Linking the Physical and Biological Properties of Sea Ice Habitats

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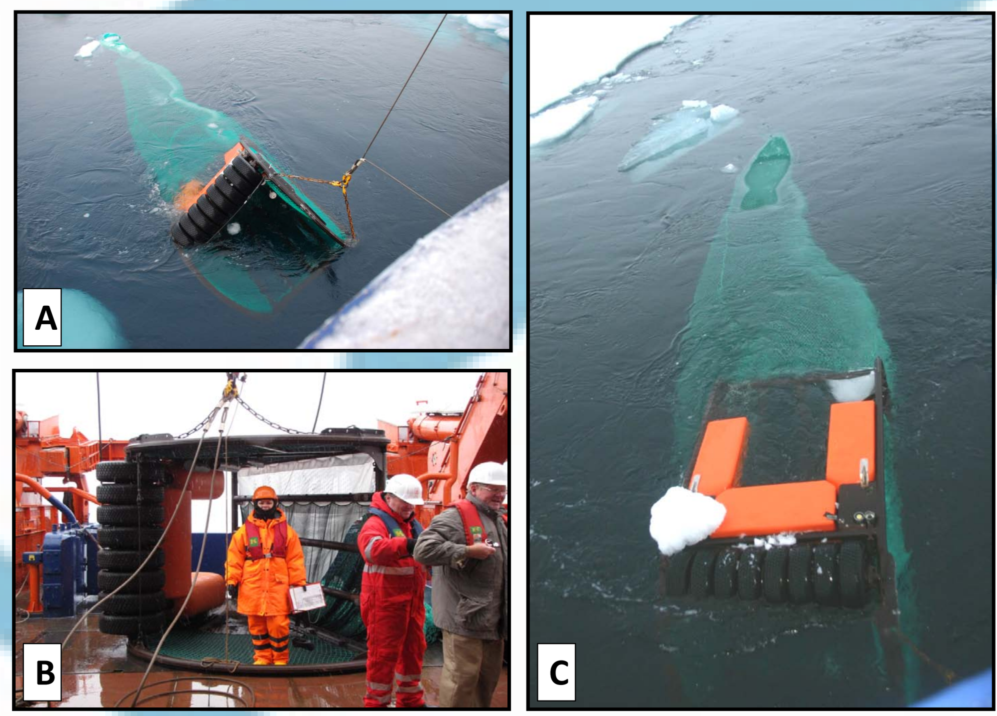
Introduction:

- Accelerated decline in Arctic sea ice cover[1] with a new record minimum ice extent set in September 2012[2]. Large losses of MYI and a shift to an Arctic dominated by FYI[3].
- During "IceArc 2012" (ARK XXVII) sea ice properties were sampled/observed during this exceptional period.
- Decreased Arctic sea ice has resulted in pelagic PP rising over the past decade[4]. There remains uncertainty in projections of PP in an ice-free Arctic due to unknown contributions of ice algae.
- Sea ice associated fauna probably play a key role in carbon transfer within Arctic food webs[5,6]. This process is poorly understood due to the inaccessibility of the ice underside.
- Relating key species with properties of their habitat is essential to understand future changes. This will be accomplished using a Surface and Under-Ice Trawl[7] (SUIT; Fig. 1) equipped with a sensor array (Fig.3).

Objective: Examine representativeness of sensor data for characterizing sea ice habitats sampled during SUIT hauls.

Figure 1: SUIT net system: A) being winched out of water after deployment; B) on deck of the Polarstern laying on its side, with Carmen David and crew members. and; C) in the water just before being removed.



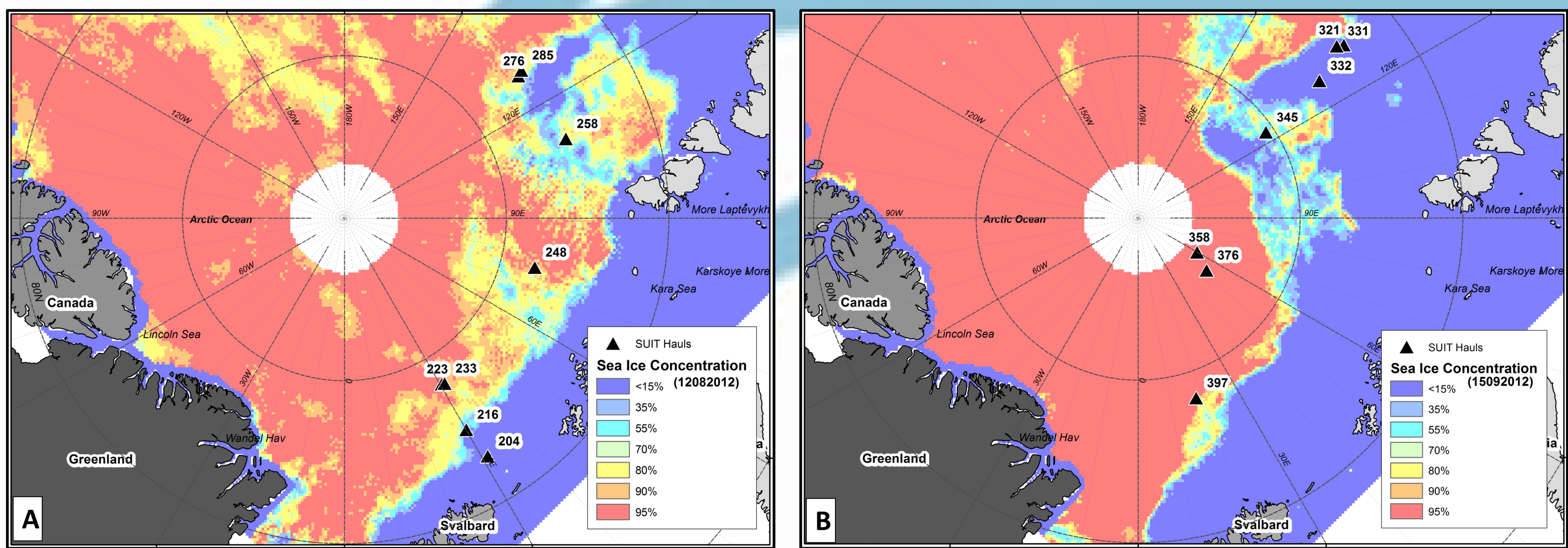


Figure 2: Map of the Arctic Ocean with locations of SUIT hauls, during ARK XXVII/3, conducted: A) between Aug 05-26, 2012 overlaid on sea ice concentration data acquired 12.08.2012 and: B) between Sept 04-29 overlaid on sea ice concentration data acquired 15.09.2012 (sea ice concentration data courtesy of Bremen University).

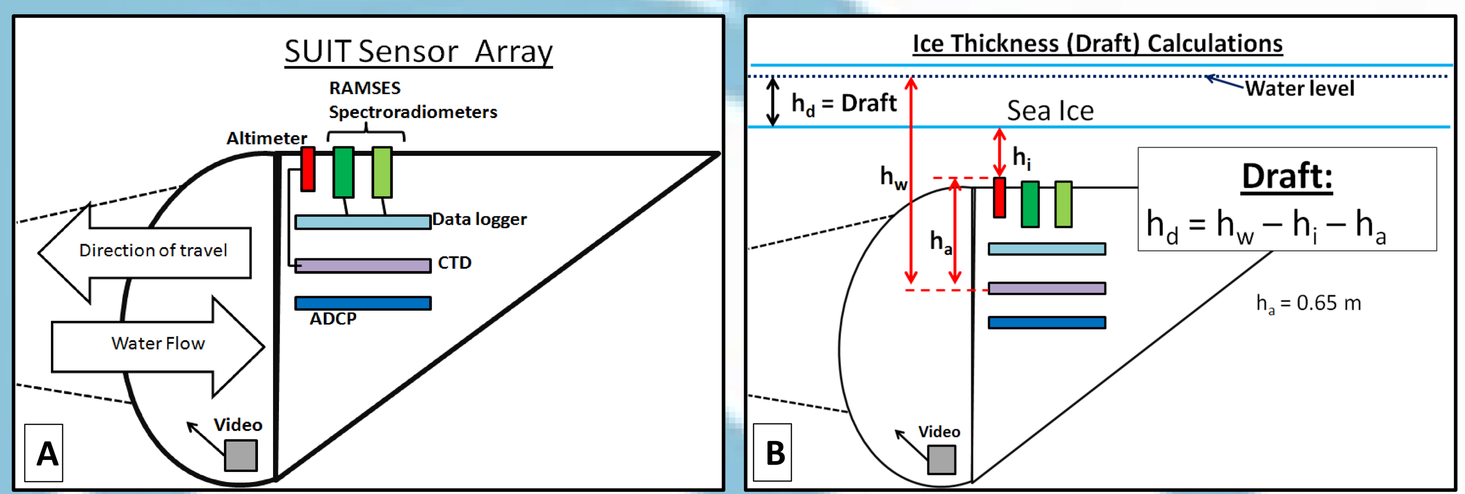


Figure 3: Generalized renditions of: A) SUIT sensor array setup and: B) sea ice draft calculations based on sensor measurements.

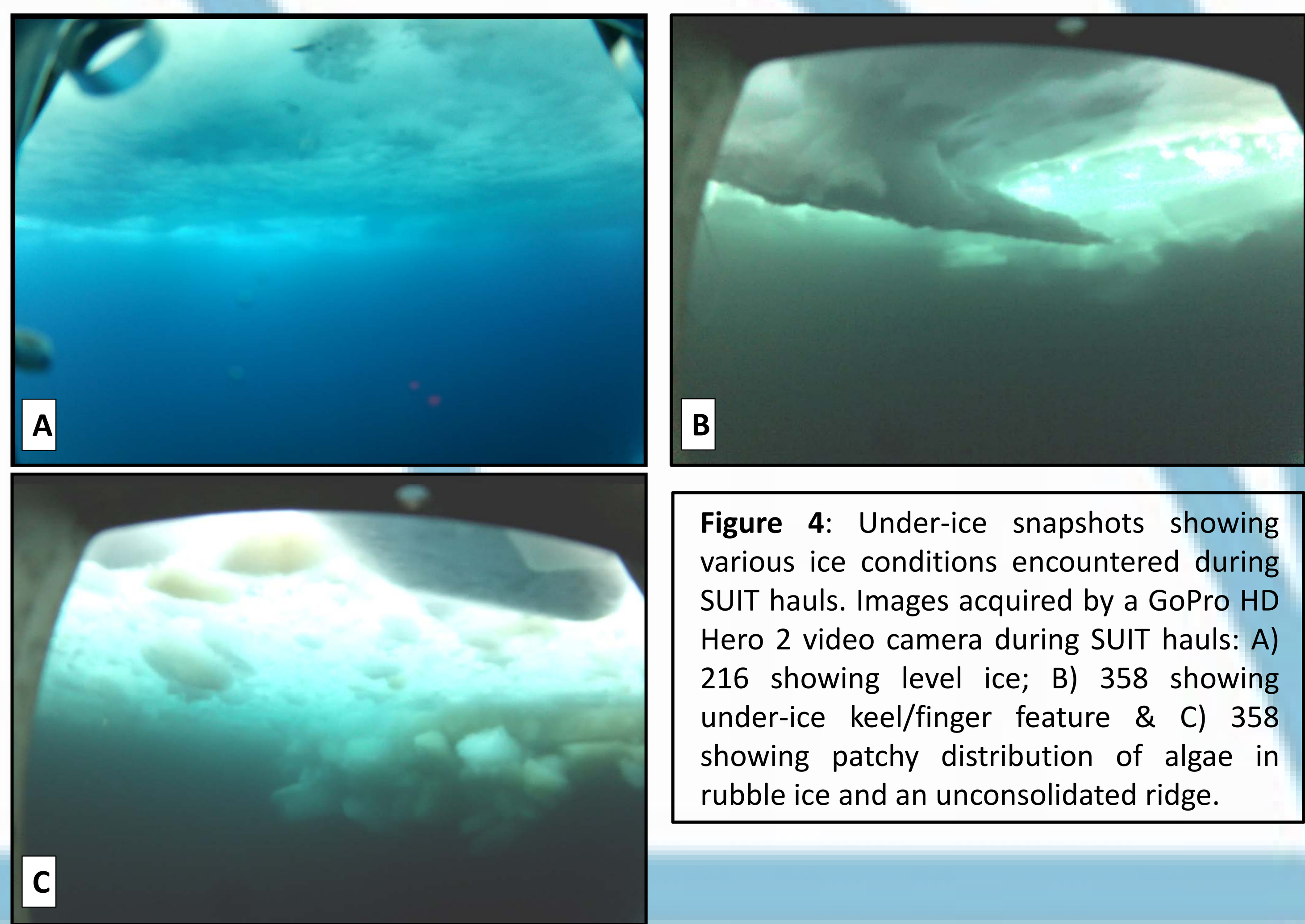


Figure 4: Under-ice snapshots showing various ice conditions encountered during SUIT hauls. Images acquired by a GoPro HD Hero 2 video camera during SUIT hauls: A) 216 showing level ice; B) 358 showing under-ice keel/finger feature & C) 358 showing patchy distribution of algae in rubble ice and an unconsolidated ridge.

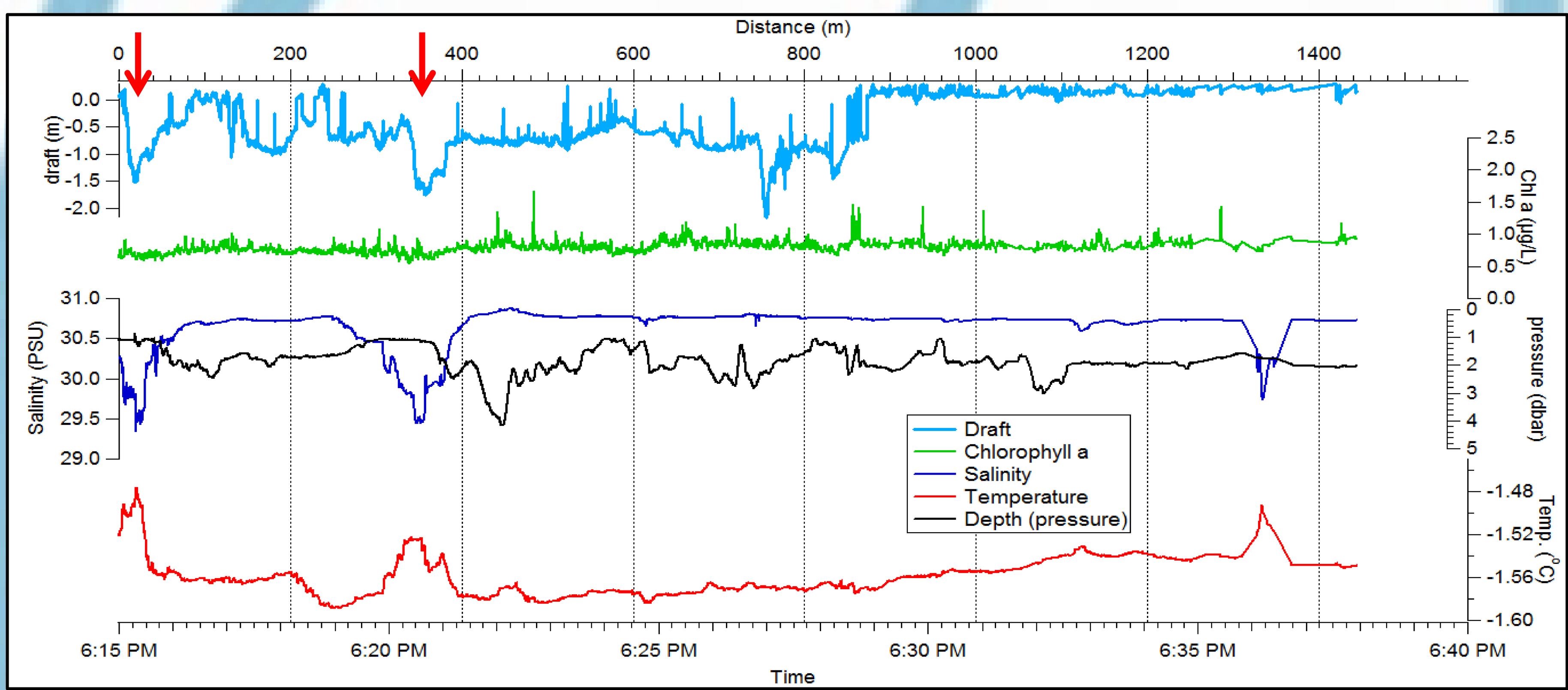


Figure 5: Profiles of sea ice and under-ice biophysical properties measured and derived from the CTD during SUIT haul 285 (see Fig. 2). Profiles are coincident with Fig. 6.

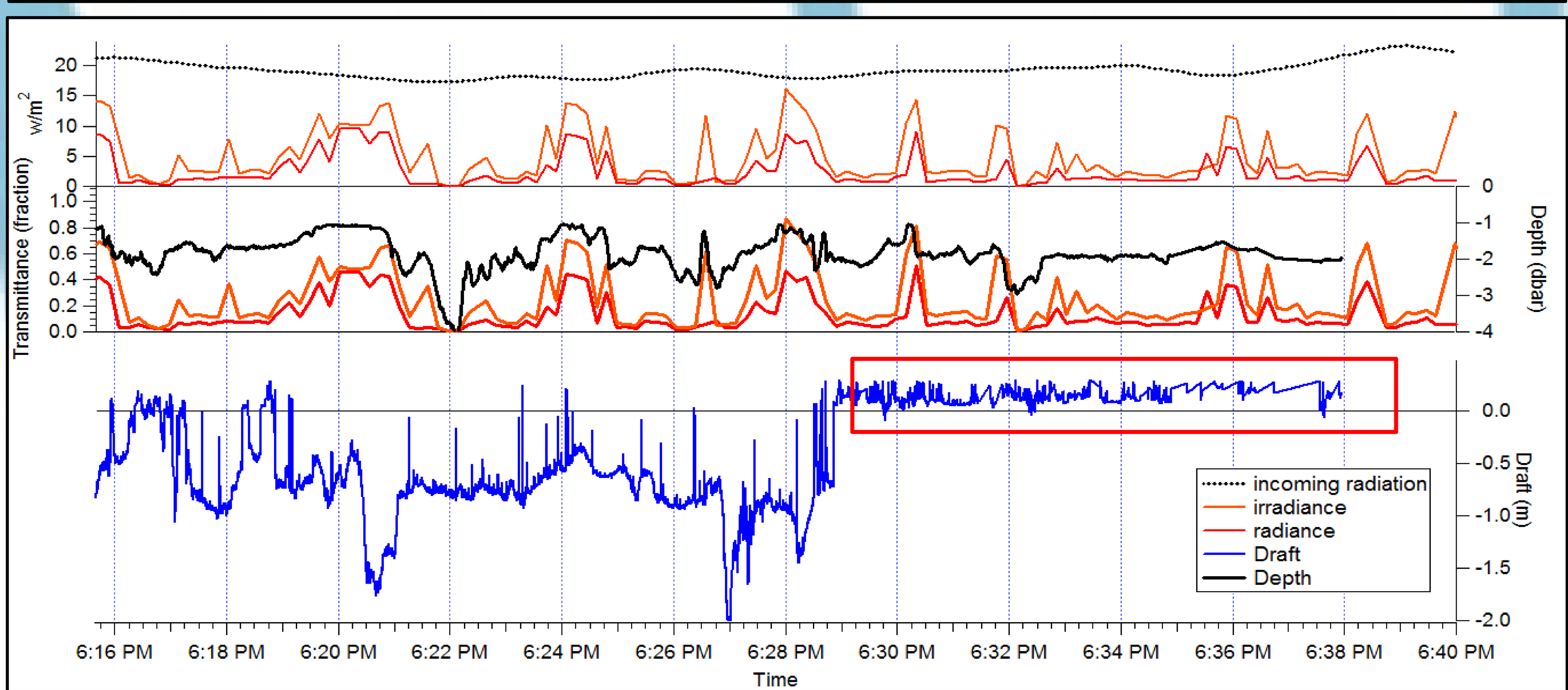


Figure 6: Profiles of incoming radiation and light transmission through sea ice observed during SUIT haul 285 with coincident draft and depth profiles. Transmittance values are calculated as: energy measured by SUIT RAMSES divided by incoming radiation.

Materials & Methods: SUIT hauls were conducted at 15 stations in the Arctic Ocean during the Polarstern cruise ARKXXVII/3 "*IceArc*" (Fig.2). The SUIT consists of a sideward-shearing 2x2 m steel frame equipped with floaters enabling the net to glide in close contact with the ice-underside and away from the ships wake. The frame was equipped with two parallel nets: a shrimp net covering 1.54 m and a zooplankton net covering 0.42 m of the opening. A bio-environmental sensor array was mounted in the SUIT frame, consisting of an Acoustic Doppler Current Profiler (ADCP), a CTD probe, two spectral radiometers, and a video camera (Fig.3). Water inflow (calculated at 3 locations within the SUIT), temperature, pressure, pitch, role and heading were measured by the ADCP. Conductivity, salinity, chl *a* concentrations, distance to ice bottom and additional temperature and pressure data were measured using a CTD that incorporates a fluorometer (chl *a*) and an altimeter. Sea ice draft was calculated from the pressure (depth) and altimeter data (Fig.3b). Draft was then converted into ice thickness by using ice density data determined from nearby ice station ice core samples. Under-ice light transmission was measured using two Ramses spectral radiometers (Fig.3a) with a spectral range of 350-920 nm. One Ramses had a 7° field-of-view, used to determine optical properties of sea ice (radiance). The other Ramses had a cosine receptor (integrating all energy from above), used to determine the overall energy budget (irradiance). Coincident incoming solar radiation was acquired from a ship mounted Ramses sensor (cosine receptor). Ramses data are shown in Fig.6. Video footage was acquired by a camera mounted on the lower edge of the mouth pointing upward at a 45° angle. Under-ice snapshots are shown in Fig.4.

Preliminary Results:

- All sensor data are representative and accurate upon preliminary analysis.
- Interesting fresh water features (pockets) appear near ridges (Fig.5 red arrows; could be sheltered from currents).
- Anomalous data are easily detected within profile (e.g. ice/slush covering altimeter/RAMSES Fig.6 red box).
- Sea ice thickness data agree well with EM-31 surveys (Fig. 7)
- RAMSES light transmission data appear within the range of expected values but require further spectral quality inspection.

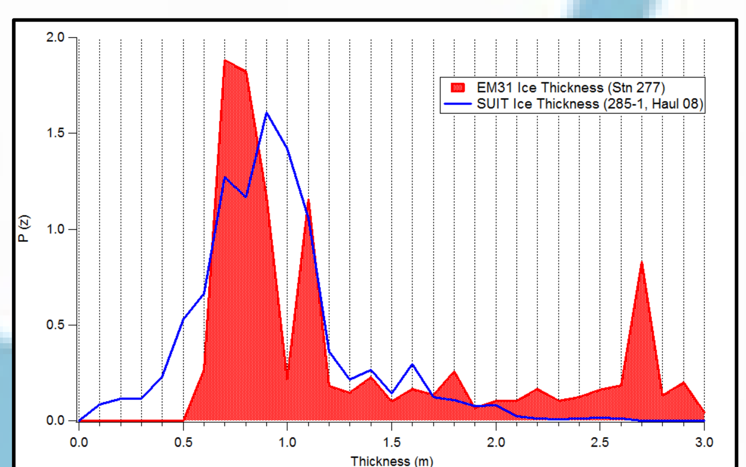


Figure 7: Sea ice thickness distributions comparing SUIT haul 285 and an EM-31 survey of a nearby ice station.

Conclusions:

- These findings demonstrate that the SUIT sensor array data can be used to representatively characterize biophysical properties of sea ice habitats in order to relate them with under-ice communities.
- Spectral information may also be used to characterize the sea ice algal communities based on spectral absorption features (e.g. ref. 8).

References:

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