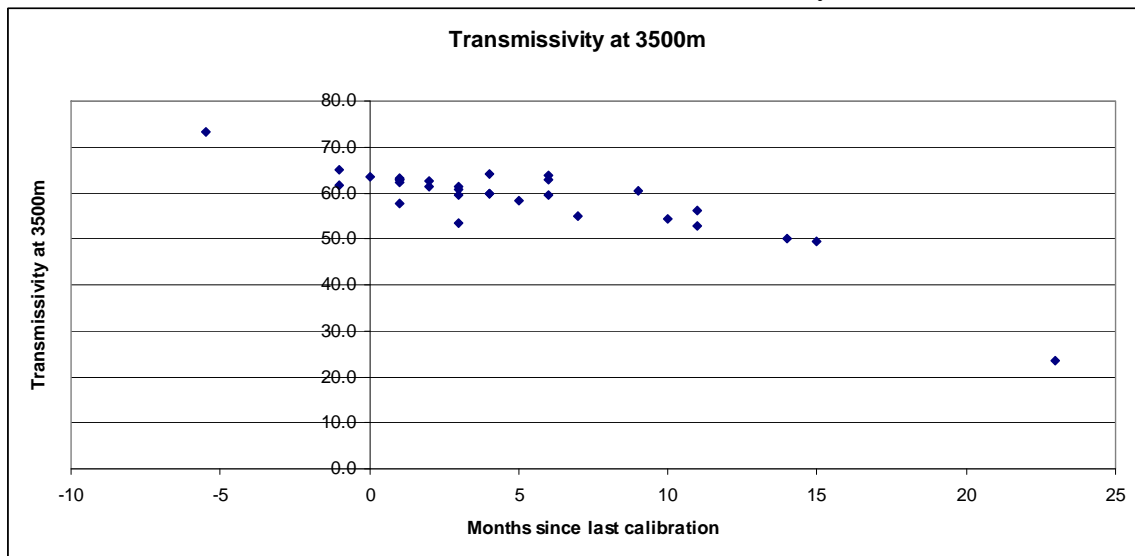


Transmissometer 1005DR Corrections

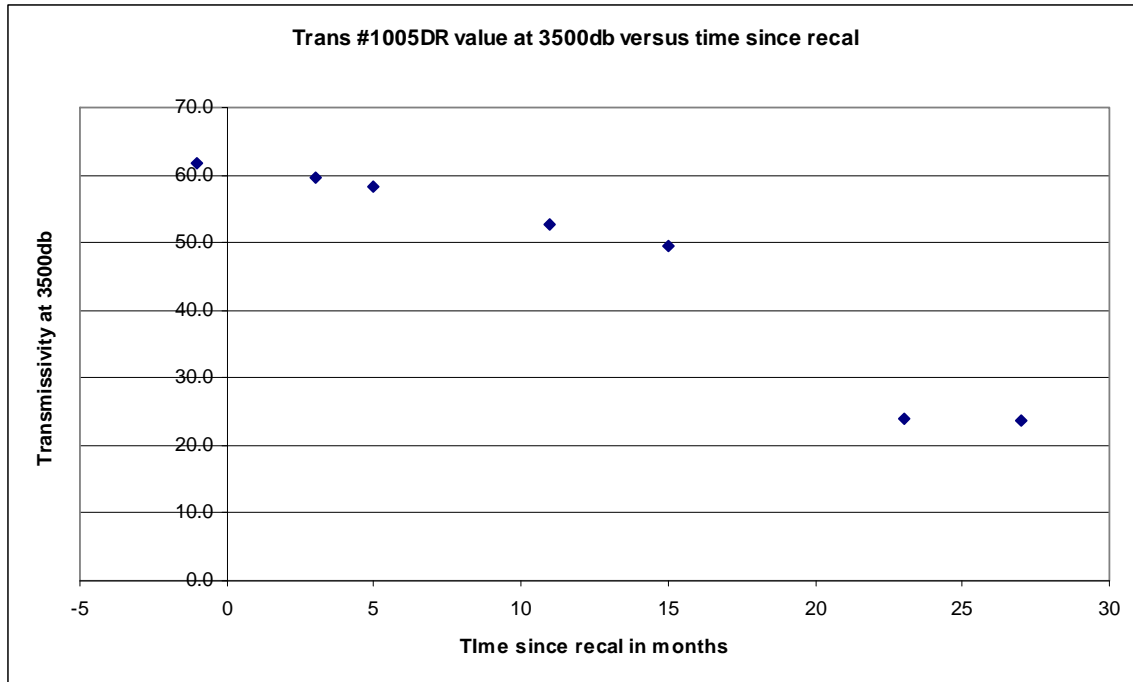
In July 2010 it was noticed that transmissometer 1005DR was producing values that were much too low when calibration parameters from March 2008 were used to convert the data. A calibration performed on July 20, 2010 produced good results when applied to a cast from a cruise that started on the same day. However, it produced values that were too high when applied to data from May 2010 and earlier. This shows that the calibration was drifting significantly.

Transmissivity values from 3500m were plotted against time in months between the cruise start and the calibration date; all sensors are included. A negative value indicates that a post-cruise calibration was applied. Based on the graph below a recommendation was made that transmissometers be recalibrated at least twice a year in future.



We do not generally recalibrate transmissivity and in the headers of the archived files it is stated that the values are nominal. However, since values were as low as 24% per m (Feb. 2010) in deep offshore waters where we expect ~65% per m, a study was made to produce a reasonable scheme to correct the data.

Transmissivity data at levels 50, 100, 250, 500, 1000, 2000 and 3500m were recorded for station P26 since 2000; this included data from 7 different transmissometers. No seasonal trend was noted in transmissivity below 500m. (A quick check also showed that upcast data were just slightly lower, by ~1% per m.) The data confirmed that transmissometer #1005DR was drifting significantly and values since February 2009 were low enough to warrant correction. No seasonal trend was found. While the calibration drift was seen to be accelerating towards the end of the period studied, there was insufficient data to resolve that. (The data used can be found at the end of this document.)



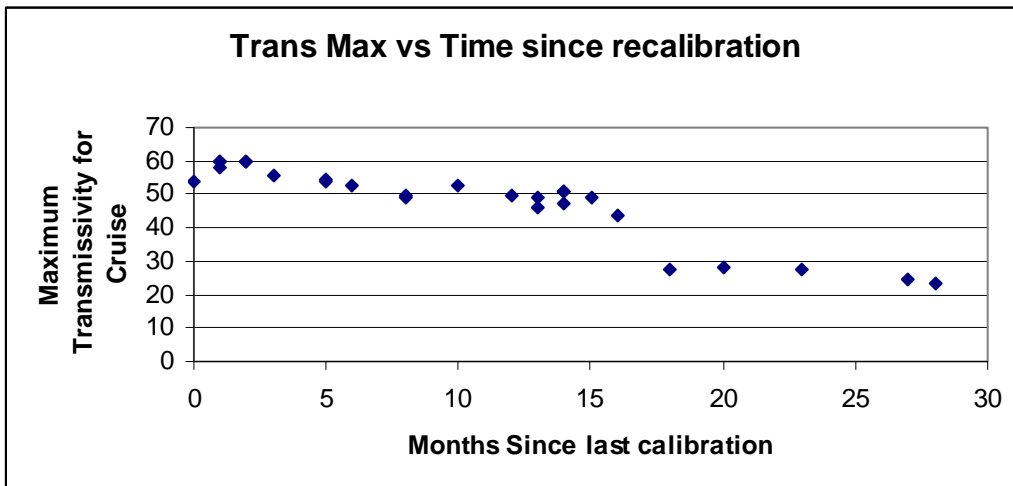
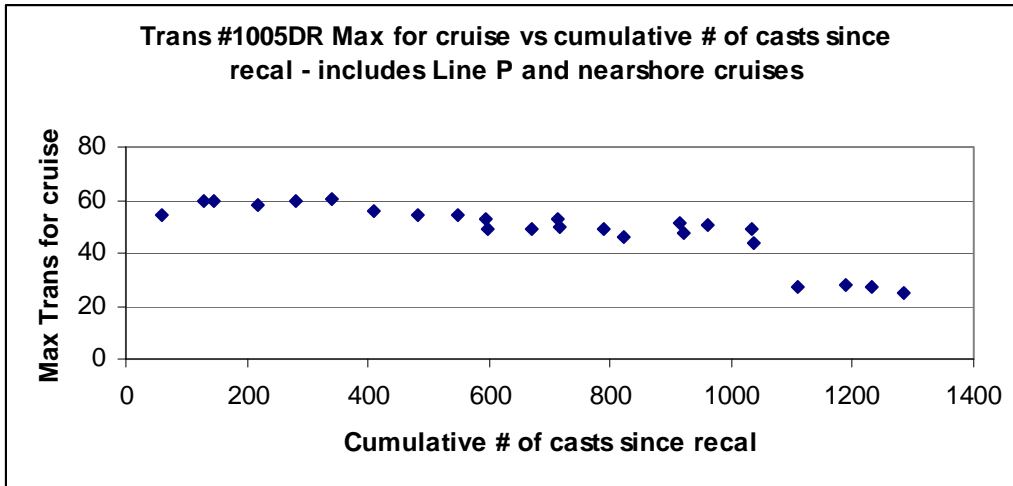
One other odd feature noted is the decrease in transmissivity with increasing pressure (below 500m) for sensor 1005DR in 2010. This was not seen for any of the other sensors, nor was it seen for Line P in 2009 for 1005DR. Upcast data show the same pattern. Using the July 2010 calibration still produces a decrease with pressure. This may be an indication of a pressure-related problem with this sensor. For the Sept. 2009 and Nov 2009 cruises there are decreases with pressure; while near-bottom transmissivity can be lower in Juan de Fuca Strait and the Strait of Georgia, the consistency is suggestive that there has been a change in the sensor response.

Tests were run on a scheme to apply a linear correction based on time since the previous recalibration, but this produced values that were too high for many cruises, confirming that the non-linearity is real and a problem.

A quick examination of data from other cruises than Line P data indicates that many will be useful in tracking the calibration drift. So a second set of data were collected with all cruises that used sensor 1005DR since March 2008. Included were the number of casts on which it was used so that we can check to see if usage is more significant than date, and the area sampled so we have a rough idea what variability is likely at depth. The data are at the end of the report. The WCVI cruises usually have some deep sampling, so those data are particularly valuable. There was one Laurier cruise from the north Pacific that should show high transmissivity and it does.

A plot of maximum transmissivity versus the cumulative # of casts since the transmissometer had been recalibrated suggests a fairly steady reduction with use to July 2009, and then a sudden drop-off in September 2009. All casts within each of the July and September 2009 cruises had similar transmissivity maxima, so it does not appear that

the problem arose during a cruise. Sometime between July 24 and Sept. 14, 2009 there was a non-linear shift, and the fact that the values appear to be decreasing at depth from that point onwards suggests that the sensor may have been damaged. Neither of the cruises before and after the shift involved deep deployment, so pressure would not seem to be an issue. (It is possible the sensor was used on a cruise that has not been archived.) There are few data after the shift, so 1 cast from 2010-36 in July was converted using the March 2008 calibration to see if there really was further drift happening and the maximum value was ~23%/m so it does appear to be going down.



Recalibration appears warranted from February 2009 onwards, but the data must be split into groups and separate consideration is needed for data that have not yet been processed.

- For data from March 2008 to July 2009, a linear fit looks reasonable. For March 2008 we will assume that the correction factor is 1. We will assume that the maximum for June 2009 Line P cruise should be 62% whereas it is actually 49%, so the correction factor is 1.265 after 15 months. From that the corrected transmissivity is determined to be:

$TR(\text{corrected}) = (1 + 0.265 * (\# \text{ of months since cal}) / 15 \text{ months}) * TR(\text{March 2008 cal})$

To test that this is a reasonable estimate, the results were applied to other casts during that period, with particular attention to those that sampled deep waters. All values were between 54%/m and 64%/m and those that sampled deep waters (WCVI and Line P) ranged from 58.9%/m and 61.3%/m. Thus the fit looks useful and applying to the July 2009 cruise produces good results, but extrapolating beyond that produces very poor results, as expected.

One last question is how far back to go in recalibrating. The differences are slight compared to the uncertainties with differences $< \text{ or } = 5\%/m$. From September 2008 onwards corrections are $>5\%/m$ and rising fairly rapidly. This also fits the results of another study that included several transmissometers and found that calibration drift became obvious at about the 6-month mark. .

- Next, we consider data that have been processed from September 2009 to June 2010. The deep offshore values are very low and drifting lower, though no faster than before the shift. A linear fit looks reasonable, though there is not a lot of data to test this. If we again presume 62% as the maximum expected value for the 2 Line P cruises (February and June 2010 – 23 and 27 months after calibration) we find that:

$TR(\text{corrected}) = (2.5 + 0.236 * (\# \text{ of months since cal} - 23 \text{ months}) / 4 \text{ months}) * TR(\text{using March 2008 cal})$

For the 3 casts from September 2009 and November 2009 this produces maxima of 54%/m, 58%/m and 59%/m, which are reasonable for Strait of Georgia cruises. This is a very rough estimate based on only a few cruises, but applying the correction to one cast from cruise 2010-38 in July gives a maximum of $>59\%$ for WCVI. The method will not have to be extrapolated any further since we have a July 2010 calibration. The slopes of the drifts before and after the shift are of a similar size.

- For the conversion of cruises from 2010 that have not yet been processed, we can either derive slopes and offsets that lead to the corrected values, or use the March 2008 values and apply a correction. The latter is probably a better idea, since the results from those cruises might lead to refinement in the approach, so a decision on recalibration made late in processing might be best. Also, doing the correction this way will make the steps clear for users.

Summary of Station P26 data from 2000-2009 plus one cast from P20 when P26 was not available and one from 1996. A few casts from 2010 cruises are included to compare different March 08 and July 10 calibrations. 2010-36-0013 is the only cast that is not from Line P.

These are values as of July 2010 before any corrections were applied.

cast #	m o n t h	Tran s/n	date	cal date	mont hs since cal	Pressure						
						50.0	100.0	250.0	500.0	1000.0	2000.0	3500.0
2000-10-0053	6	333	Jun-00	Mar-00	3	56.2	59.8	60.0	60.5	60.5	60.6	60.7
2000-25-0057	8	333	Aug-00	Jul-00	1	54.6	56.8	56.8	57.4	57.5	57.6	57.6
2001-06-0034	2	333	Feb-01	Jul-00	7	51.4	53.5	54.4	54.9	54.9	55.0	54.9
2001-08-0186	6	333	Jun-01	May-01	1	58.5	62.3	62.6	63.0	63.0	63.1	63.1
2003-11-0047	6	333	Jun-03	Oct-02	4	51.3	58.6	59.2	59.7	59.8	60.0	60.0
2004-05-0047	2	333	Feb-04	Jan-04	1	56.1	58.6	61.8	62.2	62.2	62.3	62.3
2005-01-0057	2	333	Feb-05	Nov-04	3	49.9	50.6	53.0	53.4	53.4	53.4	53.4
2002-01-0033	2	498	Feb-02	Aug-01	6	55.9	56.0	59.0	59.5	59.3	59.5	59.6
2002-16-0034	7	498	Jul-02	Apr-02	3	55.5	59.8	60.6	60.9	61.1	61.2	61.3
2002-30-0057	8	498	Aug-02	Aug-02	0	57.9	62.2	62.6	62.8	63.0	63.3	63.4
2003-01-0016	2	498	Feb-03	Aug-02	6	58.3	61.7	62.0	62.6	62.7	62.8	63.0
2003-27-0059	9	498	Sep-03	Aug-03	1	54.8	60.5	61.4	62.1	62.5	62.7	62.8
2004-10-0042	6	498	Jun-04	Apr-04	2	56.2	60.6	60.9	62.3	62.4	62.7	62.7
2006-08-0056	2	498	Feb-06	May-05	9	55.1	55.1	59.9	60.1	60.2	60.4	60.5
2006-15-0067	9	723	Sep-06	Mar-06	6	59.0	61.9	62.5	63.0	63.4	63.6	63.8
2004-20-0036	8	732	Aug-04	Oct-03	10	48.6	52.7	52.9	53.1	53.5	53.9	54.3
2005-12-0052	6	732	Jun-05	May-05	1	56.1	61.2	61.9	62.2	62.4	62.7	62.8
2005-21-0061	8	732	Aug-05	May-05	4	57.5	62.0	62.8	63.5	63.6	63.8	64.0
2007-01-0068	2	953	Feb-07	Mar-06	11	52.8	53.3	55.7	56.2	56.2	56.3	56.3
2007-13-0067	6	953	Jun-07	Apr-07	2	56.6	59.7	60.6	61.1	61.2	61.4	61.3
2007-15-0048	8	953	Aug-07	Apr-07	4	53.4	58.3	59.0	59.4	59.5	59.7	59.7
2009-10-0044	8	983	Aug-09	Jun-06	14	47.2	49.3	49.9	50.1	50.0	50.1	50.2
2008-01-0046	2	1005	Feb-08	Mar-08	-1	57.8	59.2	61.0	61.4	61.5	61.7	61.7
2008-26-0063	6	1005	Jun-08	Mar-08	3	48.5	57.8	58.6	59.2	59.3	59.4	59.5
2008-27-0072	8	1005	Aug-08	Mar-08	5	55.5	56.7	57.3	57.7	58.0	58.2	58.3
2009-03-0040	2	1005	Feb-09	Mar-08	11	49.5	49.6	52.2	52.4	52.4	52.6	52.7
2009-09-0076	6	1005	Jun-09	Mar-08	15	44.9	48.0	48.9	49.3	49.3	49.5	49.5
2010-01-0034	2	1005	Feb10	Mar08	3	23.4	24.7	24.9	24.8	24.5	24.0	23.4
2010-13-0071	6	1005	Jun-10	Jul-10	-1	56.4	67.2	68.1	68.3	37.7	66.3	65.1
2010-13-0071	6	1005	Jun-10	Jul-10	-1	56.4	67.2	68.1	68.3	37.7	66.3	65.1
2010-36-0089	7	1005	Jul-10	Jul-10	0	58.6	63	63.7	63.2	63.1	n/a	n/a
1996-01-0068	2	?	feb	?	?	56.0	58.4	63.8	64.8	65.1	65.5	65.8

Sensor #1005 DR all uses since March 2008 calibration

Cruise	Start month	Area	# of casts	Max Trans	months since cal	cumulative # of casts	Max Trans	Comments
2008-07	Mar-08	Inlets	59	54.1	0	59	54.1	
2008-32	Apr-08	WCVI	70	59.9	1	129	59.9	Expect >60
2008-28	Apr-08	Inlets	16	59.9	1	145	59.9	
2008-19	Apr-08	SoG	74	58	1	219	58	
2008-26	May-08	Line P	61	59.9	2	280	59.9	Expect >60
2008-05	May-08	WCVI	60	60.1	2	340	60.1	Expect >60
2008-41	Jun-08	SoG	71	55.7	3	411	55.7	
2008-27	Aug-08	Line P	70	54.1	5	481	54.1	Expect >60
2008-10	Aug-08	WCVI	68	54.7	5	549	54.7	Expect >60
2008-50	Sep-08	WCVI	44	52.8	6	593	52.8	Expect >60
2008-63	Nov-08	SoG	3	48.8	8	596	48.8	
2008-61	Nov-08	SoG	74	49.4	8	670	49.4	
2009-03	Jan-09	Line P	44	52.7	10	714	52.7	Expect >60
2009-27	Mar-09	SoG	2	49.5	12	716	49.5	
2009-26	Apr-09	SoG	72	49	13	788	49	
2009-34	Apr-09	SoG	33	46.2	13	821	46.2	
2009-08	May-09	WCVI	92	51.1	14	913	51.1	Expect>60
2009-38	May-09	SoG	9	47.5	14	922	47.5	
2009-40	May-09	WCVI	40	50.6	14	962	50.6	Expect >60
2009-09	Jun-09	Line P	72	49	15	1034	49	Expect >60
2009-51	Jul-09	SoG	4	43.6	16	1038	43.6	few casts
2009-14	Sep-09	SoG	73	27.4	18	1111	27.4	
2009-64	Nov-09	SoG	77	28.3	20	1188	28.3	
2009-60	Nov-09	SoG	2	27.9	23	1190	27.9	Only 2 casts
2010-01	Feb-10	Line P	45	27.4	23	1235	27.4	Expect >60
2010-13	Jun-10	Line P	53	24.8	27	1288	24.8	1 deep offshore cast Expect >60
2010-36	Jul-10	WCVI	?	23.2	28	?	23.2	1 cast to ~1500db