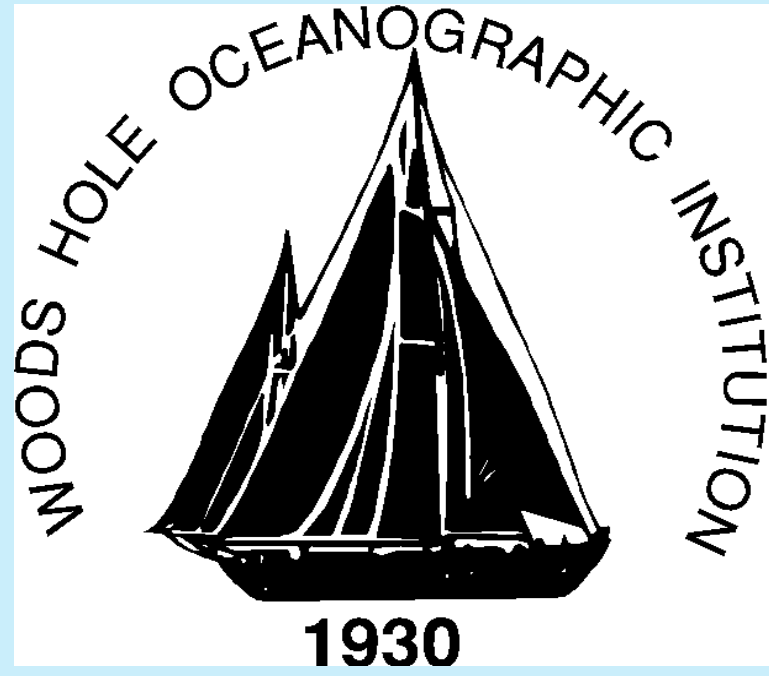




Toward An Interferometer for Absolute Salinity

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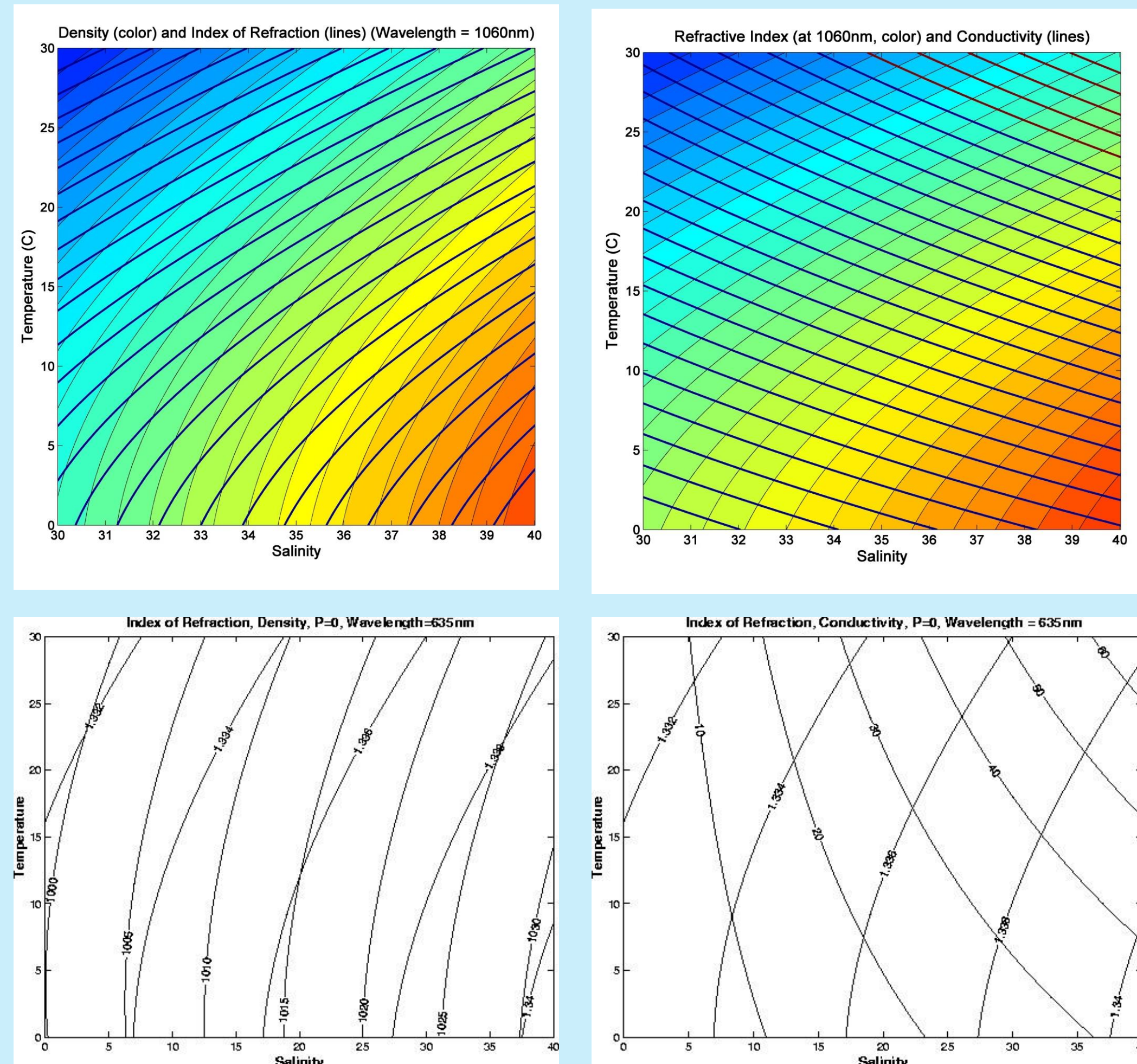


There is a recognition of the need to measure “Absolute Salinity” instead of the conductivity based “Practical Salinity”.

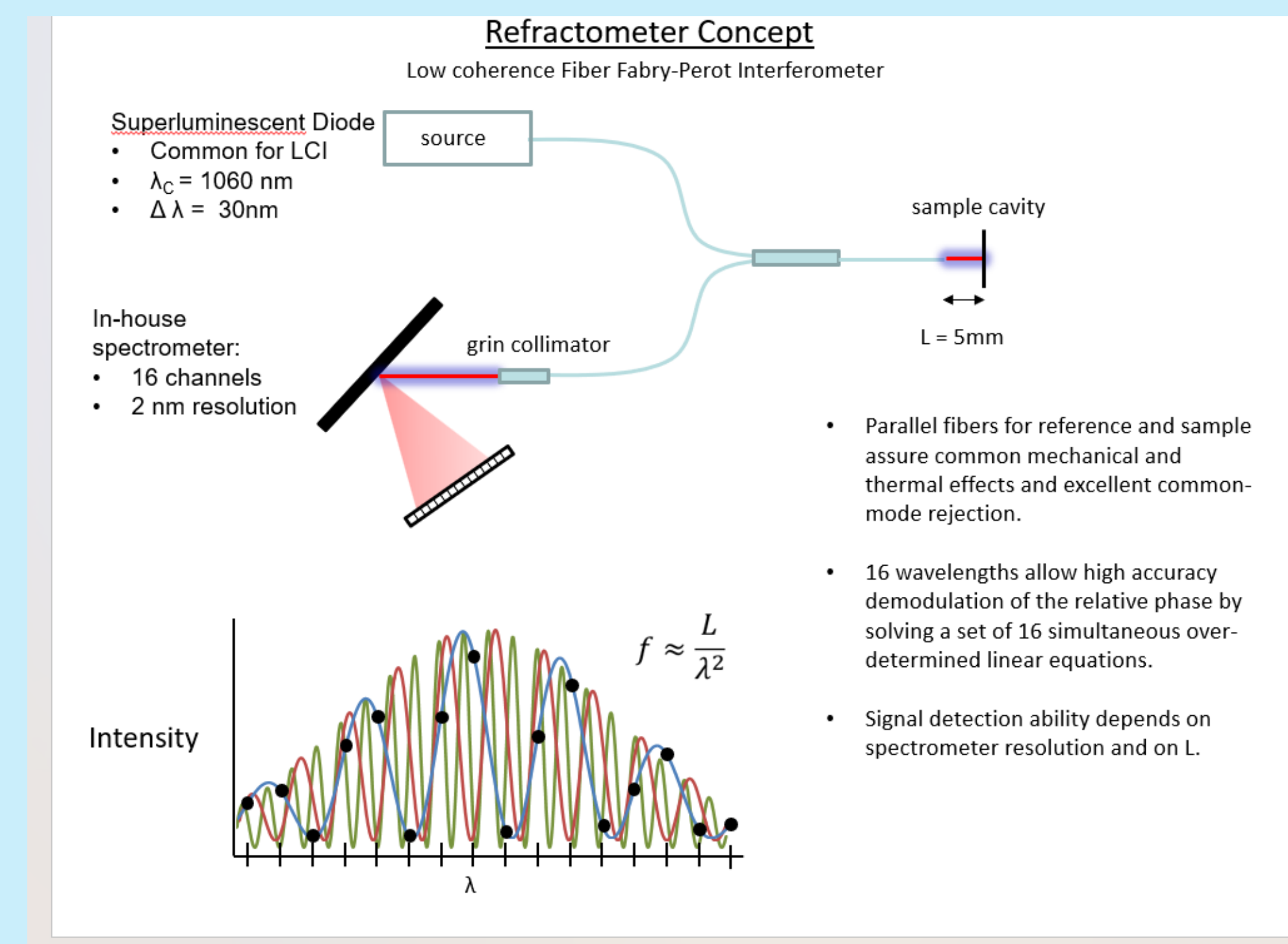
Refractive Index corresponds more closely to density, so is superior for Absolute Salinity, which differs from Practical Salinity because of variations in Silica and CO₂ which are non-ionic but do affect density. While measuring T and C to one part in 30,000 is sufficient, Index must be measured to better than 1 part per million!

Oceanic variation in Index is small, so very high resolution is required.

Abbe Refractometers have boundary layer/thermal mass problems, thus the interferometric approach used here.



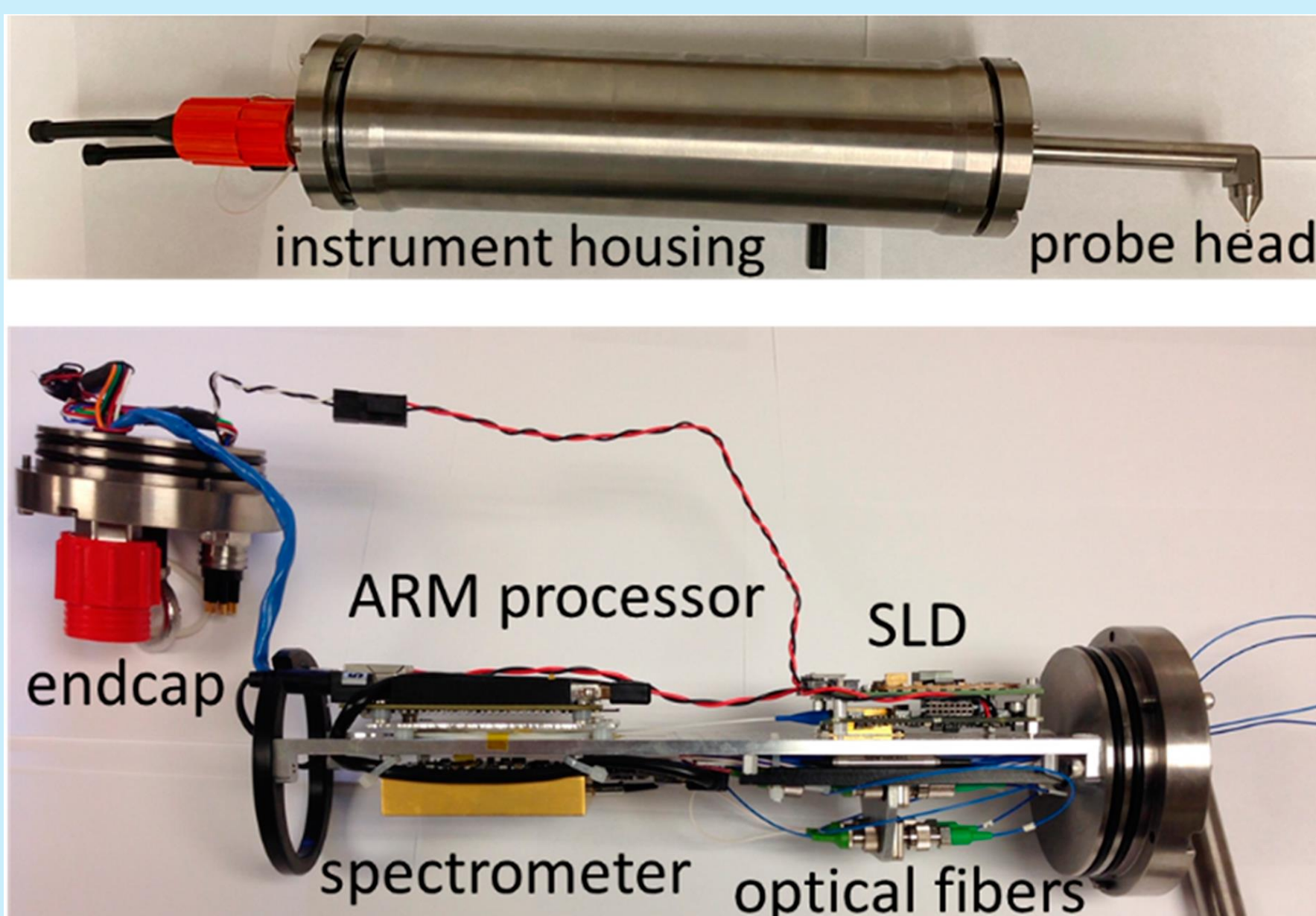
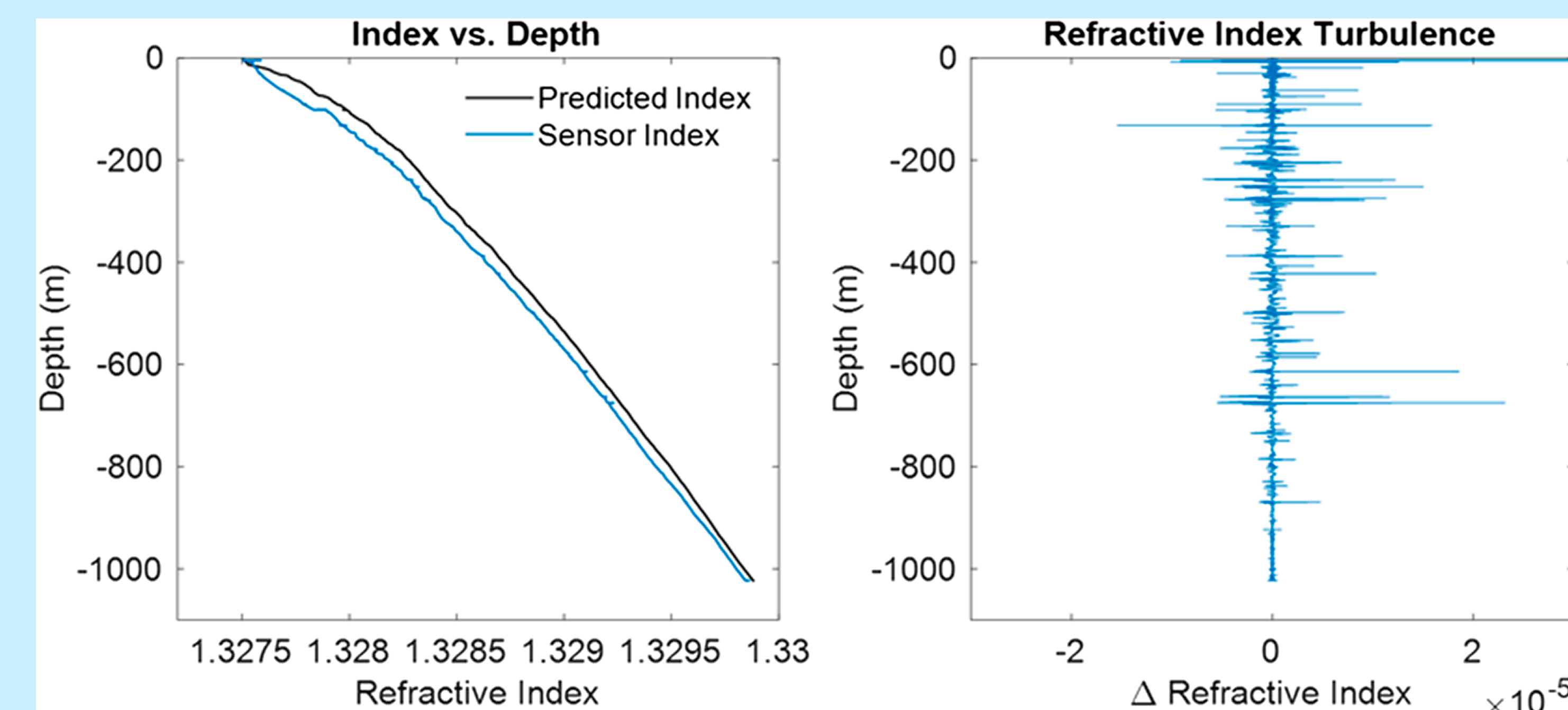
Abstract: We have developed an optical sensor for measuring millimeter-scale thermohaline density variations in the ocean. The instrument is based on a fiber Fabry-Perot "white light" interferometer which can resolve the refractive index of water to better than 2×10^{-8} within a sample volume smaller than 1 mm^3 at a sample rate of 500 Hz. This equates to detectable absolute salinity variations of 0.0001 g/kg , temperature variations smaller than 0.0007°C , and density variations of 0.00007 kg/m^3 . Data collected from laboratory characterization and a field deployment suggest the sensor could be useful as a gradiometer for measuring density and salinity microstructure down to sub-millimeter scales (Kapit, Farr, and Schmitt, 2025). While obtaining high absolute accuracy in refractive index and density was not a primary consideration for this microstructure instrument, we are in the process of evaluating a new design with longer path length. Since refractive index corresponds closely with density it represents an attractive alternative to conductivity-based salinity estimates (which correspond more closely with "Spice") for determining Absolute Salinity, which differs from Practical Salinity due to the non-ionic silicate and carbonate constituents of seawater. Kapit, J.A., Farr, N.E. and Schmitt, R.W., 2025. A Refractometer for Measuring Thermohaline Density Microstructure in the Ocean. Journal of Atmospheric and Oceanic Technology, 42(11), pp.1369-1379. <https://doi.org/10.1175/JTECH-D-24-0072.1>



Needs for further development.

1. The first is for the oceanographic community to agree upon a standard wavelength at which Absolute Salinity is measured. This would significantly reduce uncertainties by eliminating wavelength dependence. Thus far, in situ instruments have been created with wavelength operation between 635 and 1300 nm. Selecting a wavelength in the near-infrared, perhaps close to 850 nm, would likely yield several benefits. This wavelength region has reasonably good transmission through water, making it adaptable to most previous sensor architectures. The near-infrared also contains a wide variety of light sources including lasers, light-emitting diodes (LEDs), and super-luminescent diodes. Furthermore, optical components including detectors, lenses, filters, and fiber optics are common due to the development of near-infrared technology from the telecom and optical sensing industries. Thus, components are generally commercially available and relatively inexpensive.
2. The second need is for a characterization of water's refractive index, at the chosen wavelength, which is suitable for all oceanographic needs. This need has been highlighted previously and would ideally include designing and using a test chamber to measure the refractive index of standard seawater with an accuracy of 2.3×10^{-7} for a full matrix of salinity (0–40 g kg⁻¹), temperature (0–30°C), and pressure (0–10 000 dbar). Variations in composition should also be studied such as the effect of silica, salt ratios, and dissolved gases. Such an effort would be a significant undertaking but could provide the requisite information necessary for utilizing refractive index more broadly in oceanography.
3. Cost of Spectrometers has been rising, not falling!
4. Bubbles can be a problem for the microstructure sensor.
5. Opportunities for deployment of the Index Microstructure Sensor with other microstructure instruments are being sought.

Field Data



Photograph of the probe tip containing the sample and reference interferometers. The tip is fabricated from a 1.8-mm-diameter glass fiber ferrule with two bores. A 1-mm-wide notch is machined to allow access to the sample water. Both interferometers are created by placing the light delivery fibers opposite mirror-coated optical fiber tips. The gaps for the sample and reference interferometers are approximately 1 and 2 mm, respectively. The ferrule and fibers are fixed in place using fiber optic epoxy.

Refractive Index Microstructure Probe

