

RBR

Precision Instruments

for over 30 years

**A look into the future of
direct comparison
ambient temperature
salinometry**

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Salinometer FAQ

With my AutoSal™, can I:

- | | |
|---|----|
| 1. Use it on a small boat? | NO |
| 2. Transport it in my suitcase? | NO |
| 3. Characterize different seawaters over temperature? | NO |
| 4. Test the salinity of Guacamole? | NO |
| 5. Run it off of a car battery? | NO |
| 6. Set it up and use within 1 hour? | NO |

Outline

- Why Salinometry?
- Standard Methods of Salinometry
- Basic limitations
- The future of Salinometry
- Conclusion/Discussion

Why Salinometry?

Salinity is a key property of seawater from which density and sound speed may be derived; these are fundamental to ocean science and climatology.

Salinometers provide a reference to the widely accepted Practical Salinity Scale.

Standard Method

CTD & Water Samples → AutoSAL

Practical Salinity Scale (1978)

$$R = C(S, t, p) / C(35, 15, 0) = C(S, t, p) / 42.914$$

$$R_t = R / r_t R_p$$

$$R_p = C(S, t, p) / C(S, t, 0) = 1 + \frac{p(e_1 + e_2 p + e_3 p^2)}{1 + d_1 t + d_2 t^2 + (d_3 + d_4 t) R}$$

$$S = \sum_{i=0}^5 a_i R_t^{i/2} + \frac{t-15}{1+k(t-15)} \sum_{i=0}^5 b_i R_t^{i/2}$$

$$r_t = C(35, t, 0) / C(35, 15, 0) = \sum_{i=0}^4 c_i t^i$$

$$a_0 = 0.0080$$

$$b_0 = 0.0005$$

$$c_0 = 0.6766097$$

$$d_1 = 3.426e-2$$

$$e_1 = 2.070e-5$$

$$a_1 = -0.1692$$

$$b_1 = -0.0056$$

$$c_1 = 2.00564e-2$$

$$d_2 = 4.464e-4$$

$$a_2 = 25.3851$$

$$b_2 = -0.0066$$

$$c_2 = 1.104259e-4$$

$$d_3 = 4.215e-1$$

$$a_3 = 14.0941$$

$$b_3 = -0.0375$$

$$c_3 = -6.9698e-7$$

$$d_4 = -3.107e-3$$

$$a_4 = -7.0261$$

$$b_4 = 0.0636$$

$$c_4 = 1.0031e-9$$

$$a_5 = 2.7081$$

$$b_5 = -0.0144$$

$$k = 0.0162$$



Standard Method - Standardization



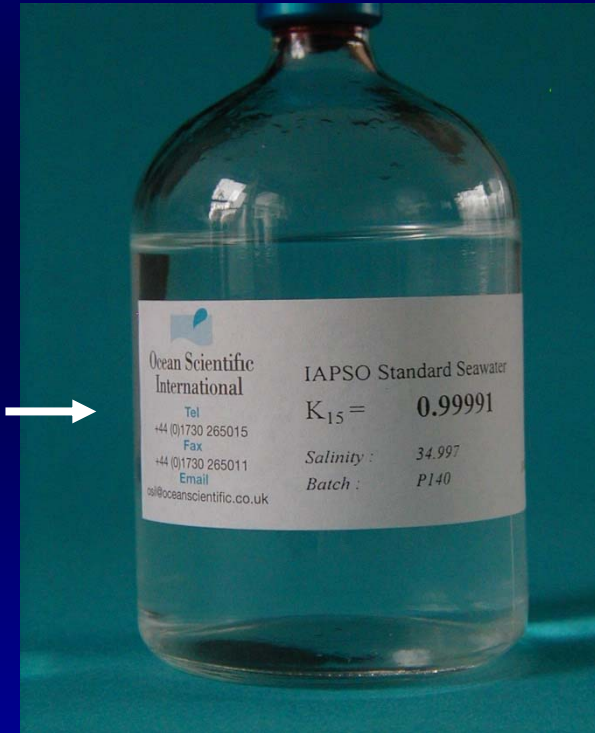
Salinometer

referenced to

Standard Seawater



sequential samples



Limitations

- Temperature stabilized environment
- Sequential standardization
- Skilled staff
- SSW is expensive
- Warming samples may change apparent salinity

The Future...now

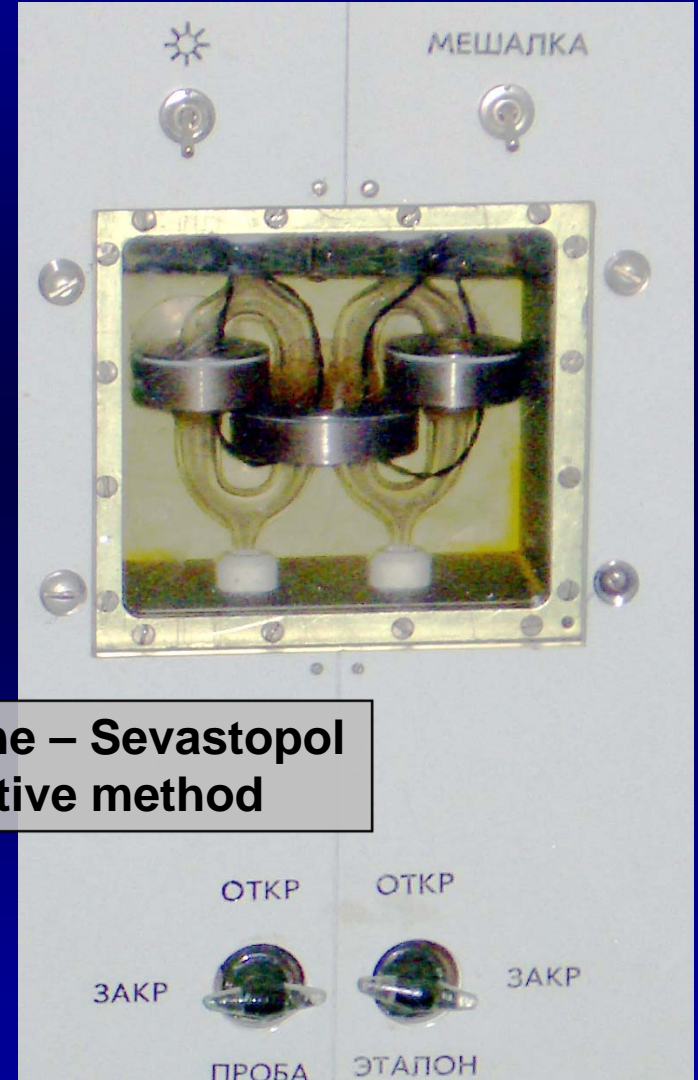
- High Performance
- Easy to Use
- Operates at *in situ* temperatures
- Small size



Concepts of the Small Salinometer:

- 1. Direct comparison of conductivity of sample and standard**
2. Direct reading of R_t over wide temperature range

Previous works



(b) Ukraine – Sevastopol
Inductive method

(a) China – Tienjin. in Collaboration
with Tim Dauphinee, NSERC Canada
Two conductive cells

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Oceanographic

Freshwater

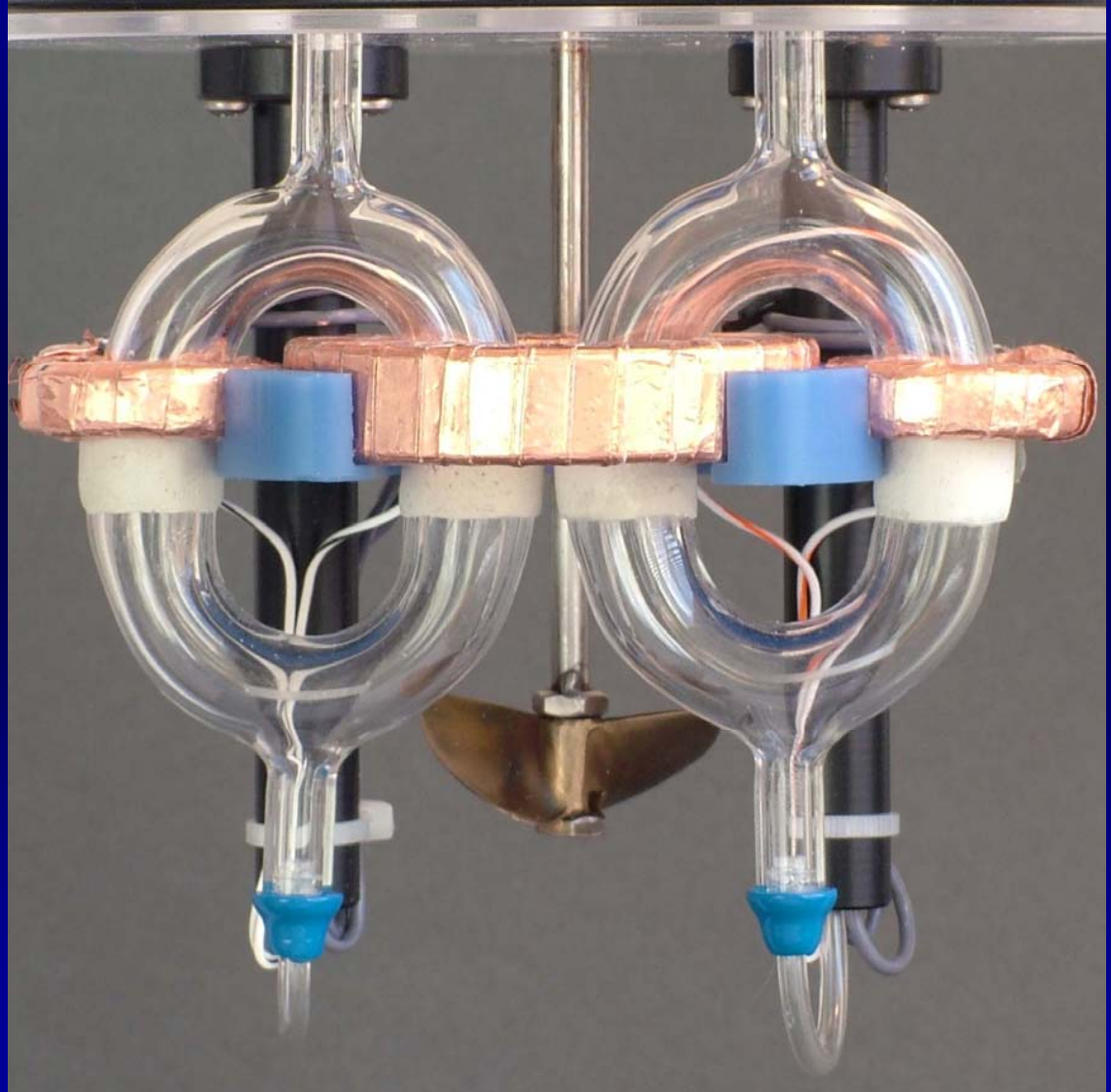
Gryospheric

Precision Instruments

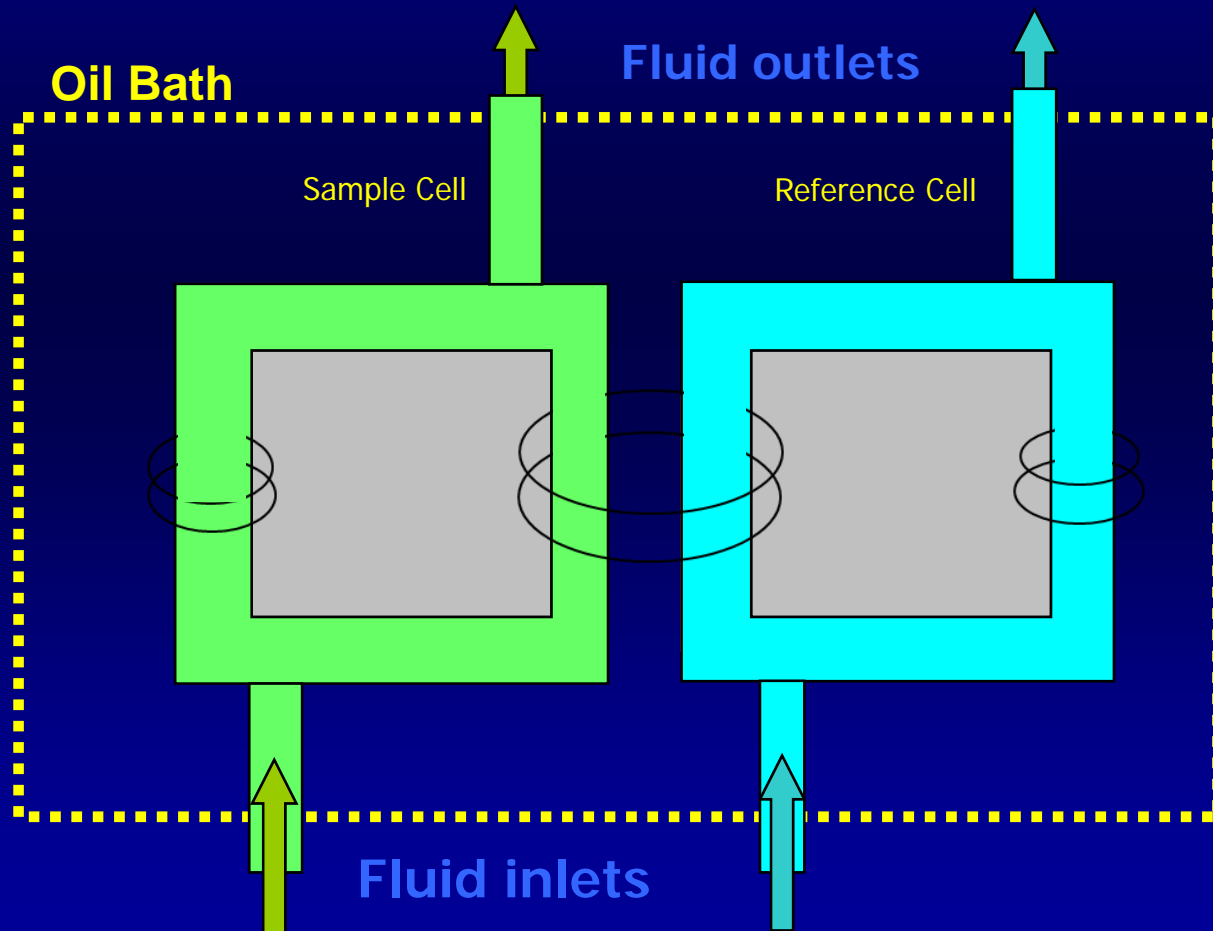
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Dual chamber Inductive system

Based on standard
RBR technology



Dual Chamber principle



Concepts of the Small Salinometer:

1. Direct comparison of conductivity of sample and standard
2. Direct reading of R_t over wide temperature range

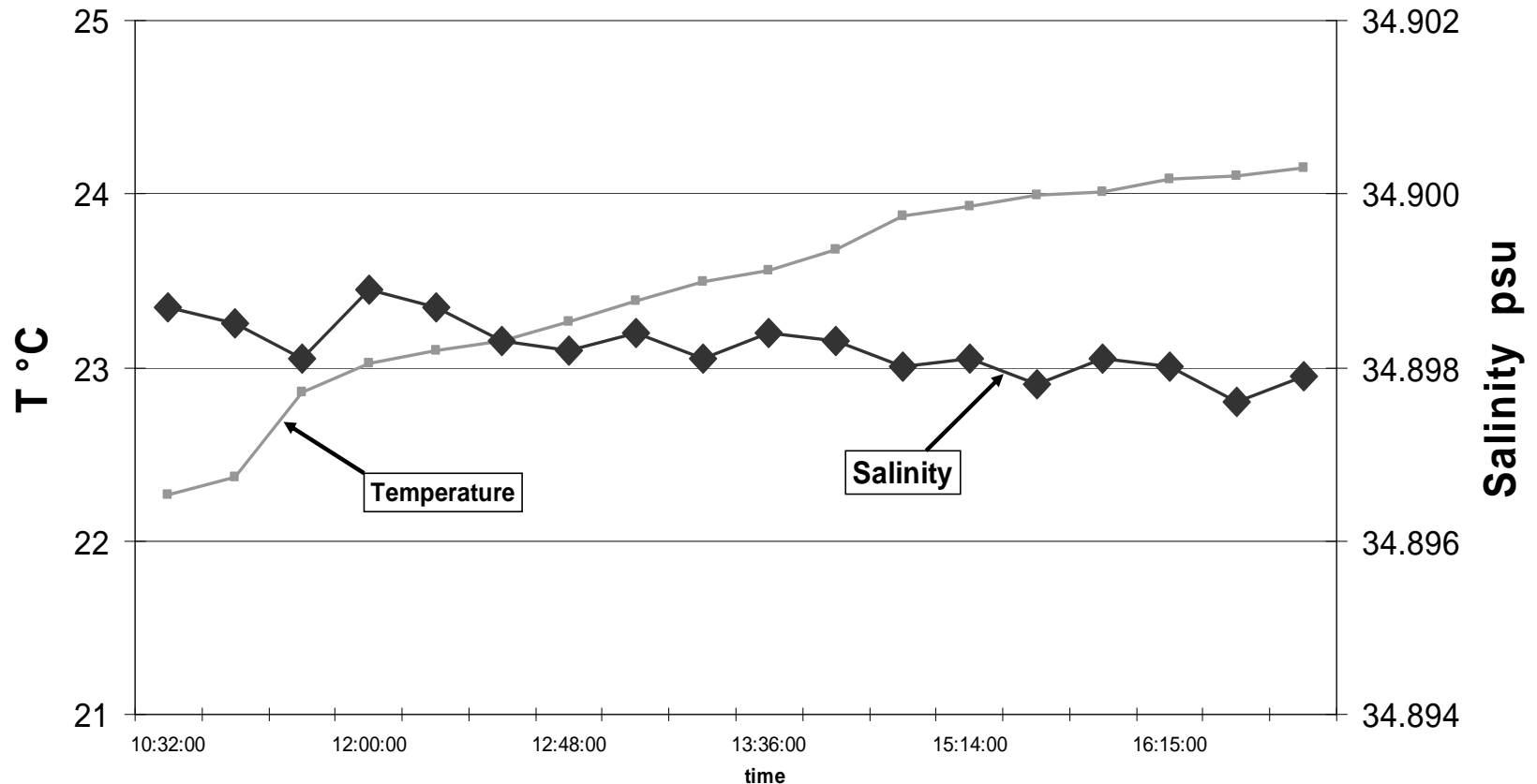
Salinometers measure R_t

$$S = a_0 + a_1 R_t^{\frac{1}{2}} + a_2 R_t + a_3 R_t^{\frac{3}{2}} + a_4 R_t^2 + a_5 R_t^{\frac{5}{2}} +$$
$$+ \frac{T-15}{1+k(T-15)} (b_0 + b_1 R_t^{\frac{1}{2}} + b_2 R_t + b_3 R_t^{\frac{3}{2}} + b_4 R_t^2 + b_5 R_t^{\frac{5}{2}})$$

Practical Salinity Scale - 1978

Test Results

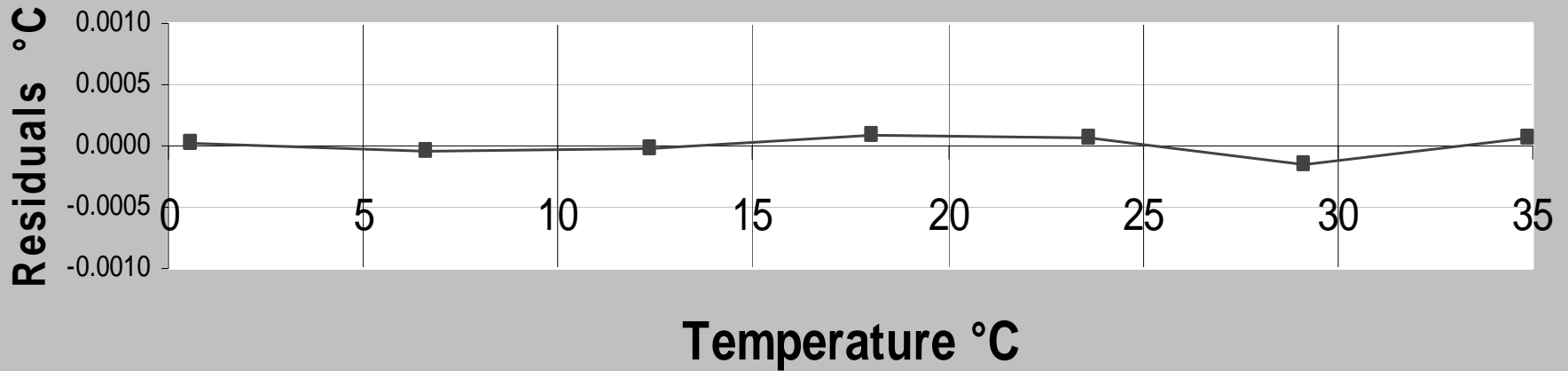
MS-310 Repeatability Using Samples of Constant Salinity



Test Results

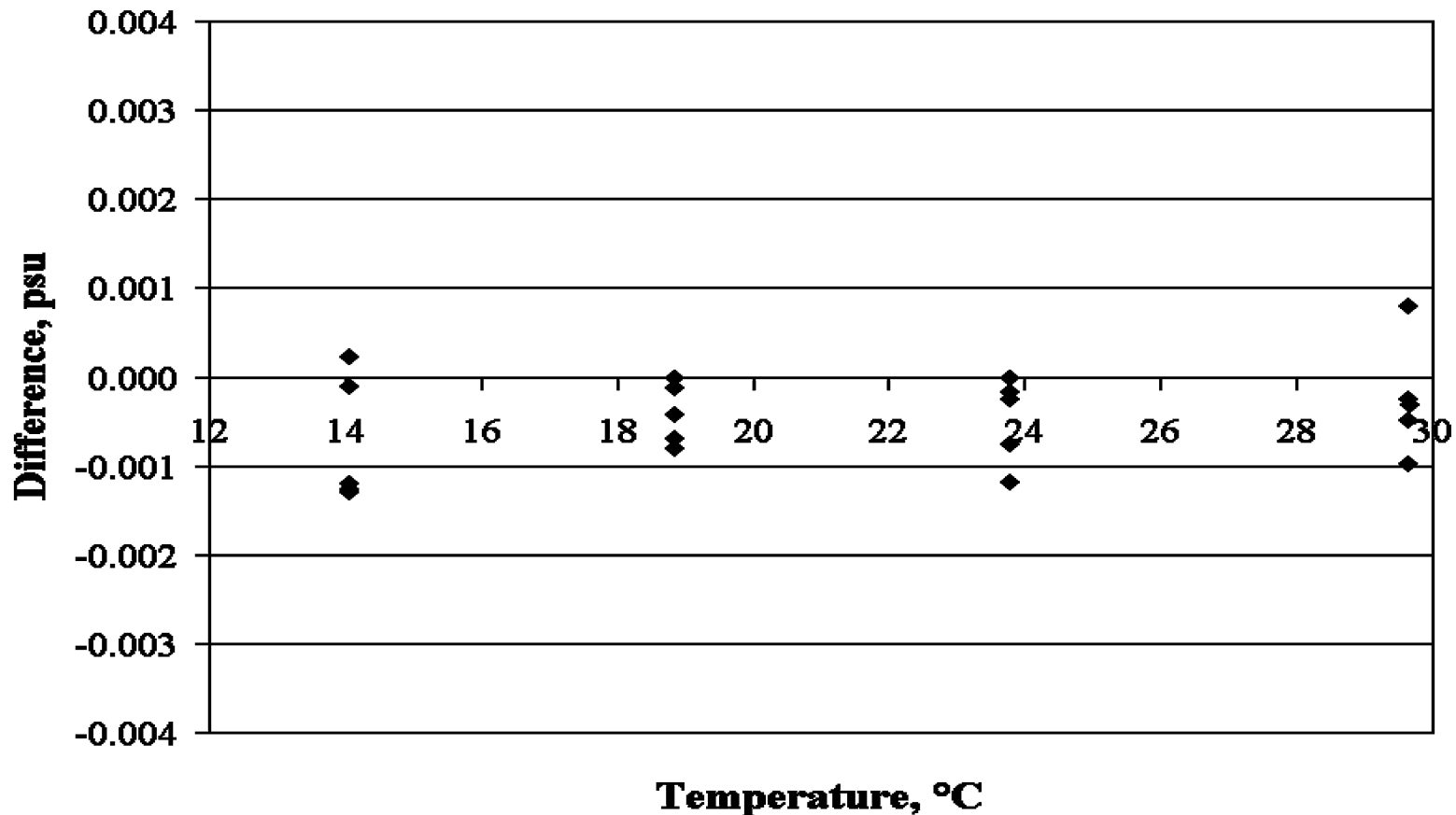
Calibration of Temperature Sensor

Residuals Versus Temperature



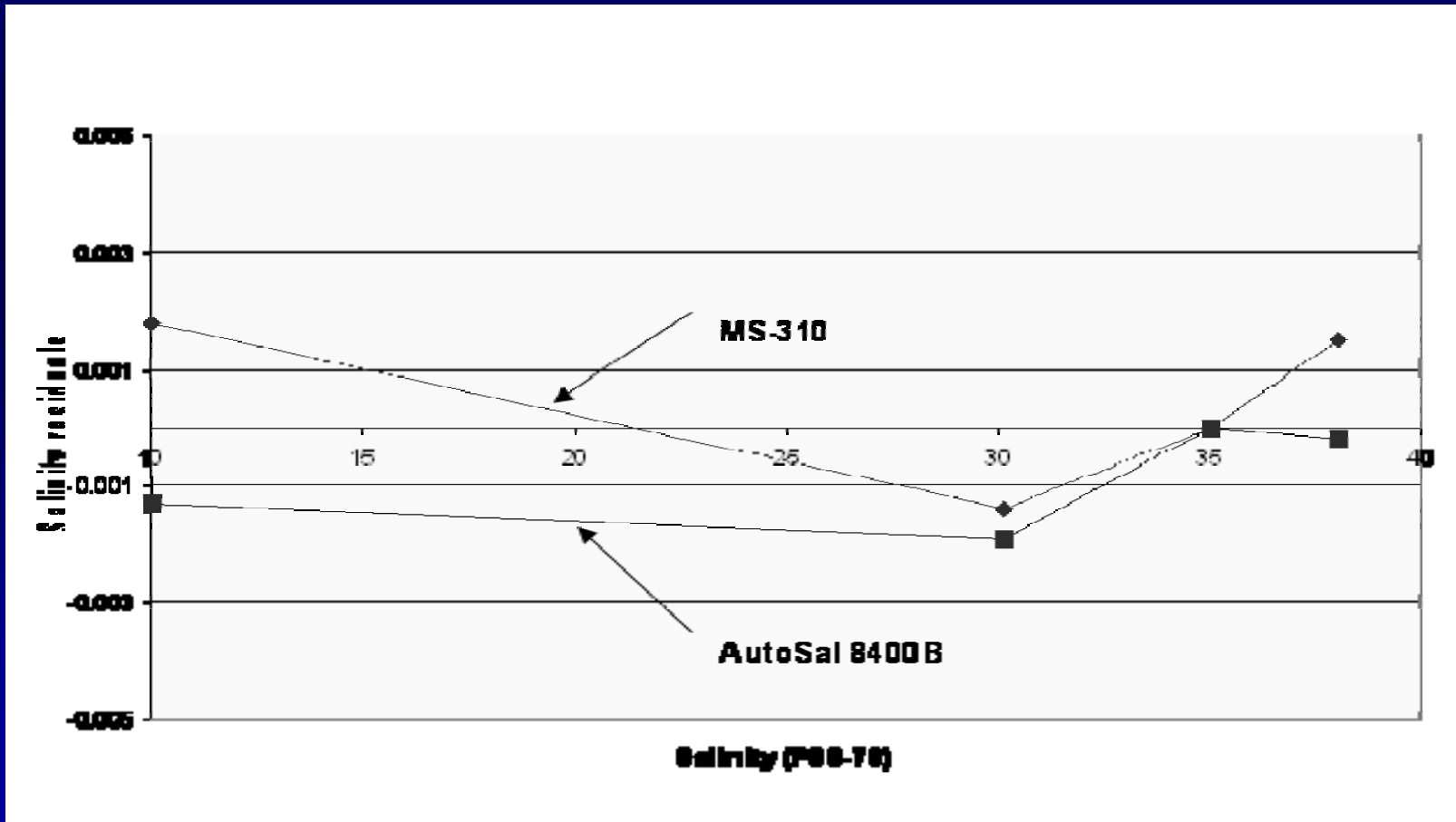
Test Results

R_t variation with temperature for samples of Standard Seawater

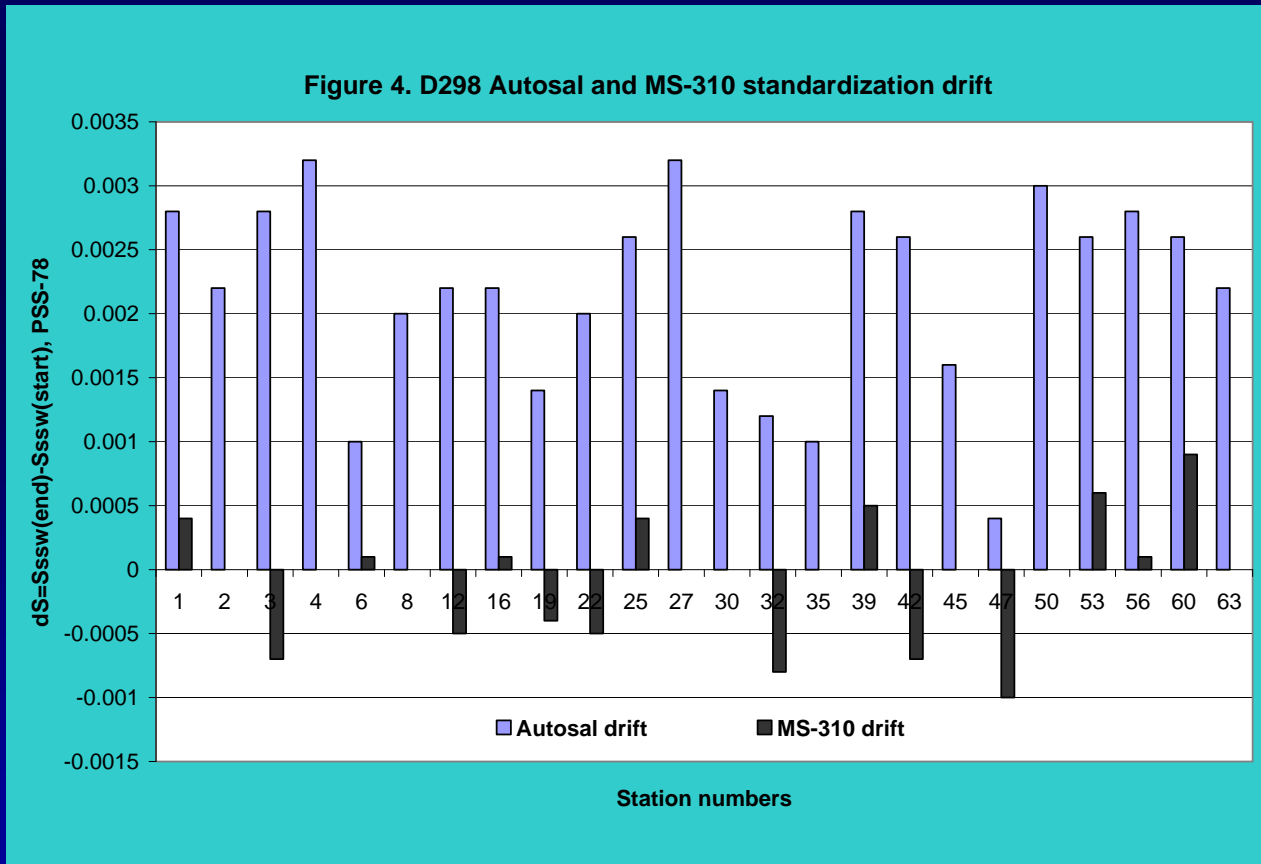


Test Results

MS-310 and AutoSal 8400B against OSIL Linearity pack (1 trial)



Salinometer Drift Comparison



Performance data compared with PortaSal and AutoSal

	AutoSal 8400B	PortaSal 8410A	MicroSal MS-310	
Range	0.0001 to 1.15	0.0001 to 1.15	0.0001 to 2.00	Rt
Accuracy	0.002	0.003	0.002	psu
Resolution	0.0002	0.0003	0.0002	Psu
Room Temp	+0°; -2°	+0°; -2°	15° to 30°	C
Bath	16.8	9	2	Litres
Weight	70	29	5	kg
Power	400	200	10	watts
Supply Voltage	110/220 AC	110/220 AC	12 DC	volts

Easy to use

MS-310 User Interface

Windows[®]-based
control panel streamlines
And simplifies operation

The screenshot shows the 'RBR Micro-Salinometer Control Panel' window. The title bar is blue with the text 'RBR Micro-Salinometer Control Panel'. Below the title bar, the instrument ID 'MS-310 012048' is displayed. The main area is divided into sections. The 'Main' section shows 'Temperature: 22.3814 degrees C' and 'Ratio (Rt): 0.88206'. Below this is 'Sample salinity: 30.4106 (PSS-78)' with '(30 second averages)' underneath. A vertical status indicator on the right shows three circles: the top two are grey and the bottom one is green. A text box below the salinity reads: 'Over the last 60 seconds, the averaged values of salinity had a mean of: 30.4103 and standard error of: 0.0002'. A button labeled '<< Default information' is at the bottom right of this section. Below the main area, there is a field for 'Readings to be averaged over: 30 seconds (max 30)'. A checked checkbox 'Output to file:' is followed by the file path 'C:\rbr\sal\012048temp.sal'. A 'Browse..' button is to the right. At the bottom, there are 'Close' and 'Calibrate>>' buttons.

RBR Micro-Salinometer Control Panel

MS-310 012048

Main

Temperature: 22.3814 degrees C
Ratio (Rt): 0.88206

Sample salinity: 30.4106 (PSS-78)
(30 second averages)

Over the last 60 seconds, the averaged values of salinity had a mean of: 30.4103
and standard error of: 0.0002

<< Default information

Readings to be averaged over: 30 seconds (max 30)

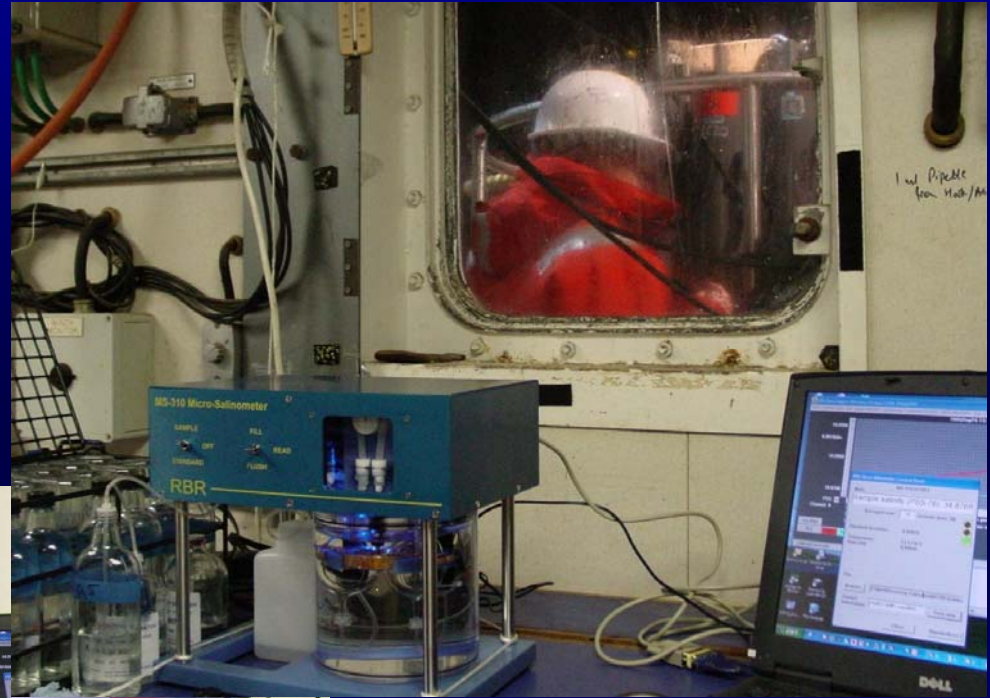
Output to file: C:\rbr\sal\012048temp.sal

Data are being saved in the file. Browse..

Close Calibrate>>

Small Size

- 280mm x 280mm x 180mm
- 5kg
- 12VDC

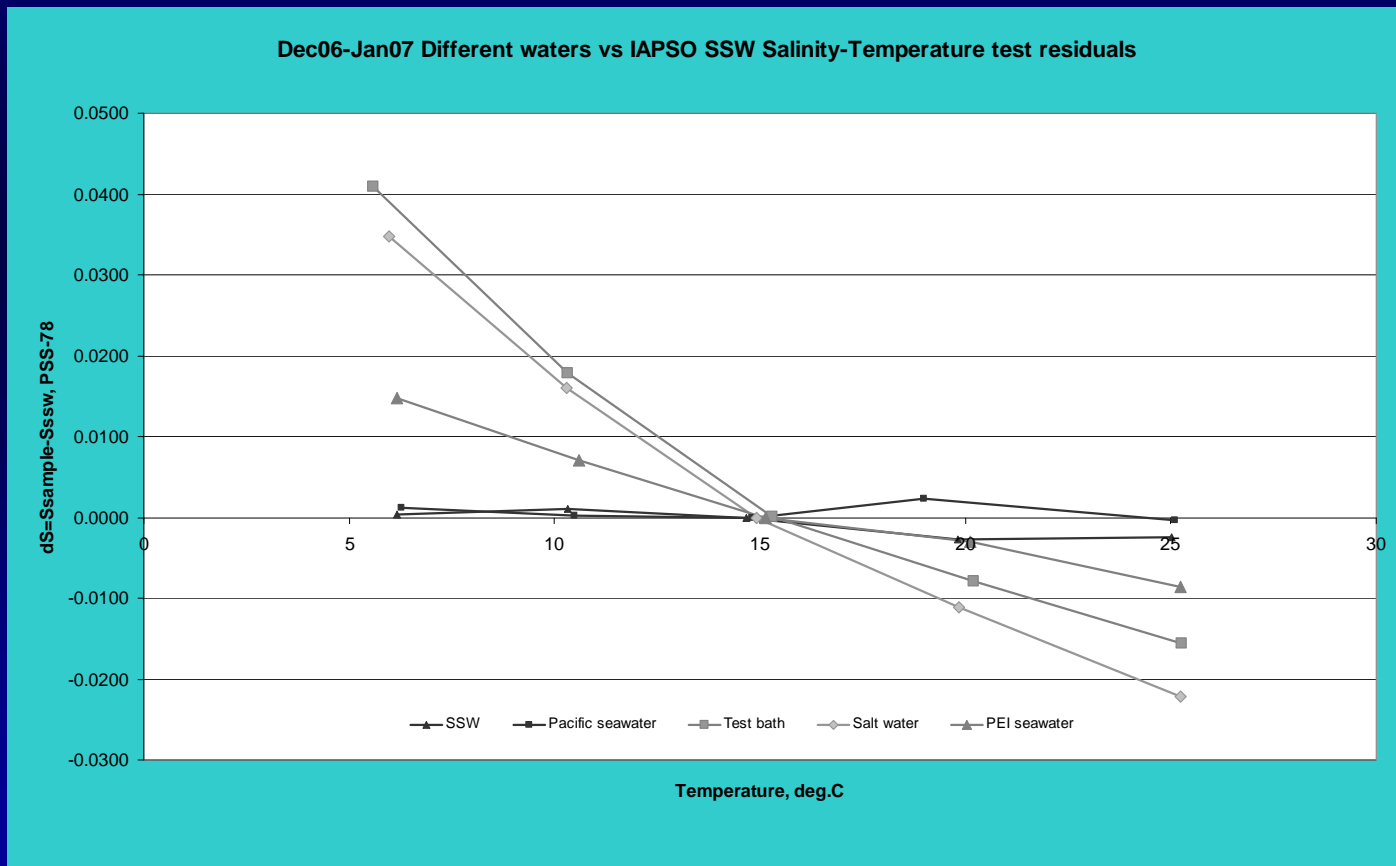


What else can I do with the MS-310?

- Thermosalinograph
- Measure other fluids (guacamole?)
- Immerse in bath for direct calibration of CTDs
- Autosamplers
- Submersible ocean salinometer (ZEFICC)
- Investigate behaviour of seawater types



Characterization of various seawater types over temperature range



Conclusions

The MS-310 represents the future of scientific salinity measurement, allowing measurement of salinity samples directly after CTD retrieval, outside the lab; the nearest thing to *in situ* salinometry.

This offers a new perspective for understanding the nature of the conductivity measurements of seawater and opens doors beyond the PSS-78.

*Water samples should not have to be adjusted to a salinometer's comfort conditions, rather the salinometer should adjust to the CTD measurement conditions – **this is the future of salinity technology***