CRUISE REPORT

R/V Aranda

COMBINE 2 / 2016

28 May - 10 June, 2016

This report is based on preliminary data and is subject to changes.

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COMBINE 2 / 2016

Period: 28.5. – 10.6. 2016

Chief scientist: Kari K. Lehtonen (Finnish Environment Institute, Marine Research Centre)

Photos in the report by KKL.

1. General description of the cruise

The COMBINE2 expedition headed first to the Gulf of Bothnia, continuing then to the central part of the Gotland Basin in the Baltic Proper. The main purpose of the expedition was to take samples for the monitoring of macrozoobenthos, bottom water oxygen levels and general hydrography in Baltic Sea open-sea areas. Sampling carried out onboard contributes to the HELCOM Baltic Sea monitoring programme and also to the long-term monitoring study on macrozoobenthic communities of SYKE Marine Research Centre. Monitoring samples were also collected for phyto- and zooplankton. In addition, water and sediment samples were collected for the monitoring of radioactive substances (HELCOM-MORS and Finnish Radiation and Nuclear Safety Authority). Mussel cages were deployed for monitoring of contaminants along the coastline. Also other studies were carried out during the cruise, including sampling for microplastics in water and sediments and observations on the progress and effects of recent saltwater inflows to the Baltic Sea.

2. Participants

The scientific staff of COMBINE 2 consisted of employees of the Marine Research Centre (MRC) of the Finnish Environment Institute (SYKE) and Finnish Meteorological Institute (FMI).

Scientific staff:

Chief scientist:	Kari Lehtonen	SYKE	28.05.2016 - 10.06.2016
	Panu Hänninen	SYKE	28.05.2016 - 10.06.2016
	Jan-Erik Bruun	SYKE	28.05.2016 - 10.06.2016
	Marko Jaale	SYKE	28.05.2016 - 10.06.2016
	Markku Jansson	FMI	06.06.2016 - 10.06.2016
	Heidi Hällfors	SYKE	28.05.2016 - 03.06.2016
	Harri Kankaanpää	SYKE	06.06.2016 - 10.06.2016
	Tarja Katajisto	SYKE	06.06.2016 - 10.06.2016
	Tanja Kinnunen	SYKE	28.05.2016 - 03.06.2016
	Pekka Kosloff	FMI	28.05.2016 - 10.06.2016

Ilkka Lastumäki	SYKE	06.06.2016 - 10.06.2016
Anu Lastumäki	SYKE	28.05.2016 - 03.06.2016
Jere Riikonen	SYKE	28.05.2016 - 10.06.2016
Milla Johansson	FMI	06.06.2016 - 10.06.2016
Julia Talvitie	SYKE	28.05.2016 - 03.06.2016
KimmoTikka	FMI	28.05.2016 - 03.06.2016
Tuomo Roine	FMI	28.05.2016 - 03.06.2016
Pia Varmanen	SYKE	28.05.2016 - 10.06.2016
Elina Bertell	SYKE	28.05.2016 - 10.06.2016
Ulla Riihimäki	SYKE	28.05.2016 - 10.06.2016

3. Cruise route

The COMBINE 2 cruise departed from Helsinki (Jätkäsaari Harbour) on Saturday, May 28, 2016 at 10:00 hours. The first main areas visited for sampling and observations were located in the Bothnian Sea and the Bothnian Bay. After a weekend break in Turku the expedition continued towards the Åland Sea, continuing then south to the Baltic Proper and Eastern Gotland Basin. Completing the cruise with observations in the western Gulf of Finland *Aranda* returned to its home harbour on Friday evening June 10, 2016 at 18:45.
The cruise route in its different parts is shown in Fig. 1. The cruise route (in two maps showing the two legs of the cruise) with all the stations is presented in Fig. 1. Station data with coordinates, depth and arrival time is given in Table 1.

4. Sampling information

A synopsis of the samples collected and observations made is given in the tables below. CTD data was obtained from all study sites while all other sampling activities were carried out according to a pre-agreed sampling programme (with some obligatory modifications). In Fig. 5, examples of CTD profiles are given from selected stations visited during the cruise.

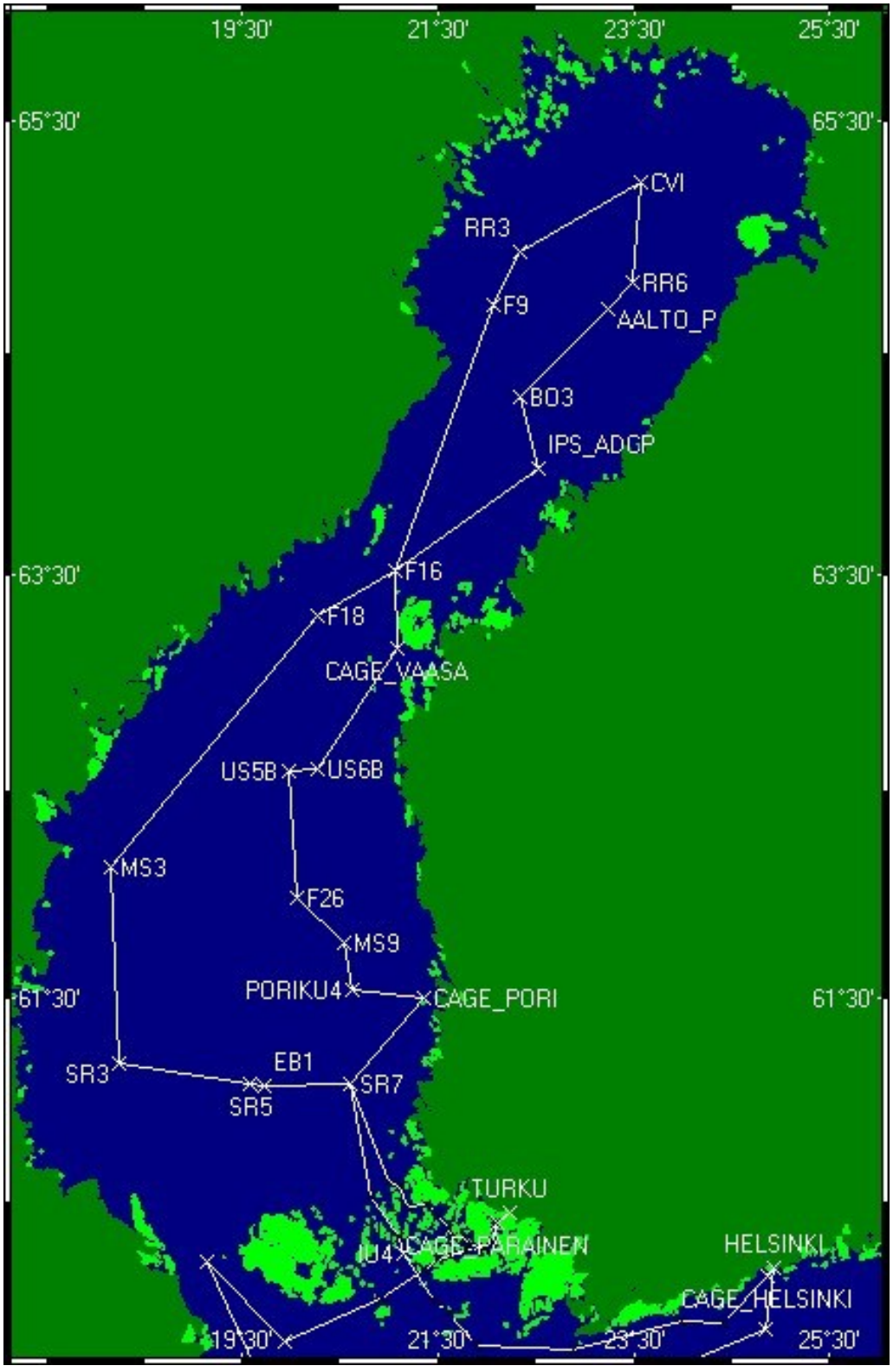


Fig. 1. COMBINE 2 2016 expedition. Sampling stations in the Gulf of Bothnia.

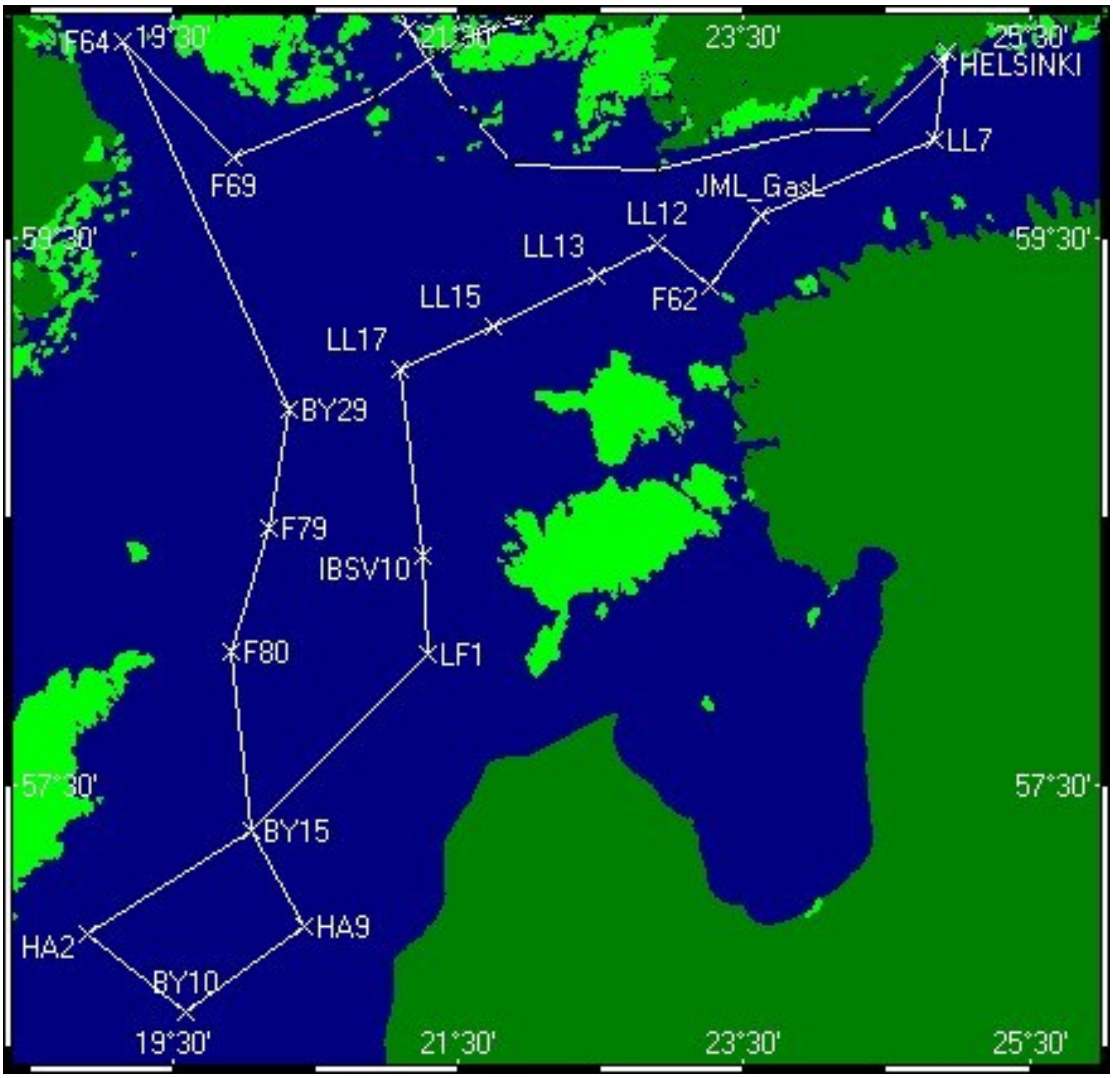


Fig. 1 (Cont'd). COMBINE 2 2016 expedition. Sampling stations in the Baltic Proper and Eastern Gotland Basin.

Table 1. Station data from the COMBINE 2 2016 expedition.

INDEX	STATION	LAT.	LON.	DEPTH [m]	DATE	TIME [UTC]
283	CAGE_HELSI	N60.0689	E024.5195	21.00	20160528	0930
284	IU4	N60.1400	E021.0897	51.00	20160528	0025
285	SR7	N61.0500	E020.3597	79.00	20160529	0542
286	EB1	N61.0399	E019.4379	131.00	20160529	0920
287	SR5	N61.0500	E019.3478	125.00	20160528	1150
288	SR3	N60.1100	E018.1380	75.00	20160529	1800
289	MS3	N62.0807	E018.0978	84.00	20160529	2345
290	F18	N63.1886	E020.1636	103.00	20160530	0850
291	F16	N63.3101	E021.0377	49.00	20160530	1330
292	F9	N64.4225	E022.0377	122.00	20160530	2105
293	RR3	N64.5638	E022.2156	96.00	20160531	0442
294	RR3	N64.5638	E022.2156	96.00	20160531	0442
295	CVI	N65.1402	E023.3377	68.00	20160531	0850
296	RR6	N64.4802	E023.2877	87.00	20160531	1340
297	AALTO_PM	N64.4105	E023.1435	82.00	20160531	1550
298	BO3	N64.1820	E022.2084	115.00	20160531	1910
299	IPS_ADCP	N63.5873	E022.3144	32.00	20160601	0005
300	CAGE_VAASA	N63.0998	E021.0540	24.00	20160601	0900
301	US6B	N62.3601	E020.1578	82.00	20160601	1340
302	US5B	N62.3517	E019.5813	221.00	20160601	1550
303	F26	N61.5901	E020.0378	138.00	20160601	2330
304	MS9	N61.4610	E020.3127	101.00	20260502	0245
305	PORIKU4	N61.3241	E020.3719	97.00	20160602	0540
306	CAGE_PORI	N61.2987	E021.2065	23.00	20160602	0930
307	CAGE-PARAi	N60.2302	E022.0680	38.00	20160503	0525
308	F69	N59.4700	E019.5580	191.00	20160606	1640
309	F64	N60.1134	E019.0855	286.00	20160606	2150
310	BY29	N58.5300	E020.1900	164.00	20160607	0830
311	F79	N58.2700	E020.1000	102.00	20160607	1210
312	F80	N58.0000	E019.5381	195.00	20160607	1550
313	BY15	N57.1920	E020.0300	238.00	20160607	2120
314	HA2	N56.5590	E018.5390	124.00	20160608	0600
315	BY10	N56.3800	E019.3500	143.00	20160608	1020
316	HA9	N56.5750	E020.2460	85.00	20160608	1600
317	BY15	N57.1920	E020.0300	238.00	20160608	2020
318	LF1	N57.5895	E021.1684	67.00	20160609	0140
319	IBSV10	N58.2100	E021.1481	79.00	20160609	0500

Table 1. (Continued)

320	LL17	N59.0200	E021.0477	171.00	20160609	1015
321	LL15	N59.1100	E021.4481	131.00	20160609	1620
322	LL13	N59.2200	E022.2781	104.00	20160609	2000
323	LL12	N59.2901	E022.5381	83.00	20160609	2245
324	F62	N59.2001	E023.1581	95.00	20160610	0300
325	JML_GASL	N59.3489	E023.3696	83.00	20160610	0628

Table 2. Sampling during the COMBINE 2 2016 expedition: parameters and equipment used, and institutes responsible for the analyses.

Code	Purpose	Sampling device	Analysis
O2_BOTTOM	Near-bottom oxygen/H2S	Water bottle (bottom)	SYKE
CTD + NUTRIENTS	Salinity, temperature, depth, conductivity, fluorescence, nutrients (NO2, NO3, SiO2, PO4, NH4)	CTD + Rosette + water bottle (bottom)	FMI/SYKE
ZPL	Zooplankton community	WP2 net	SYKE
CHLa	Cholorophyll a in water	CTD + Rosette + water bottle (bottom)	SYKE
PHYTO	Phytoplankton community	CTD + Rosette + water bottle (bottom)	SYKE
METALS	Trace metals in water	CTD + Rosette + water bottle (bottom)	SYKE
W_STUK	Radioactivity in water	Water bottle 30 L	STUK
W_MP	Microplastics in water	Mantha trawl	SYKE
H2S/O2	Hydrogen sulphide and oxygen boundary layer in the water column	H2S and O2 probes	SYKE
SED_STUK	Radioactivity in sediments	GEMAX dual corer	STUK
BENTHOS	Benthos community	van Veen / Box corer	SYKE
SED_MP	Microplastics in sediments	Box corer	SYKE

Table 3. Sampling during the COMBINE 2 2016 expedition. Codes as in Table 2.

	WATER PHASE									SEA BOTTOM		
	O2_BOTTOM	CTD + NUTRIENTS	ZPL	CHLA	PHYTO	METALS	W_STUK	W_MP	H2S/O2 PROBE	BENTHOS	SED_STUK	SED_MP
HELSINKI												
CAGE_HELSINKI	x	x		x		x						
IU4								x				
SR7	x	x								x		
EB1	x	x					x				x	
SR5	x	x	x	x				x		x		x
SR3	x	x								x		
MS3	x	x								x		
F18	x	x						x		x		x
F16	x	x	x	x	x					x		
F9	x	x								x		
RR3	x	x								x		
CVI	x	x					x	x		x	x	x
RR6	x	x								x		
AALTO_P												
BO3	x	x	x	x	x			x		x		x
IPS_ADCP												
CAGE_VAASA	x	x				x						
US6B	x	x								x		
US5B	x	x	x	x	x		x	x		x		x
F26	x	x								x		
PORIKU4	x	x								x		
CAGE_PORI	x	x				x						
CAGE_PARAINEN	x	x				x						
TURKU												
F69	x	x								x		
F64	x	x	x	x						x		x
BY29	x	x								H2S		
F79	x	x								H2S		
F80	x	x								H2S		
BY15	x	x	x	x			x			x	x	
HA2	x	x								H2S		
BY10	x	x	x	x						H2S		
HA9	x	x								H2S		
BY15	x	x (CTD only)								x		
LF1	x	x								x		
IBSV10	x	x								x		
LL17	x	x	x	x			x			H2S	x	
LL15	x	x								H2S		
LL13	x	x										
LL12	x								x			
F62	x								x			
JML_GasL	x								x			
HELSINKI												
Additional measurements: seafloor integrity (echosounding close to Helsinki); 12 kHz overall echosounding.												

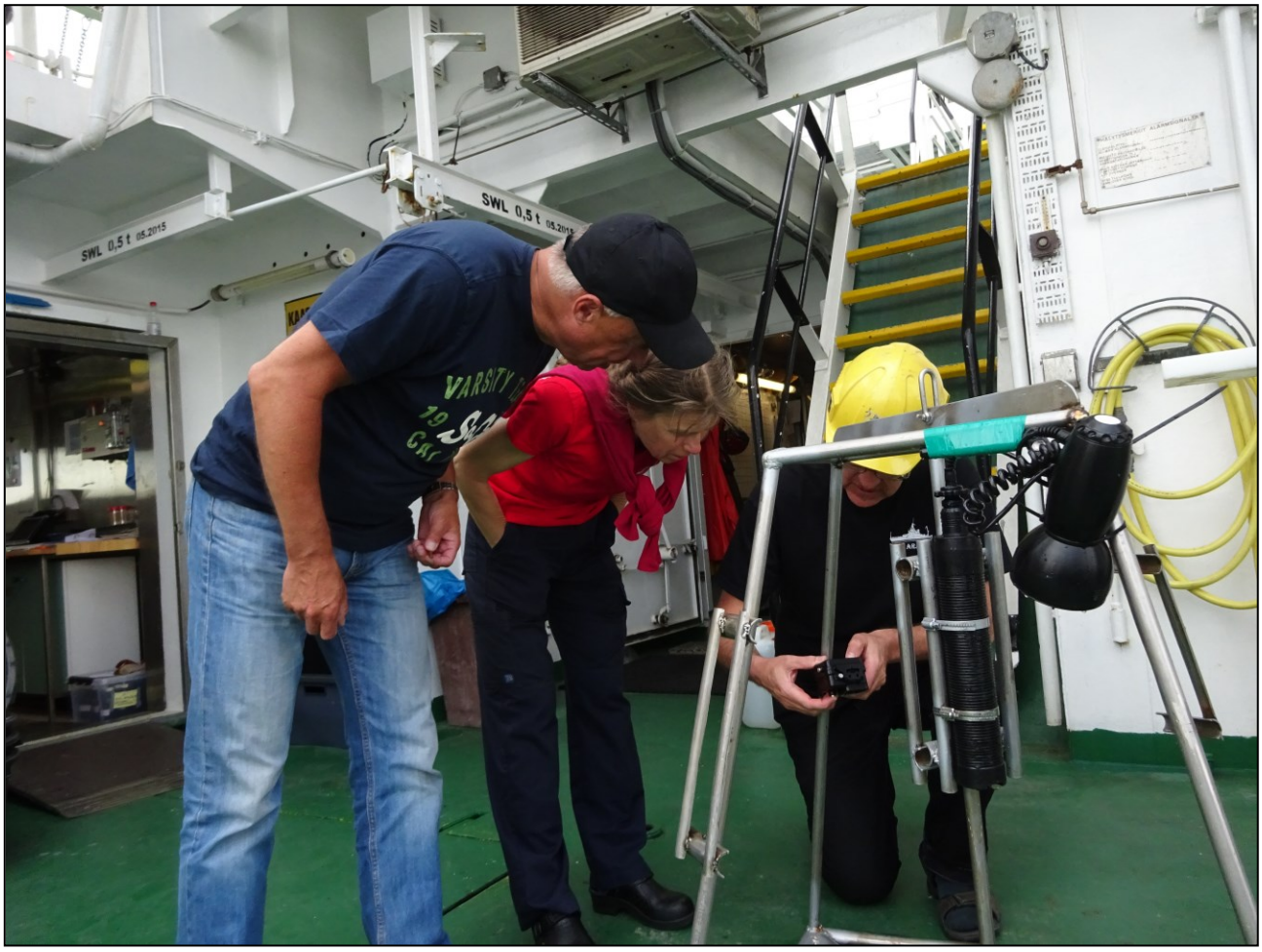


Fig. 2. The Eagle has landed – or at least will be landing soon. **Janne Bruun** and **Tarja Katajisto** observing closely the technical wizardry of **Harri Kankaanpää** who is preparing the home-made prototype benthic lander for first testings. This simple but genious gear takes us right to the bottom to visually observe and measure with various sensors what happens down in the depths.

5. Observations

Hydrography and nutrients

Vertical profiles of temperature, salinity, oxygen concentration and fluorescence at selected sampling stations are shown in Fig. 5.

The major saltwater intrusion of December 2014 had increased the salinity of the central basin of the Baltic Sea by ca. 1.5 PSU. One year later, in spring and early summer 2016, the increase had slowed down, being now only ca. 0.3 PSU higher than in 2015. North of

the central basin, in the Fårö Deep and western Gulf of Finland, the effect of the saltwater pulse could be seen especially as the relatively small but steady elevation in salinity.

In 2015, the inflow brought new, oxygen-rich water to the central basin, and this manifested half a year later as a marked increase in deepwater oxygen concentrations (from 125 m down to the bottom) in the Gotland Deep. However, in early summer 2016 the oxygen concentrations of the same water layer had decreased to almost half of that recorded in 2015 while the near-bottom oxygen conditions were close to zero. The same was observed also at the Fårö Deep where the oxygen levels have remained low also after the pulse. According to the most recent observations, the relatively high-saline deepwater reaching the western Gulf of Finland has not brought more oxygen to the near-bottom water layers in this area and therefore not being able to reduce markedly the hydrogen sulfide concentrations of the deepwater. Phosphate concentrations were measured to be slightly lower than during some previous observation periods (Table 4).

Table 4. Comparison of data from COMBINE 2 2016 to data from COMBINE 1 2016 except (1) comparison to COMBINE 2 2015 data, and (2) comparison to May 2014 data.

Station	Bottom *S*	Bottom T	Bottom oxygen	Bottom phosphate	Surface phosphate
SR5	↘	↓	↑	↘	↘
F64	→	↓	↑	→	→
BY15	↓	(↘)	↓	(↗)	↓
IBSV10	↑[1]	↑[1]	↓[1]	↑[1]	↘[1]
LL17	↑[1]	↑[1]	↑[1]	↘[1]	↓[1]
LL15	↑	↑	↘	(↘)	↘[1]
LL13	↑[2]	↑[2]	↗[2]	(↘)[2]	(↘)[2]

Benthos

In the Gulf of Bothnia no drastic changes in benthic communities could be observed. However, in the Bothnian Sea there appears to be a tendency of increasing abundance of benthic organisms in the western part of the basin while a decline in the central and eastern part seems ongoing. More detailed analyses of the long-term benthos data are required to see whether the current observations represent a true trend.

In the central basin and the western part of the Gulf of Finland the situation had worsened from 2015 when some recruitment could be observed at some stations, related to the improved oxygen conditions. Now, most of these areas were again devoid of benthic macrofauna.

Bottom echosounding

Information on bottom structure was collected with a 12 kHz sub-bottom echosounder during ca. 60% of the cruise time between Turku and Helsinki. The acoustic signal was seen to penetrate well the sea bottom. In addition, seabottom profiling was performed on three separate transects outside Helsinki for the monitoring of sea-floor integrity (MSFD Descriptor 6), now for the third year in a row.

New technologies

A prototype of a benthic lander frame was tested for the first time in video shooting of the bottom and midwater (stations HA2, LL12 and JML GasL) as well as O_2, H_2S, pH and temperature sensor measurements (stations LL12 / 2 hrs, F62 / one h and JML GasL / 3 hrs). Battery operated underwater torch, GoPro camera, AMT/SST and RBR sondes were attached to the lander. A part from the recordings at the seafloor, zooplankton (including a medusa) and sulfur “clouds” could be observed in the midwater.

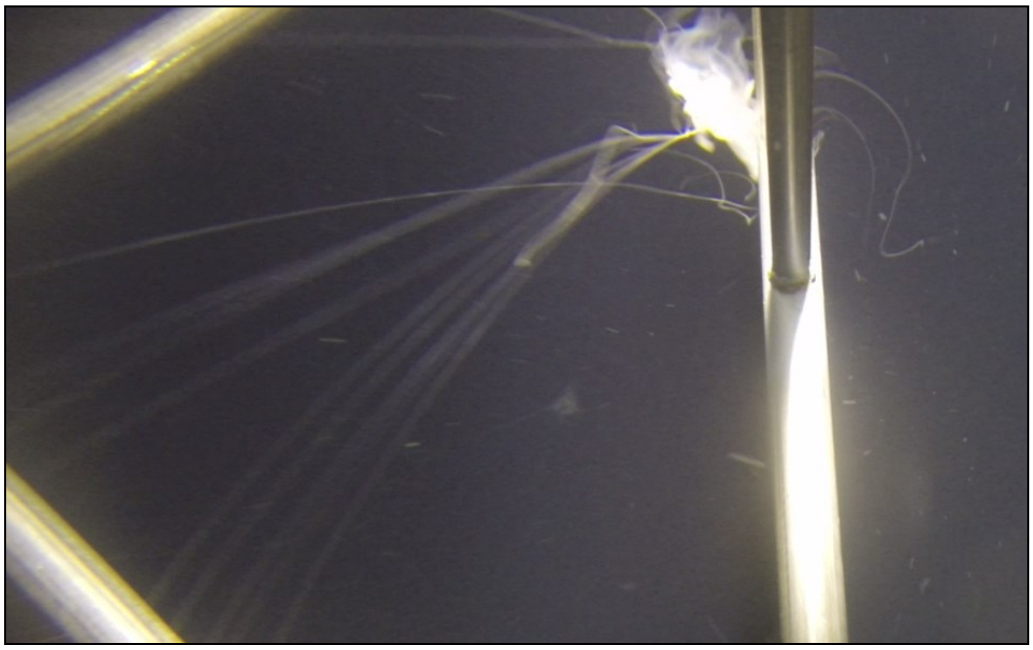


Fig. 3. Who’s that? While going down the water column west of the Gotland Deep (HA 2) the camera attached to the lander caught a sight of a **medusa** passing by.

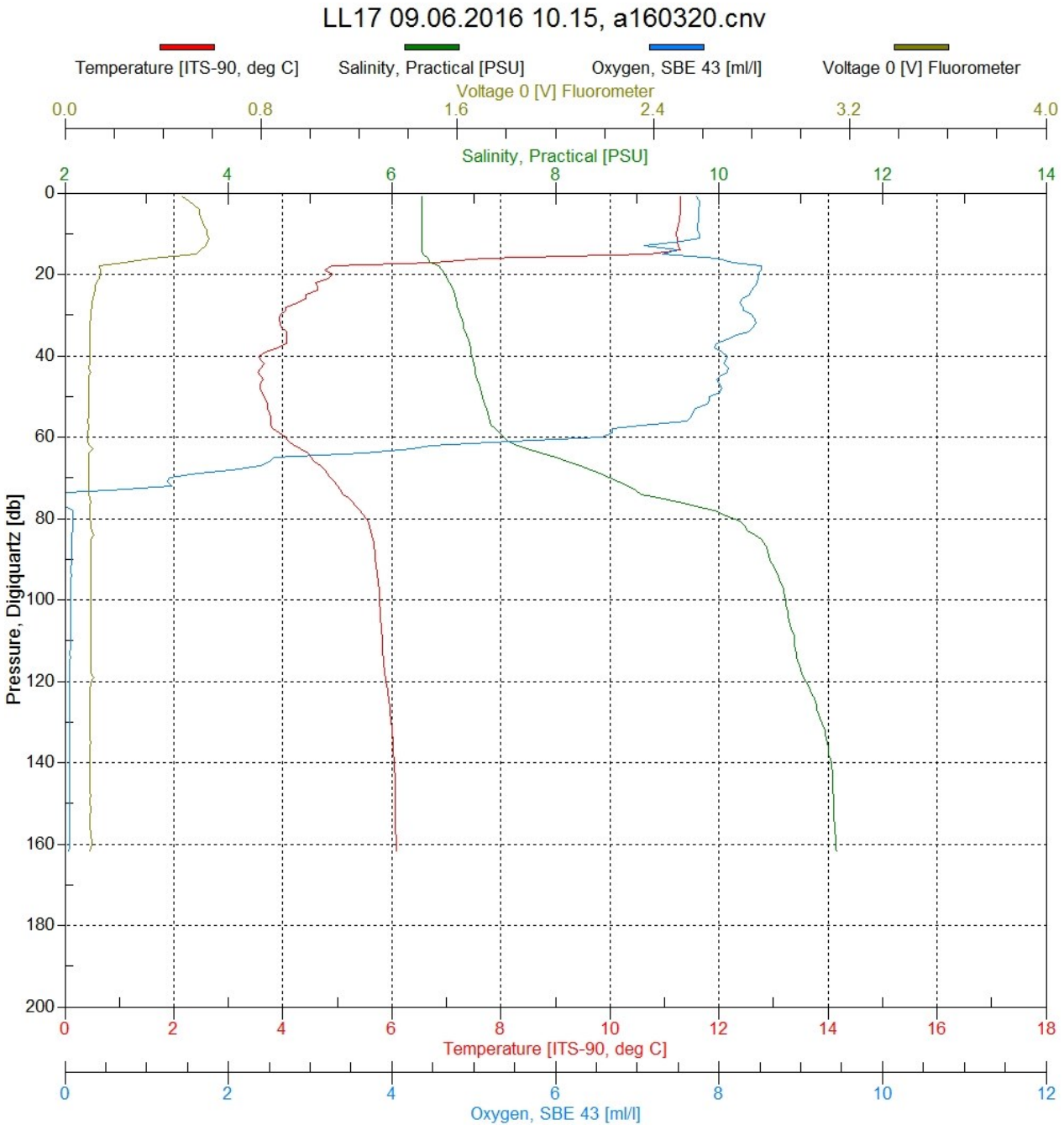


Fig. 4. *Vertical profiles of temperature, salinity, oxygen concentration and fluorescence at selected stations of the COMBINE 2 2016 cruise.*

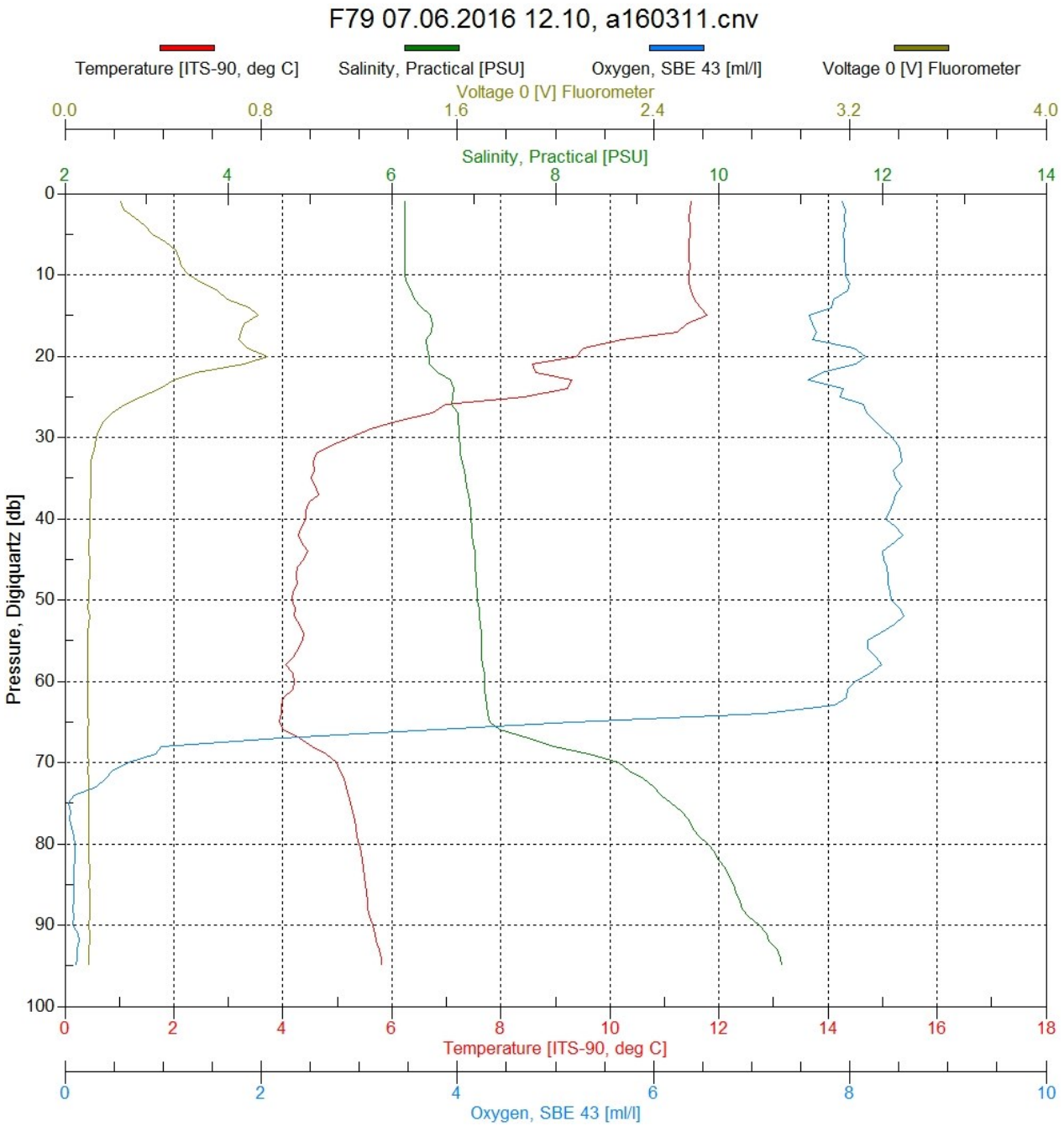

F79 07.06.2016 12.10, a160311.cnv
Temperature [ITS-90, deg C]
Salinity, Practical [PSU]
Oxygen, SBE 43 [ml/l]
Voltage 0 [V] Fluorometer
Voltage 0 [V] Fluorometer
0.0
0.8
1.6
2.4
3.2
4.0
Salinity, Practical [PSU]
2
4
6
8
10
12
14
Pressure, Digiquartz [db]
0
10
20
30
40
50
60
70
80
90
100
0
2
4
6
8
10
12
14
16
18
Temperature [ITS-90, deg C]
0
2
4
6
8
10
Oxygen, SBE 43 [ml/l]

Fig. 4 (Cont'd).

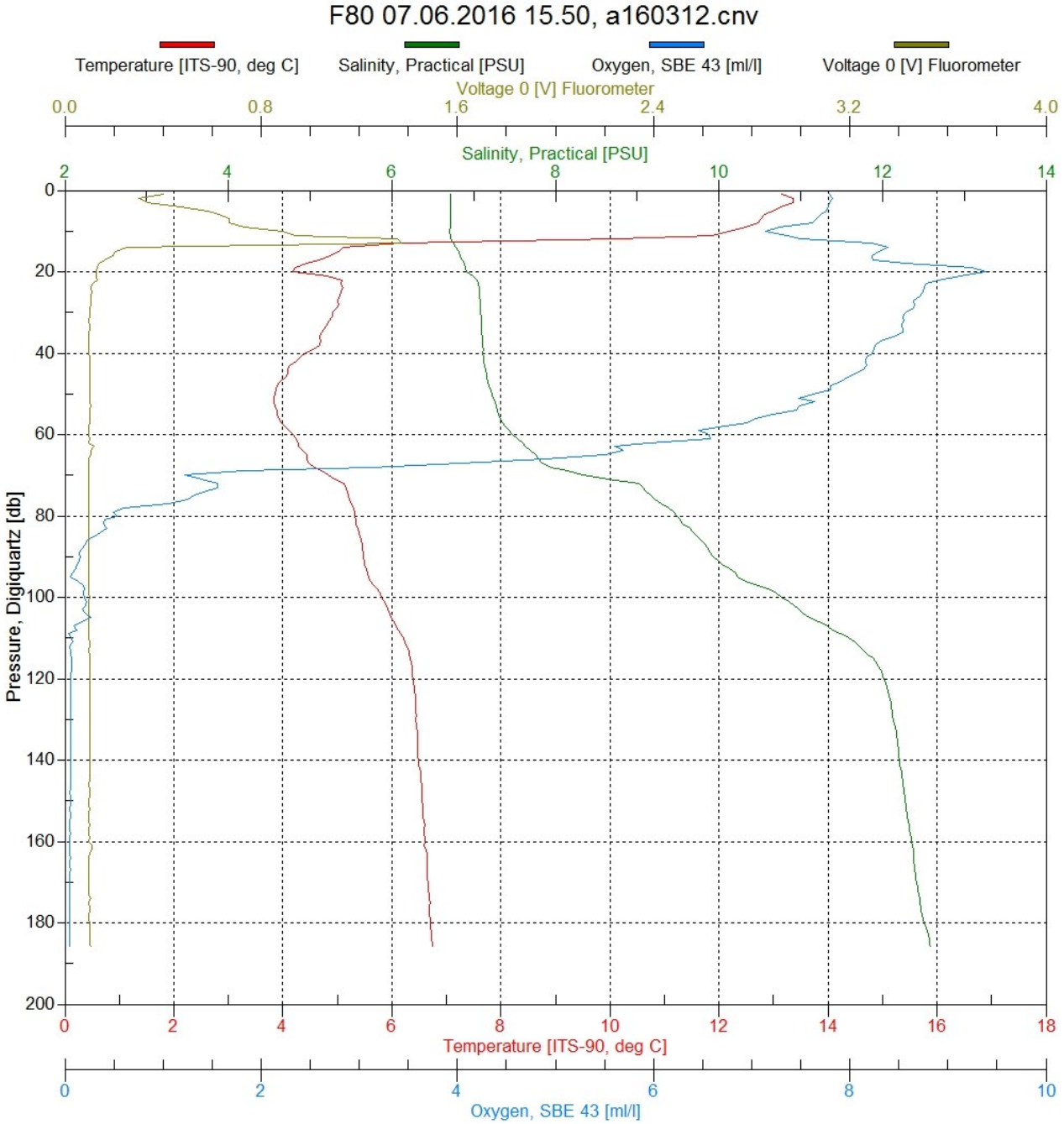
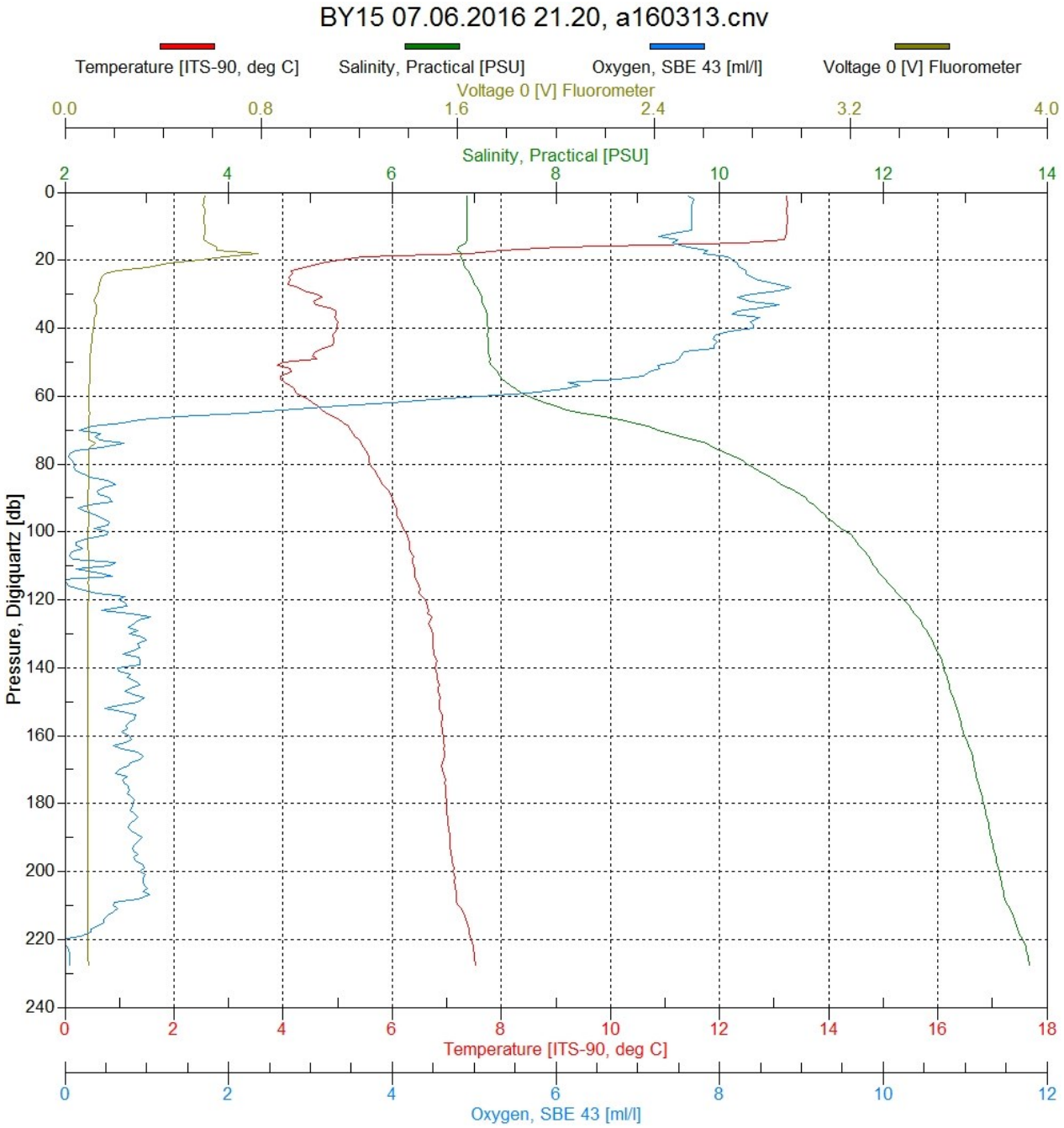

F80 07.06.2016 15.50, a160312.cnv
Temperature [ITS-90, deg C]
Salinity, Practical [PSU]
Oxygen, SBE 43 [ml/l]
Voltage 0 [V] Fluorometer
Voltage 0 [V] Fluorometer
0.0 0.8 1.6 2.4 3.2 4.0
Salinity, Practical [PSU]
2 4 6 8 10 12 14
Pressure, Digiquartz [db]
0 20 40 60 80 100 120 140 160 180 200
0 2 4 6 8 10 12 14 16 18
Temperature [ITS-90, deg C]
0 2 4 6 8 10
Oxygen, SBE 43 [ml/l]

Fig. 4 (Cont'd).


BY15 07.06.2016 21.20, a160313.cnv
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Salinity, Practical [PSU]
Oxygen, SBE 43 [ml/l]
Voltage 0 [V] Fluorometer
Voltage 0 [V] Fluorometer
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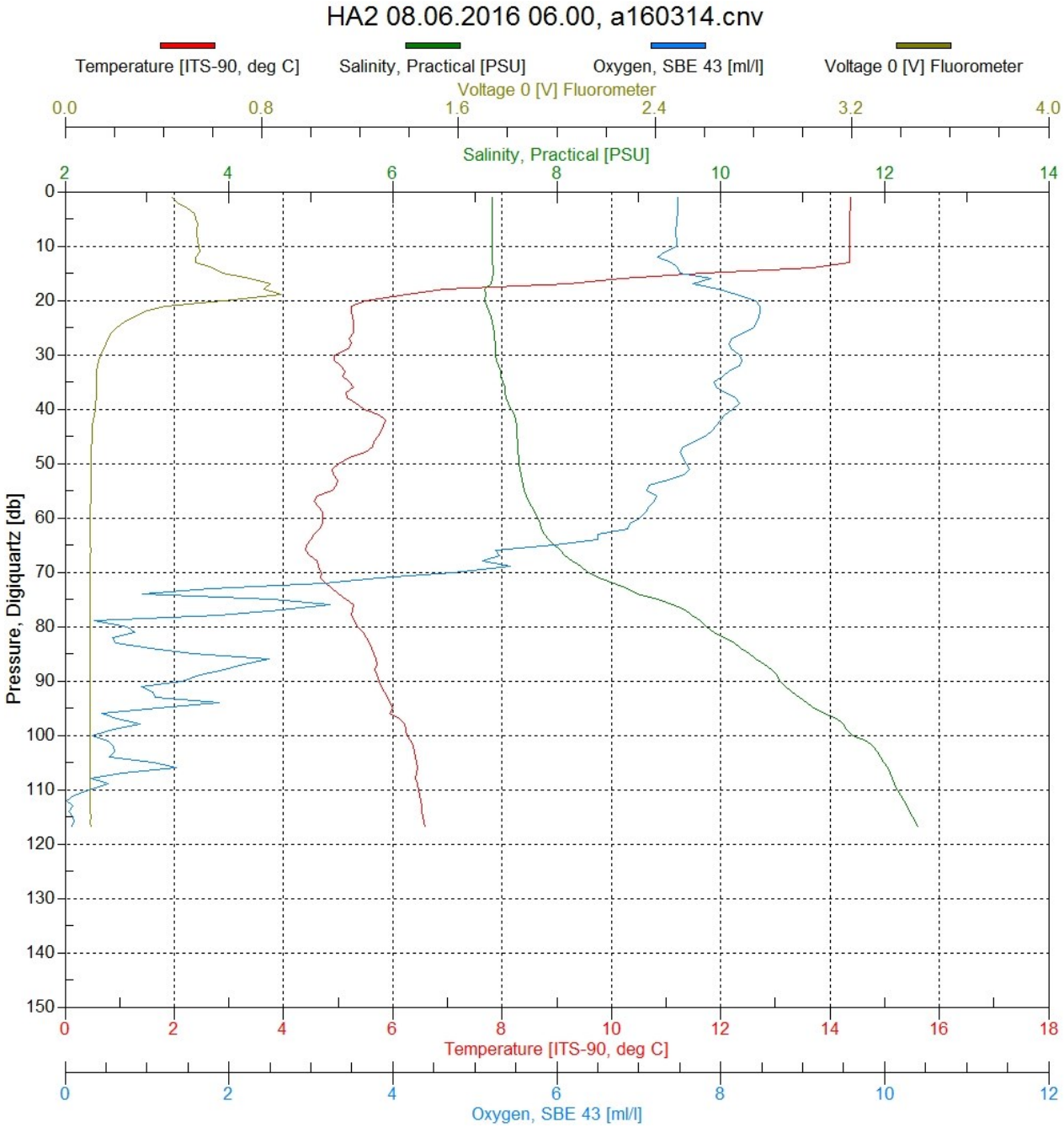
Salinity, Practical [PSU]
2 4 6 8 10 12 14
Pressure, Digiquartz [db]
0 20 40 60 80 100 120 140 160 180 200 220 240
0 2 4 6 8 10 12 14 16 18
Temperature [ITS-90, deg C]
0 2 4 6 8 10 12
Oxygen, SBE 43 [ml/l]

Fig. 4 (Cont'd).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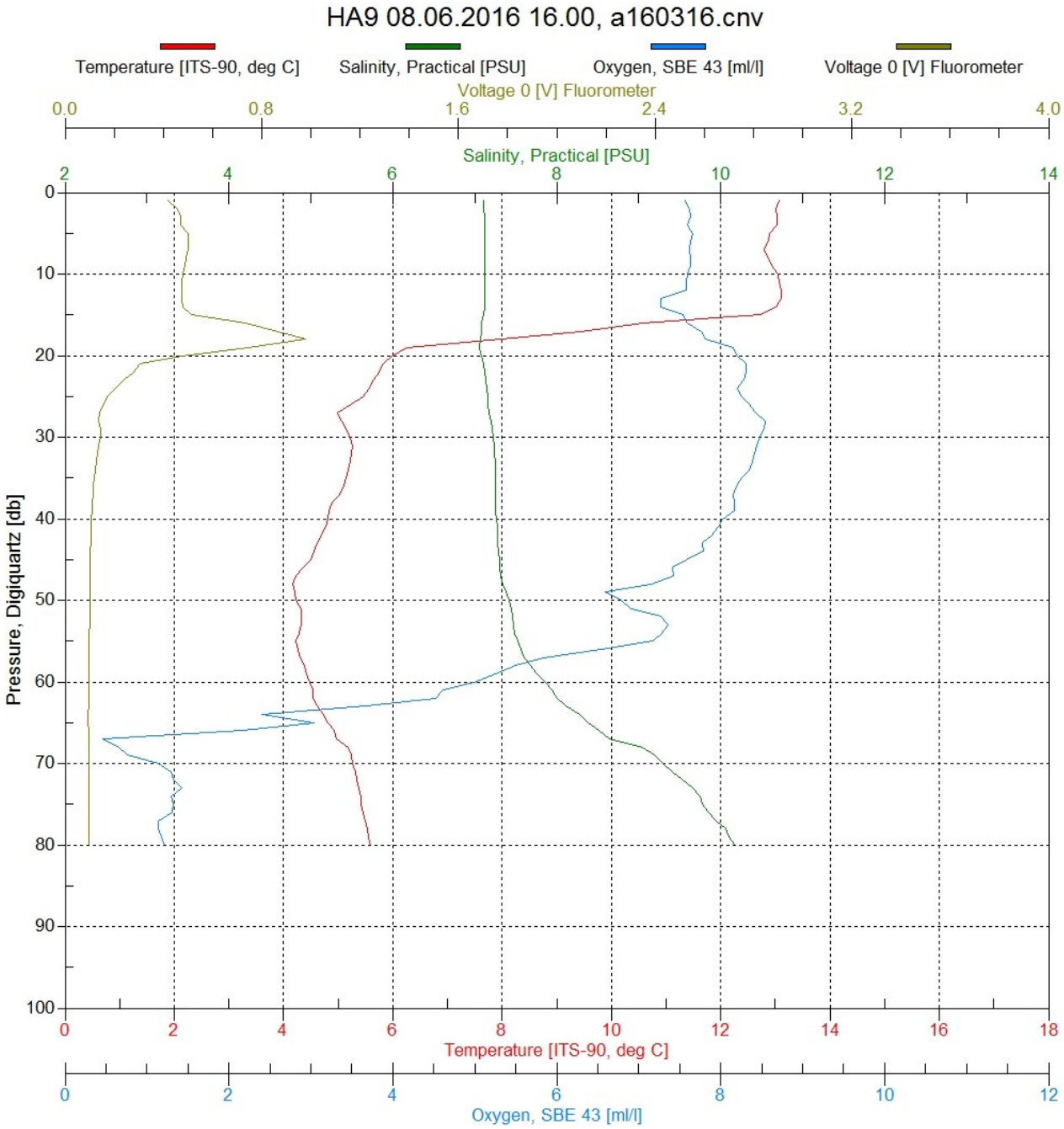
Salinity, Practical [PSU]
Oxygen, SBE 43 [ml/l]
Voltage 0 [V] Fluorometer
Voltage 0 [V] Fluorometer
0.0 0.8 1.6 2.4 3.2 4.0
Salinity, Practical [PSU]
2 4 6 8 10 12 14
Pressure, Digiquartz [db]
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150
0 2 4 6 8 10 12 14 16 18
Temperature [ITS-90, deg C]
0 2 4 6 8 10 12
Oxygen, SBE 43 [ml/l]

Fig. 4 (Cont'd).


HA9 08.06.2016 16.00, a160316.cnv
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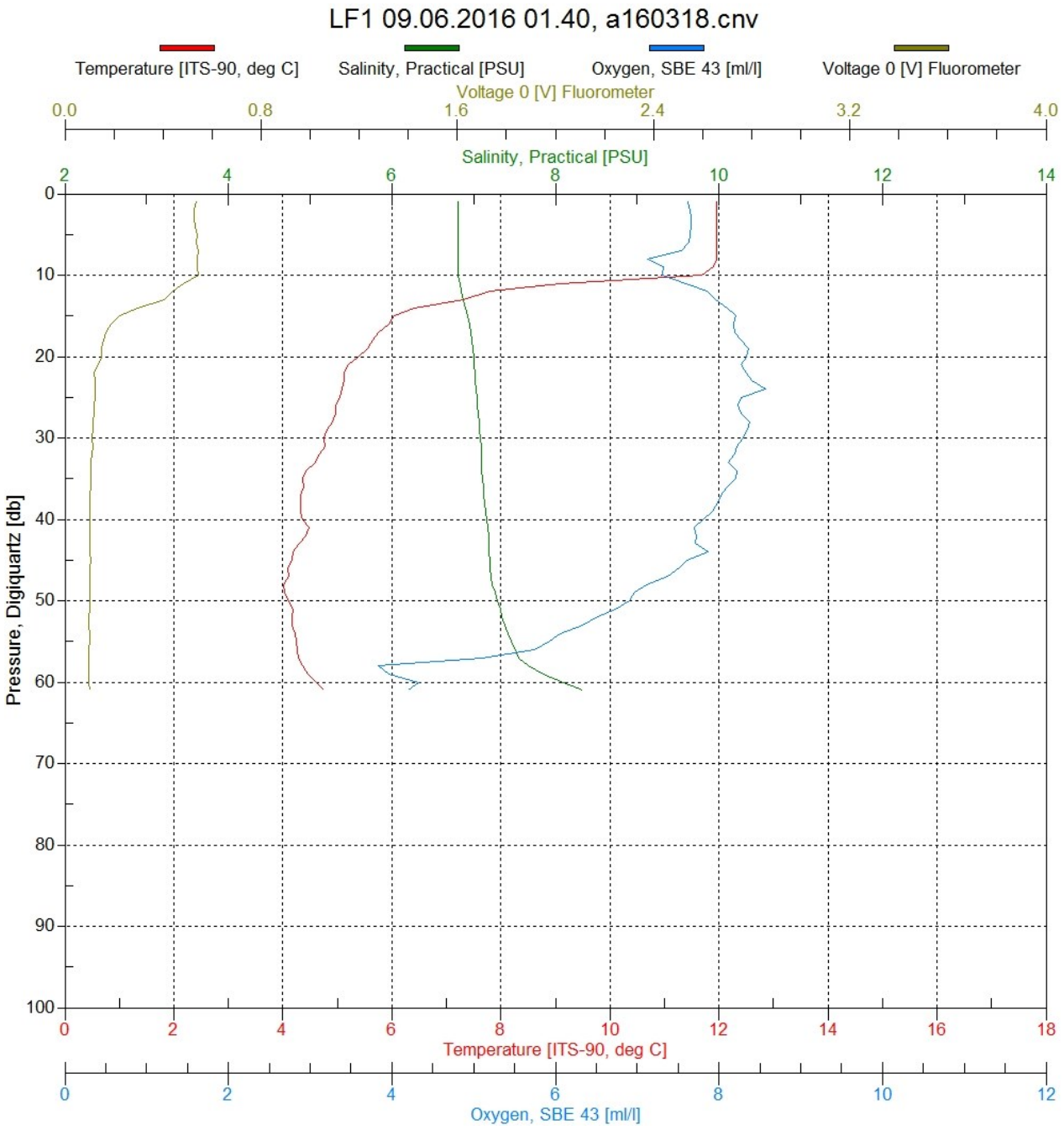
Salinity, Practical [PSU]
Oxygen, SBE 43 [ml/l]
Voltage 0 [V] Fluorometer
Voltage 0 [V] Fluorometer
0.0 0.8 1.6 2.4 3.2 4.0
Salinity, Practical [PSU]
2 4 6 8 10 12 14
Pressure, Digiquartz [db]
0 10 20 30 40 50 60 70 80 90 100
0 2 4 6 8 10 12 14 16 18
Temperature [ITS-90, deg C]
0 2 4 6 8 10 12
Oxygen, SBE 43 [ml/l]

Fig. 4 (Cont'd).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Salinity, Practical [PSU]
Oxygen, SBE 43 [ml/l]
Voltage 0 [V] Fluorometer
Voltage 0 [V] Fluorometer
0.0 0.8 1.6 2.4 3.2 4.0
Salinity, Practical [PSU]
2 4 6 8 10 12 14
Pressure, Digiquartz [db]
0 10 20 30 40 50 60 70 80 90 100
0 2 4 6 8 10 12 14 16 18
Temperature [ITS-90, deg C]
0 2 4 6 8 10 12
Oxygen, SBE 43 [ml/l]

Fig. 4 (Cont'd).