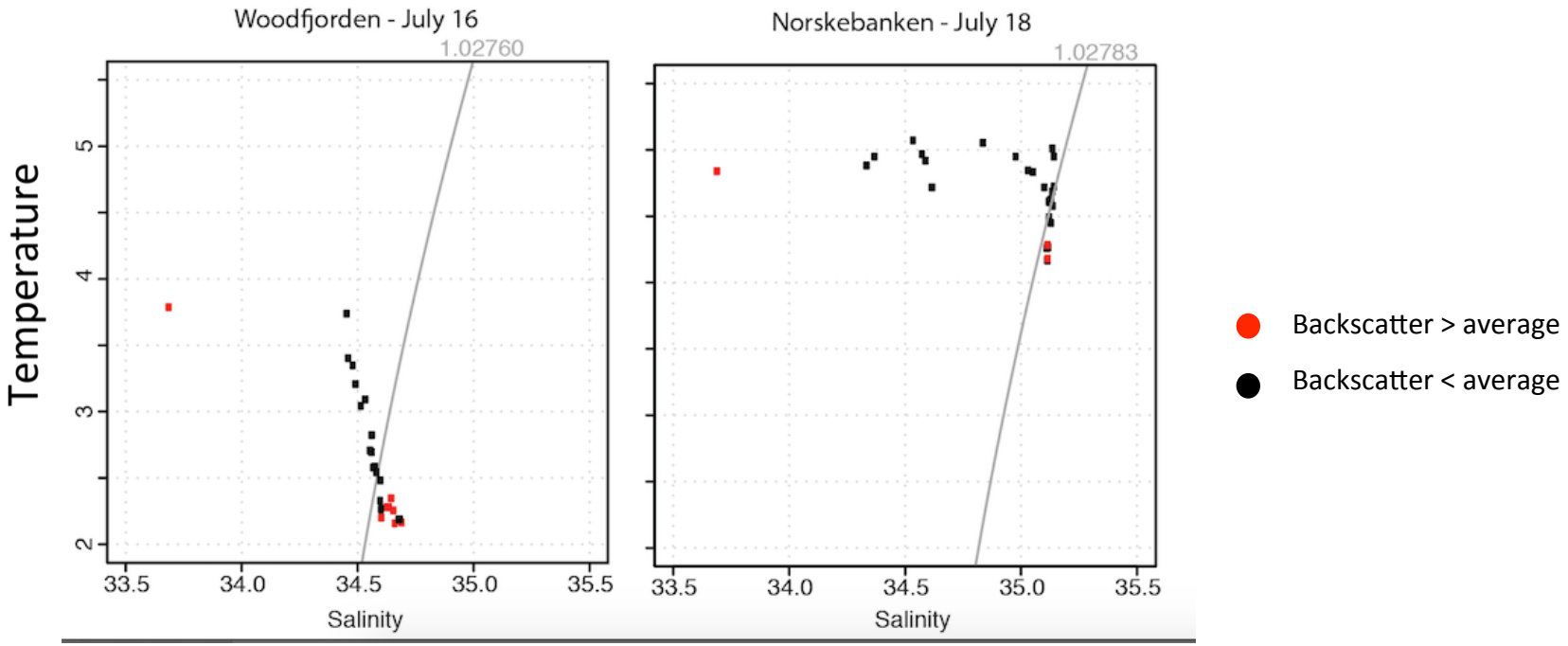


Results: Vertical Distribution



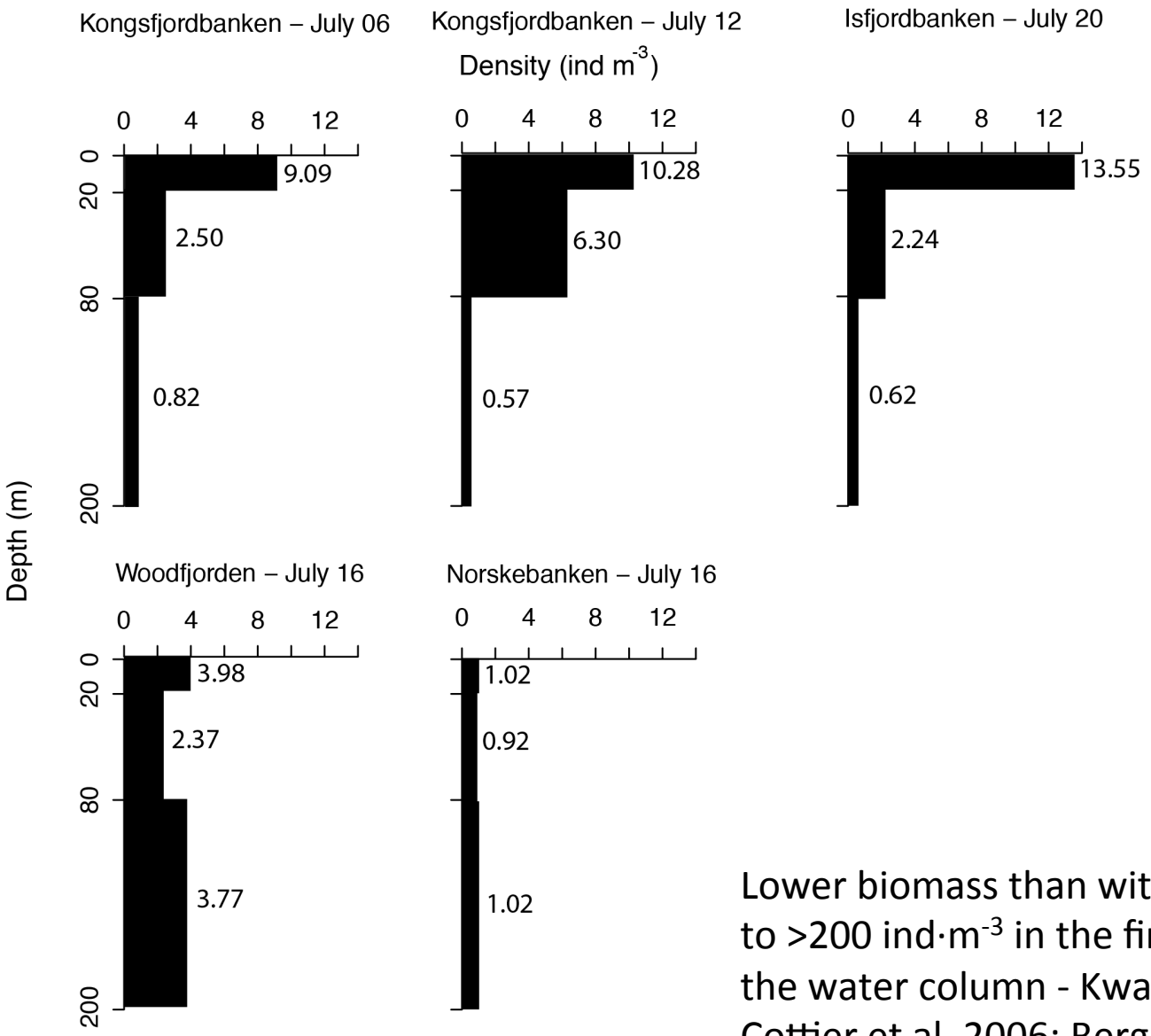
- Zooplankton backscatter greater than the average concentrated above the BOP.
- Similar to what was observed by Berge *et al*. (2014) in autumn.

Results: Vertical Distribution



- Zooplankton backscatter greater than the average concentrated below the BOP.
- Fresher and colder water at the surface (ArW vs. AtW)

Results: Density



C. finmarchicus

C. glacialis

C. glacialis

Lower biomass than within the fjords (e.g. 76 to >200 ind·m^{-3} in the first hundred meters of the water column - Kwasniewski et al. 2003; Cottier et al. 2006; Berge et al. 2014)

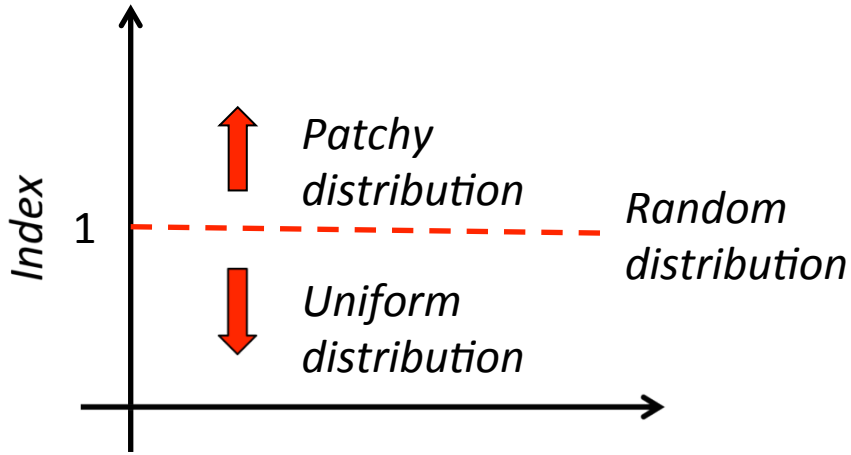
Results: Spatial Patchiness

- Lloyd's patchiness index (*I*; Lloyd, 1967)

$$I = \left[\frac{\bar{x} + \left[\left(\frac{s^2}{\bar{x}} \right) - 1 \right]}{\bar{x}} \right]$$

where $\bar{x}$ is the mean density* and s^2 is the sample variance.

*Note that the zooplankton density was calculated based on the assemblage documented by Cottier *et al*. (2006).



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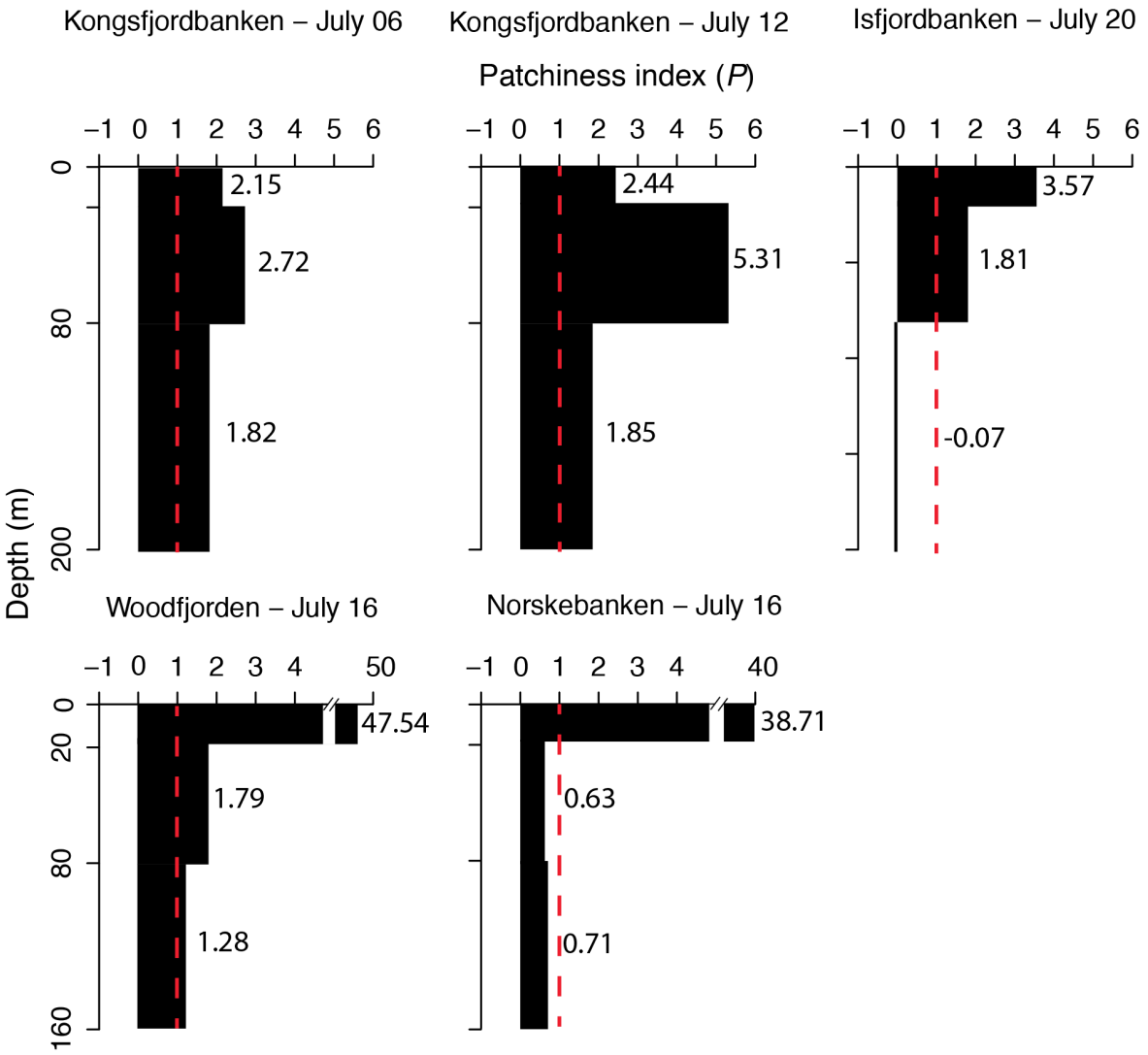

Summary and Conclusions

- **AUV-mounted ADCPs can be used effectively for zooplankton studies and the spatial coverage allows wide area estimates of horizontal and vertical distributions.**

- Vertical distribution of zooplankton is more stratified at locations dominated by AtW compared to regions with a stronger inflow of ArW – Vertical distribution might change with “atlantification” of the Arctic ocean.

- Higher abundance above the BOP at southernmost locations and below the BOP at northernmost locations – BOP acts as a physical barrier.

- Patchy distribution in the surface layer.

Images: Hopcroft/UAF/NOAA

What next?

- Review of the manuscript by co-authors.
- Chl-a measurements at each location?
- Check for vertical velocities anomalies (w'; Tarling et al. 2002) indicating unsynchronized VMs?
- Relate backscatter intensity and patchiness to turbulence measurements?

Images: Hopcroft/UAF/NOAA

Acknowledgements

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