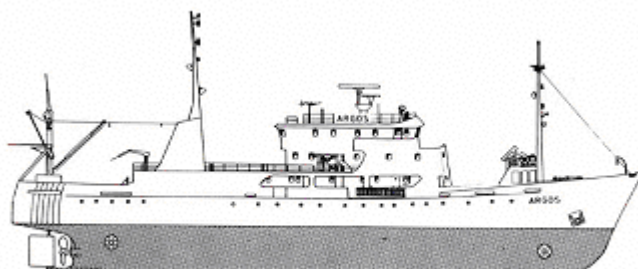


CRUISE REPORT FROM R/V ARGOS: OXYGEN SURVEY IN THE BALTIC SEA



Survey period: 2010-09-19 - 2010-10-28

Survey area: The Bothnian Sea, the Baltic Proper, the Sound, the Kattegat and the Skagerrak

Principal: SMHI & the Swedish Board of Fisheries

SUMMARY

This oxygen survey was completed in co-operation with the Swedish Board of Fisheries and the International Acoustic Survey in the Bothnian and Baltic Seas (BIAS) during weeks 38-39 and 41-43 of 2010. During week 40 SMHI performed its own regular monitoring cruise in the Skagerrak, the Kattegat, Sound and Baltic Proper. SMHI has completed this extensive oxygen survey now for the past three consecutive years. Data from the Polish and Latvian BIAS cruises were also made available, which improved the results and for which the report authors are most grateful.

The oxygen situation in the deep water of the Baltic Proper continues to be serious. About one sixth (~17%) of the bottom area in the Baltic Proper are affected by anoxia (oxygen free, with toxic hydrogen sulphide present) corresponding to ~10% of the water volume. Acute oxygen deficiency, with concentrations <2ml/l, affected about 28% of the bottom area, about 20% of the volume. This is the largest volume measured since 1960. North of Öland, hydrogen sulphide was present already from depth exceeding 45 meters. Anoxic conditions at these shallow depths have never been observed before in this area. In the south-west, in the Arkona Basin and in parts of the Bornholm Basin, oxygen conditions were good due to some smaller inflows during August and September.

PRELIMINARY RESULTS

The oxygen survey was completed in co-operation with the Swedish Board of Fisheries and the International Acoustic Survey in the Bothnian and Baltic Seas (BIAS) during week 38-39 and 41-43. During week 40, SMHI had its own regular monitoring cruise in the Skagerrak, Kattegat, Sound and Baltic Proper. Together with the oxygen surveys 2008 and 2009, this was one of the most extensive oxygen surveys performed by SMHI: 121 stations were visited and the analysis is based on about 570 oxygen and hydrogen sulphide samples. A CTD equipped with an oxygen sensor was also used at each sampling occasion, complementing the water samples analyzed by Winkler titration and/or colourimetric hydrogen sulphide analysis.

In addition to SMHI's own measurements, data from Poland (42 stations) and Latvia (25 stations) collected during their concurrent BIAS expeditions were also made available. These data were collected on board the Polish research vessel, R/V Baltica.

Thanks to Dr. Georgs Korņilovs, Head of Fish Resources Research Department at the Institute of Food Safety, Animal Health and Environment (BIOR) in Riga, Latvia and Tycjan Wodzinowski & Lena Szymanek, Department of Fishery Oceanography and Marine Ecology, Sea Fisheries Institute in Gdynia, Poland for smooth and easy data exchange.

This report is based on preliminary data, which have been subject to preliminary quality control only.

The Baltic Proper

The oxygen situation in the deep water of the Baltic Proper continues to be serious. The bad conditions measured during the beginning of the 21st century continue. About one sixth (~17%) of the bottom area in the Baltic Proper were completely oxygen free (with toxic hydrogen sulphide present), corresponding to ~10% of the volume. See figures 1-3.

Hypoxia (or acute oxygen deficiency; <2ml/l) was affecting about half ~28% of the bottom area, which is about one fifth (~20%) of the volume. This is the largest volume affected since the 1960-thies, when reliable measurements started. The extent of anoxic areas was slightly higher than in 2009, while the extent of hypoxia was of the somewhat lower than in 2009.

In Western Gotland Basin, hydrogen sulphide was present at depths exceeding 55 metres and hypoxia already at 35-45 metres depth. North of Öland contrasts were large, directly north of the island hydrogen sulphide was found at 45 metres, while in the Kalmar Sound at the same depth, oxygen conditions were good (4.18 ml/l).

In the south-western Baltic (the Arkona Basin and parts of the Bornholm Basin) oxygen conditions were good due to some smaller inflows during August and September. No other major inflow was observed during 2010.

Sub-basins of the Baltic Proper

The Northern Gotland Basin

Oxygen levels below 2 ml/l were found at depths exceeding 55-85 metres and hydrogen sulphide was present from 75 to 100 metres and deeper. The surface temperature varied from 6.9 and 12.7°C and the surface salinity was 5.2 psu at the entrance to the Bothnian Sea and 6.8 psu in the central parts. The thermocline was found at 20-50 metres depth.

The Eastern Gotland Basin

Low oxygen concentrations, <2ml/l, were found from 65 metres depth. Hydrogen sulphide was noted from 95 metres in the western parts and deeper in the central parts, from 125-140 metres. The surface temperature varied from 8.5 in the southwest to 12.5 in the northeast. Salinity in the surface water varied from 6.7 psu in the northern parts to 7.2 psu in the southern parts. The thermocline was found at 30-40 metres depth.

The Western Gotland Basin

In the southern parts, east of Öland, hydrogen sulphide was present at depths exceeding 55 metres and hypoxia already at 35-45 metres depth. North of Öland contrasts were large, directly north of the island hydrogen sulphide was found at 45 metres, while in the Kalmar Sound at the same depth, oxygen conditions were good (4.18 ml/l). Conditions were also bad close to the coast: outside Västervik hypoxia was present from a depth of 35 metres and oxygen concentrations close to the bottom close to zero. In the central and northern parts hydrogen sulphide was measured at depths exceeding 65-85 metres and hypoxia from a depth of 55-65 metres. The thermocline and halocline was located at a depth of 35-45 metres except close to the coast where they were shallower at 20 meters depth.

The Bornholm Basin and Hanö Bight

The lowest oxygen concentration was found in the central parts of the Bornholm Basin, just east of Bornholm. In the Bornholm Basin the thermocline was located at 40 metres and coincided partly with a weak halocline. Hydrogen sulphide was found at one station although at several other stations, oxygen concentrations at the bottom were close to zero. Oxygen levels below 2ml/l were found from 65 metres depth. In the eastern parts and close to the Polish coast, above 65 metres, oxygen conditions were good.

In the Hanö Bight, low oxygen concentrations, just above 0 ml/l, were found in the deeper parts. A marked thermocline was found at a depth of 35 metres while the halocline was weakly developed. In general, hypoxia was present at depths exceeding 65 metres. In the southern parts, just northeast of Bornholm, water from a recent inflow was found, resulting in high oxygen concentrations at the bottom. Oxygen levels were at a minimum of 1.16 ml/l at 80 metres, while the concentration at the bottom was 3.86 ml/l.

The Arkona Basin

Below the halocline in the Arkona Basin, the water was well oxygenated, with oxygen concentrations of 4.5 ml/l. The thermocline and the halocline coincided at 30-40 metres.

The Gdansk Bay

In the Gdansk Deep concentrations below 2 ml/l were found at depths exceeding 85 metres and the concentration at the bottom was 0.84 ml/l. No hydrogen sulphide was detected. In the inner part of the Gdansk Bay, oxygen concentrations were well above 2 ml/l at the bottom.

The Kattegat and the Sound

The lowest oxygen concentration was recorded from the bottom water in the Sound, 3.0 ml/l. This corresponds to a saturation of 50 %. In the open Kattegat oxygen conditions were good; at Anholt E the bottom oxygen concentration were 4.6 ml/l. The surface water temperature was normal for the season, about 12.5°C. The surface salinity was normal in Kattegat, between 17 and 20 psu, while it was below normal in the Sound (~8 psu). The halocline was found at 20 metres in the Kattegatt and at 10 metres in the Sound. The thermocline was weakly developed.

The Skagerrak

In Skagerrak the oxygen situation was, as normal, good. The concentrations at the bottom varied between 4.9 and 6.1 ml/l, with the exception of Släggö, in the mouth of the Gullmar fjord, which had a concentration of 3.1 ml/l. The temperature in the surface layer varied between 11.0-13.0°C. Surface salinity varied between 23.0 and 33.6 psu. The surface layer was extremely shallow in the central parts where it started already at a depth of ~6 metres. In the remaining areas it was found at depths between 20 and 40 metres. No distinct thermocline was found.

The Bothnian Sea

The oxygen situation in the deep water was good everywhere, which is normal for this area. The lowest oxygen concentration in the bottom water was found in the Åland Sea, 3.65 ml/l, corresponding to a saturation of 42%, at a depth of 90 metres. Surface temperature varied between 10.0 and 13.3 °C. A weak thermocline was detected at a depth of 10 to 40 metres.

PARTICIPANTS

Name		From
Martin Hansson, Chief scientist	v 38	SMHI Oceanographic Unit
Arne Svensson, Chief scientist	v 39	- ” -
Bengt Yhlen, Chief scientist	v 40, 42, 43	- ” -
Lars Andersson	v 40	- ” -
Sara Johansson	v 40	- ” -
Anna-Kerstin Thell	v 40	- ” -
Bodil Thorstensson	v 40	- ” -
Jan Szaron, Chief scientist	v 41	- ” -

FIGURES & APPENDICES

- Map of areal extent of hypoxia and anoxia in the Baltic Proper, 2010
- Figures of areal extent and volume of hypoxia and anoxia, 1960-2010
- Transects of oxygen conditions in the Baltic Proper and Baltic Sea
- Track charts
- Table over stations, parameters and sampling depths

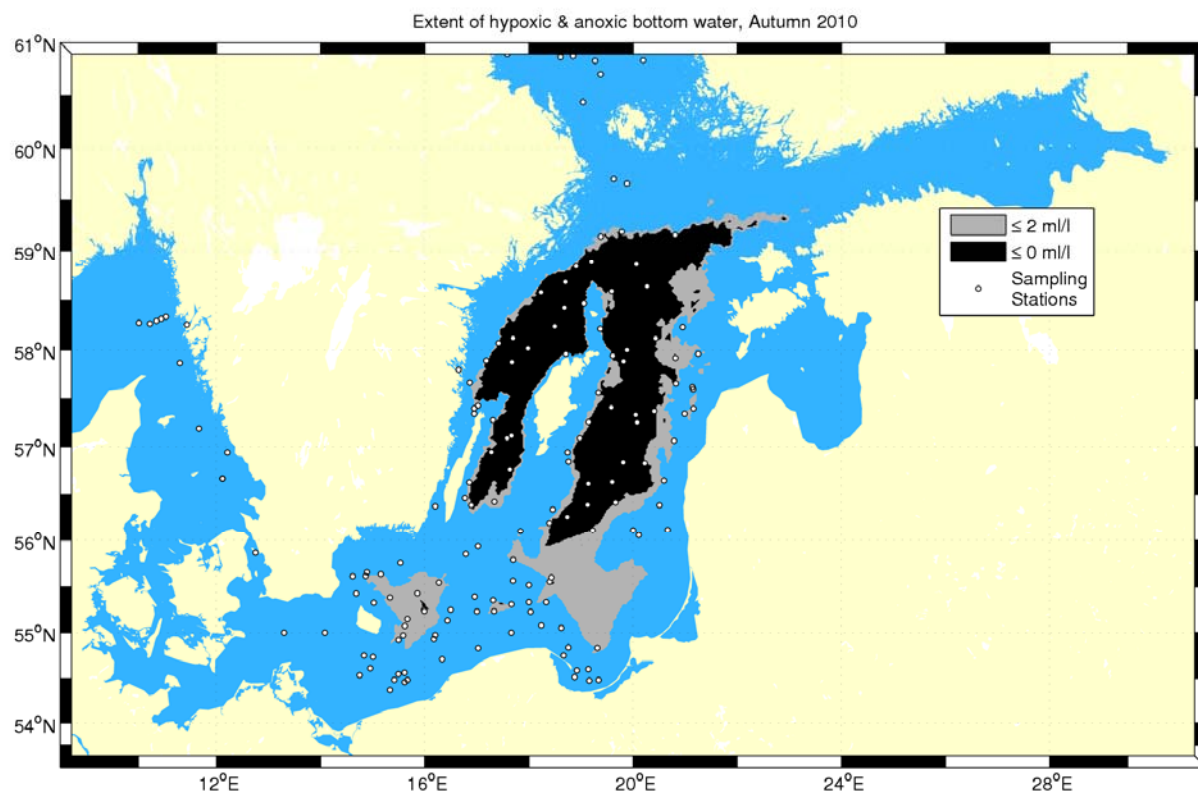


Figure 1. Extent of oxygen free areas (black) and areas with oxygen deficiency (grey) in the Baltic Sea during autumn 2010.

Areal extent of hypoxia and anoxia

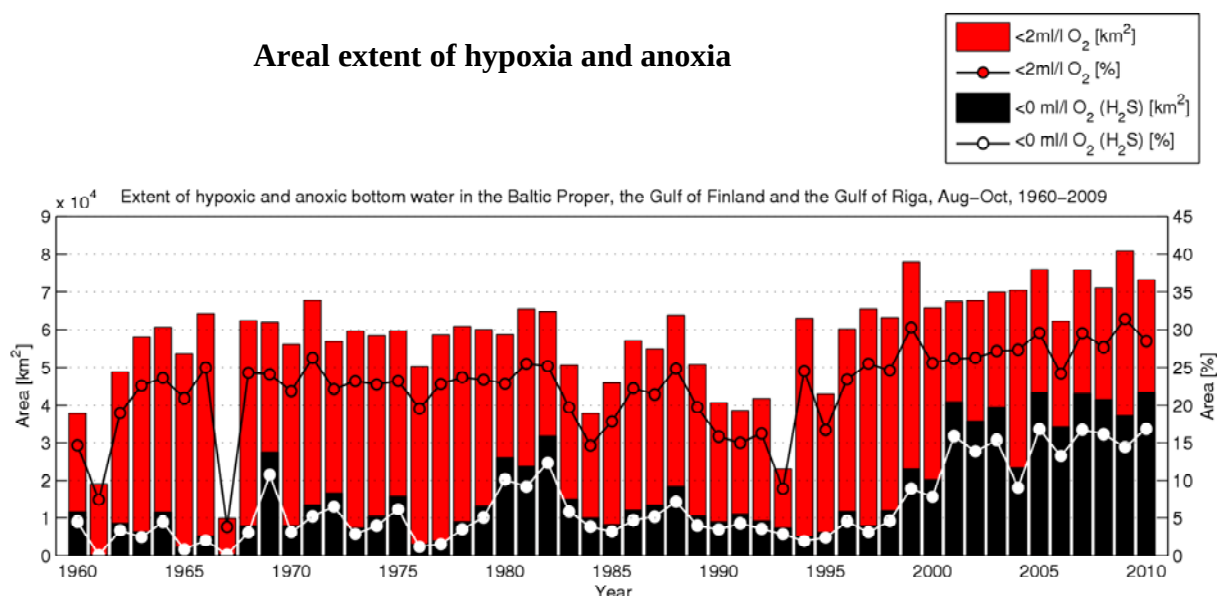


Figure 3. Areal extent of anoxia and hypoxia in the Baltic Proper, Gulf of Finland and Gulf of Riga. Based on the HELCOM/COMBINE dataset from ICES, with the exception of 2008–2009 where BIAS data are included. The result from 2010 are based on oxygen data collected during BIAS and SMHI's own data from the October cruise.

Water volume affected by hypoxia and anoxia

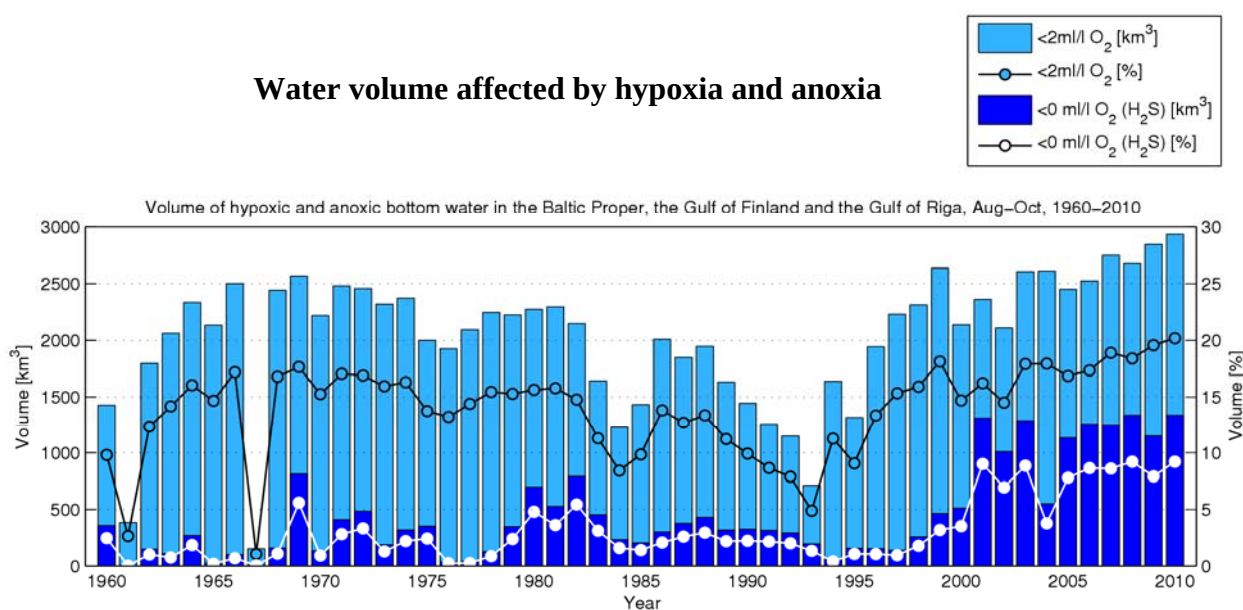
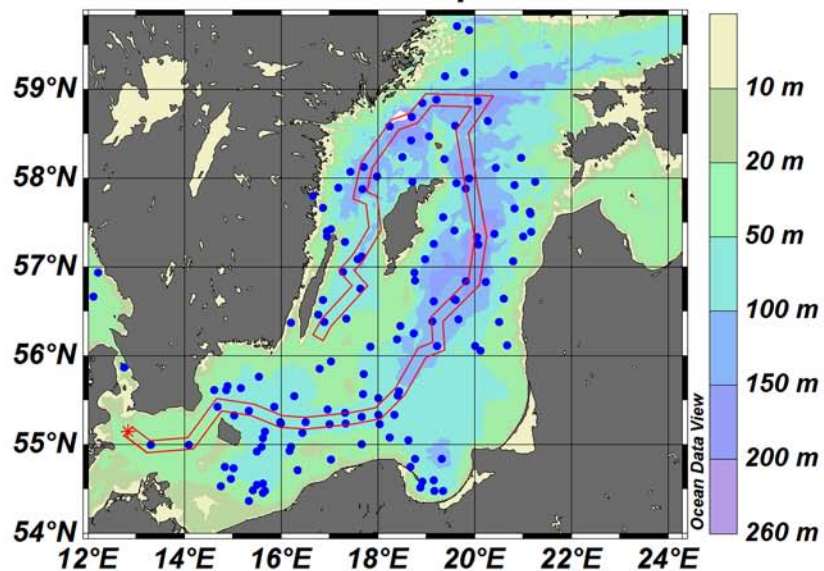


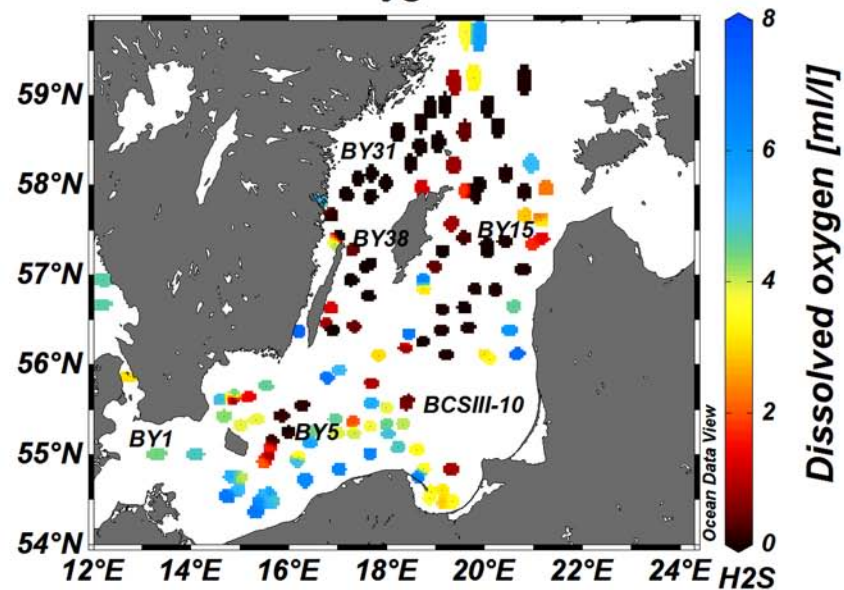
Figure 4. Volume of anoxic and hypoxic deep water in the Baltic Proper, Gulf of Finland and Gulf of Riga. Based on the HELCOM/COMBINE dataset from ICES, with the exception of 2008–2009 where BIAS data are included. The result from 2010 are based on oxygen data collected during BIAS and SMHI's own data from the October cruise.

Oxygen survey in the Baltic Proper during October 2010

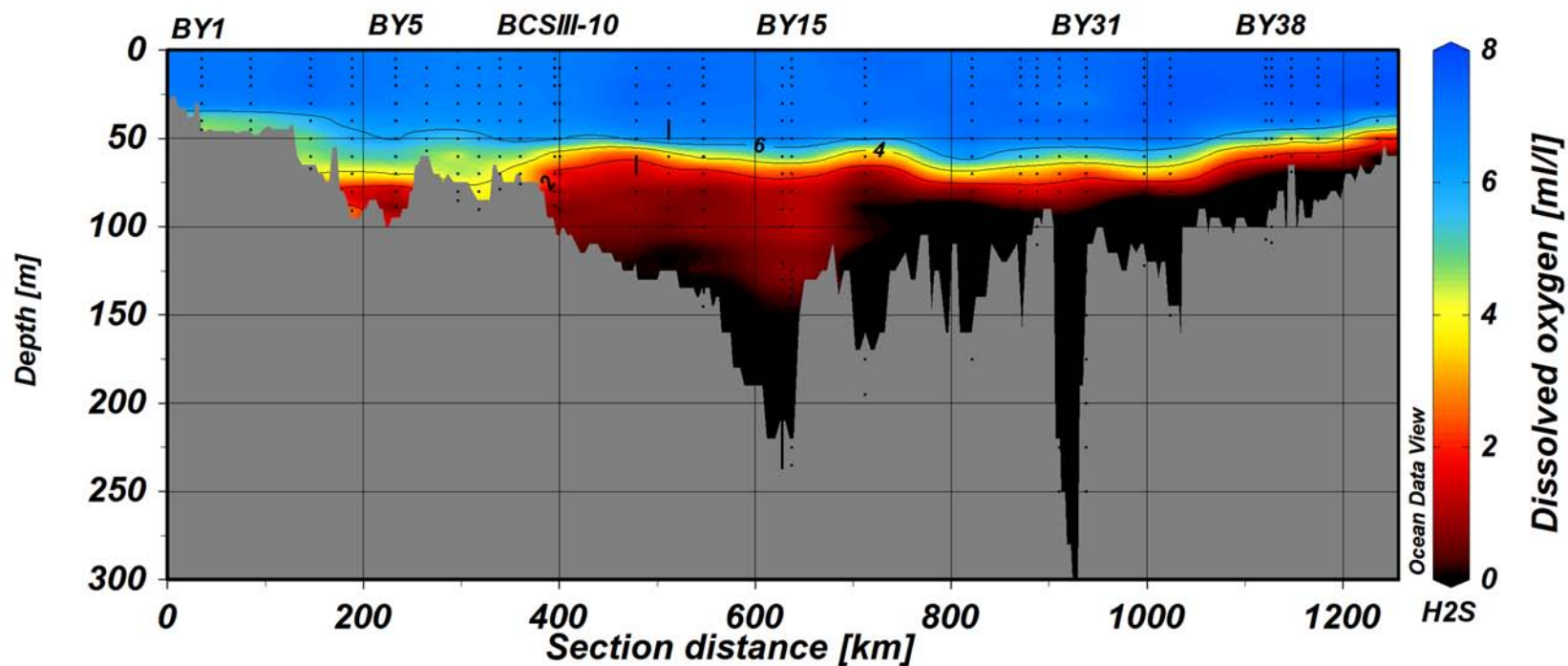
Station map



Dissolved oxygen at bottom

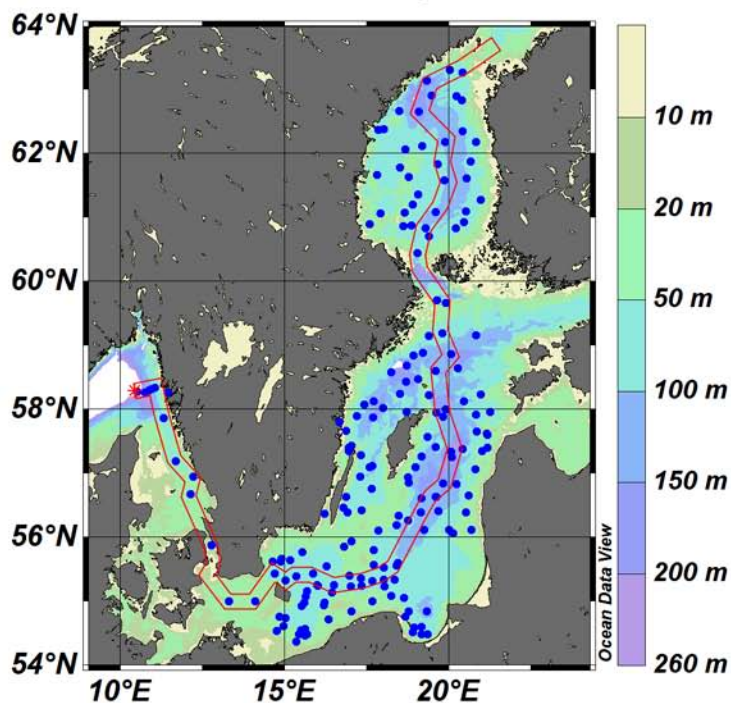


Section of The Baltic Proper

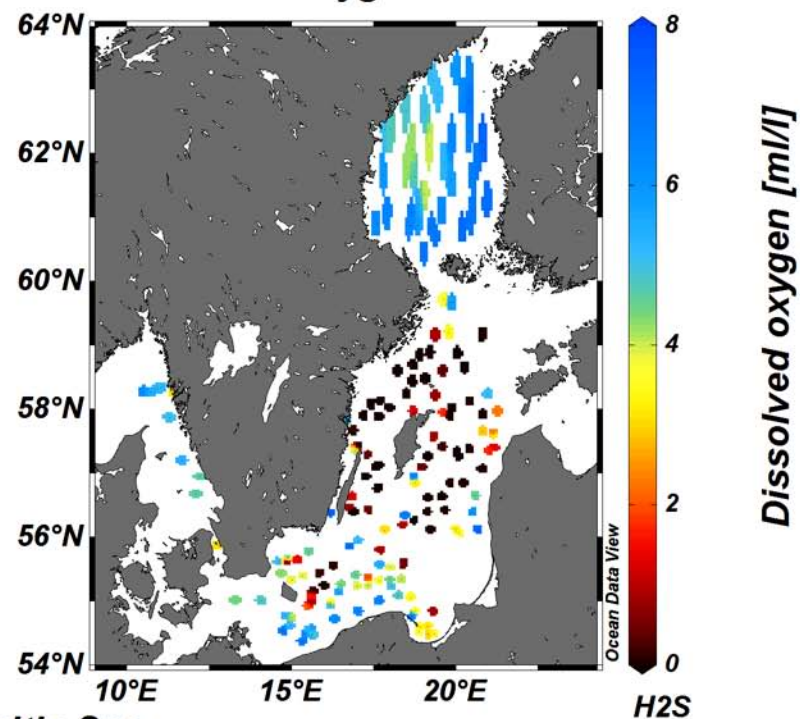


Oxygen survey in the Baltic Sea during October 2010

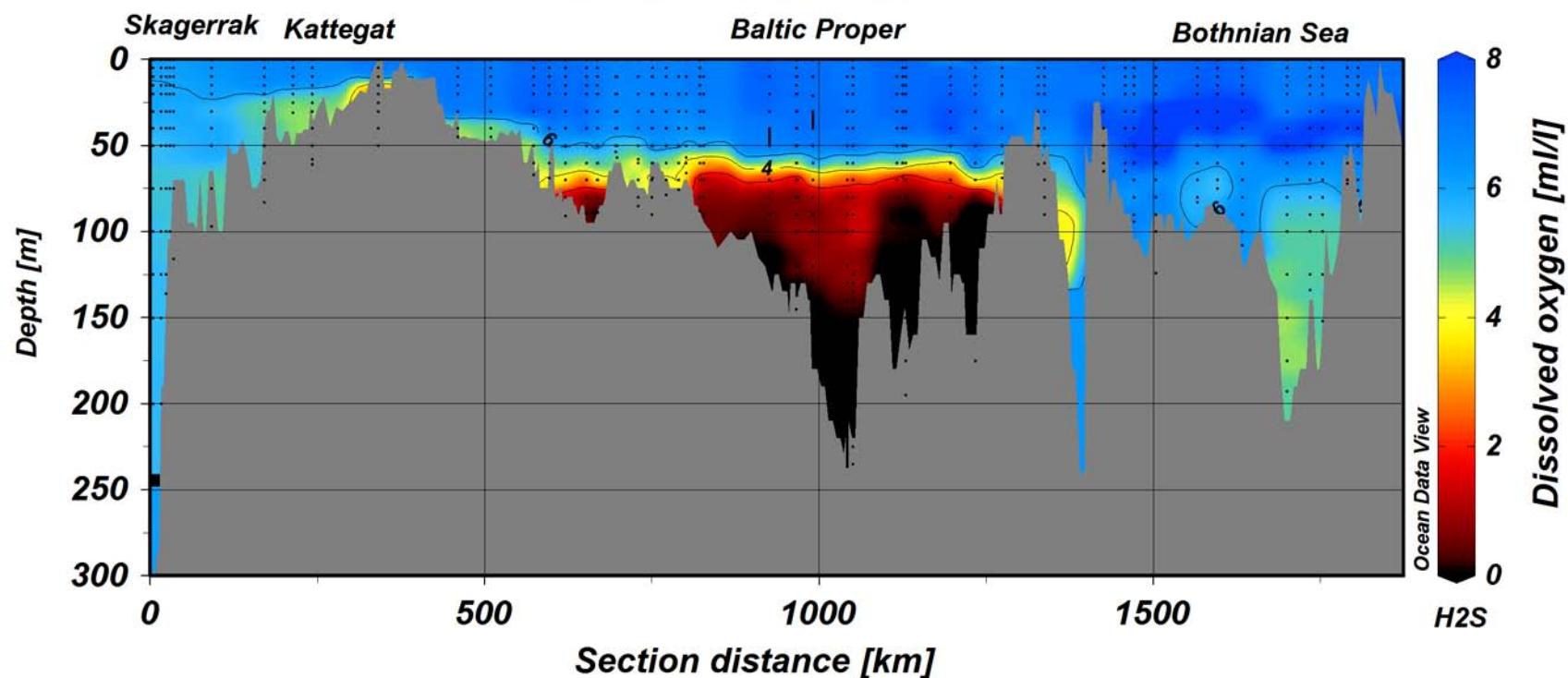
Station map



Dissolved oxygen at bottom

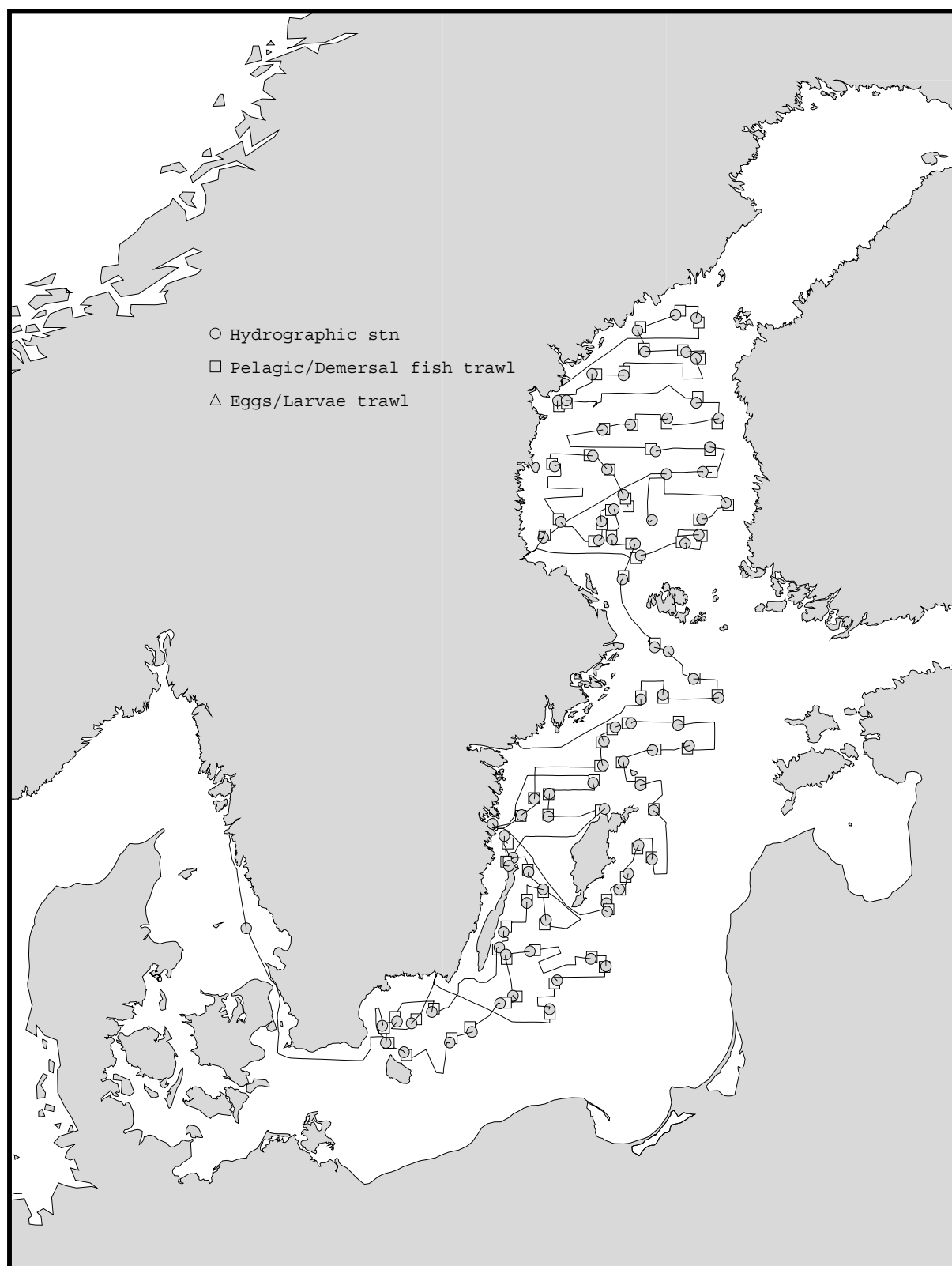


Section of The Baltic Sea



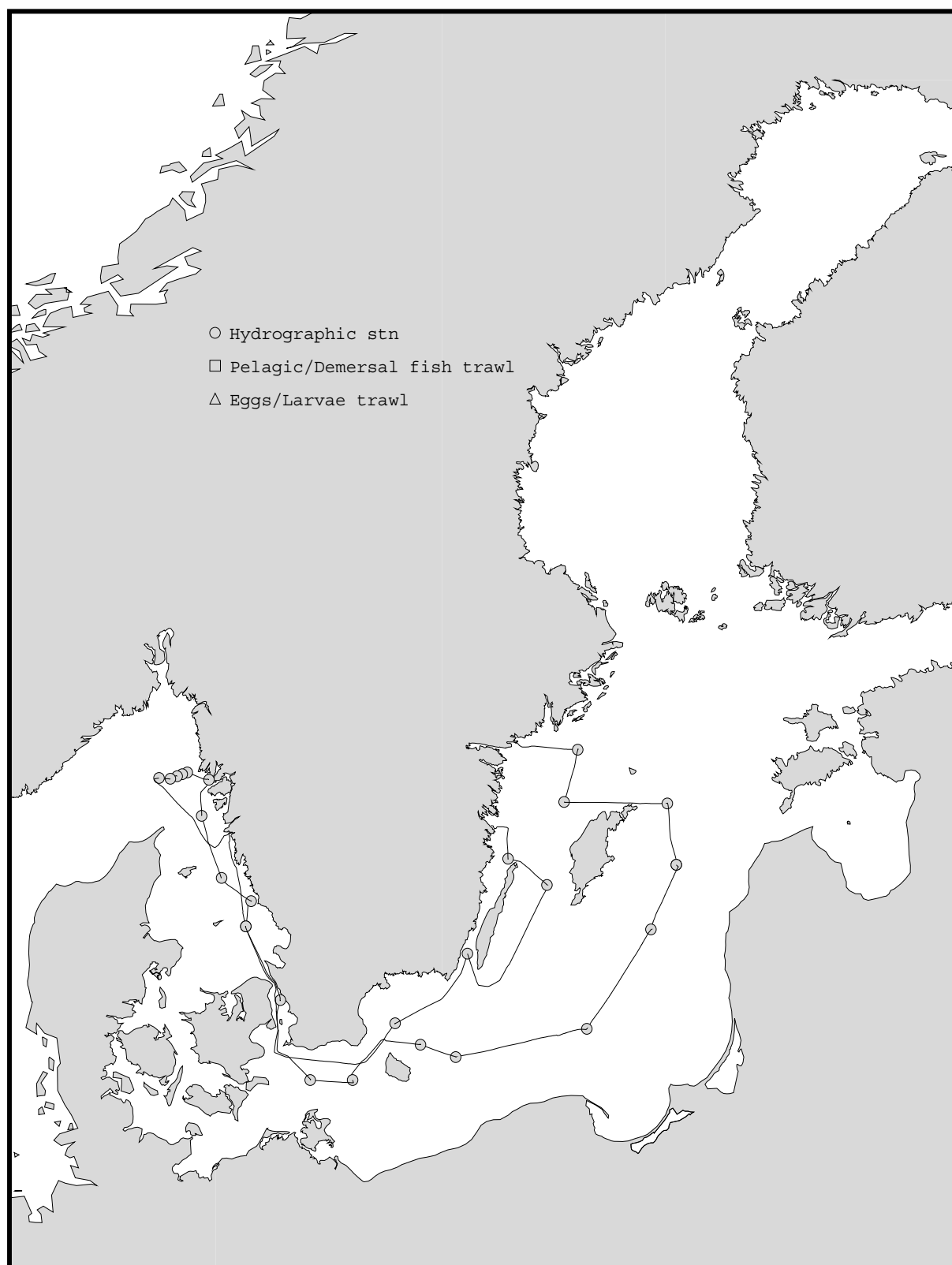
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TRACK CHART

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0559	BPNX00EKO		14SE SVENSKA BJÖRN	N5921.93	E2020.79	20100930	1031	63		30 2	11.0	1023	0010	x	-----P	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X
0560	BPNX00EKO		17S FINLANDS LEJON	N5909.69	E2048.45	20100930	1321	106		01 2	11.0	1023	0010	x	-----P	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X
0561	BPNX00EKO		20E ALMAGRUNDET	N5911.62	E1947.04	20100930	1710	69.3		09 2	11.0	1022	0010	x	-----P	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X
0562	BPNX00EKO		8ENE ALMAGRUNDET	N5908.75	E1922.73	20100930	2104	75.9		16 2	11.0	1023	9920	x	-----P	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X
0563	BPNX37EXT		BY31 LANDSORTSDJ	N5835	E1814	20101004	0050	459		16 12	11.4	1021	9990	x	--x----	23	x	x	-	x	x	x	x	x	x	x	x	x	-	x	-	-	-	-	X
0564	BPWX38BAS		BY32 NORRKÖPINGS DJ	N5801	E1759	20101004	0615	205		15 13	10.7	1020	1250	x	--x----	17	x	x	-	x	x	x	x	x	x	x	x	x	-	x	-	-	-	-	X
0565	BPEX26BAS		BY20 FÄRDJ	N5800	E1953	20101004	1300	202		16 13	11.8	1022	1250	x	--x----	17	x	x	-	x	x	x	x	x	x	x	x	x	-	x	-	-	-	-	X
0566	BPEX21BAS		BY15 GOTLANDSDJ	N5720	E2003	20101004	1830	240		15 15	11.4	1021	9990	x	---x---	19	x	x	-	x	x	x	x	x	x	x	x	x	x	-	x	-	-	-	X
0567	BPEX21EXT		BY15 GOTLAND																																

Date: 2010-11-24
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St no	Stat code	P ro j	Station-----	Lat-----	Lon-----	Date yyyymmdd	Time hhmm utc	Bottom depth m	Secchi depth m	Wind di ve	Air temp C	Air pres hPa	WCSI elec t aoae hd	C PPCPZZT Hrhhoo Cilyooa PrP l	No de	T S e a h m l i n	P O H 2 o y s g	H P 4 P P	T N 2 T N	N O 3 h o N	N T 4 t N	A S h o l i a 3	S H l o m g n	L P u i n	P O O C C m	T O O C C m			
0569	BPSE11BAS	BCS	III-10	N5533.3	E1824	20101005	1120	89		14 15	10.5	1018	1550	x --x----	12	x	x	-	x	x	x	x	x	-	x	-	-	-	x
0570	BPSB07BAS	BY5	BORNHOLMSDJ	N5515	E1559	20101005	2030	90		15 15	12.0	1016	9990	x -xxx---	12	x	x	x	x	x	x	x	x	x	x	-	-	-	x
0571	BPSB06BAS	BY4	CHRISTIANSÖ	N5523	E1520	20101005	2335	92		15 13	11.5	1016	9990	x -x-----	12	x	x	-	x	x	x	x	x	-	x	-	-	-	x
0572	BPSA03BAS	BY2	ARKONA	N5500	E1405	20101006	0630	46		14 12	10.6	1015	1450	x --xx----	8	x	x	-	x	x	x	x	x	-	x	-	-	-	x
0573	BPSA02BAS	BY1		N5500	E1318	20101006	0940	46		14 12	11.4	1014	1450	x --x-----	8	x	x	-	x	x	x	x	x	-	x	-	-	-	x
0574	SOCX39BAS	W	LANDSKRONA	N5552.0	E1245.0	20101006	1545	51		13 11	12.0	1015	2830	x -x-----	9	x	x	-	x	x	x	x	x	-	x	-	-	-	x
0575	KAEX29BAS	ANHOLT E		N5640.0	E1207.0	20101006	2150	62		15 16	13.0	1014	6990	x -xxx----	10	x	x	x	-	x	x	x	x	x	x	-	-	-	x
0576	KANX50BAS	N14	FALKENBERG	N5656.40	E1212.70	20101007	0010	32		15 15	11.9	1015	6990	x -xxx---	7	x	x	x	x	-	x	x	x	x	x	-	-	-	x
0577	KANX25BAS	FLADEN		N5711.5	E1140	20101007	0315	84		01 3	12.2	1017	6990	x -x-----	12	x	x	-	x	x	x	x	x	-	x	-	-	-	x
0578	SKEX23BAS	P2		N5752	E1118	20101007	0910	98	8	26 3	12.7	1022	1310	x -x-----	10	x	x	-	x	x	x	x	x	-	x	-	-	-	x
0579	FIBG27BAS	SLÄGGÖ		N5815.5	E1126.0	20101007	1310	76	10	27 3	12.3	1024	1210	x --xxx--	9	x	x	-	x	x	x	x	x	-	x	-	-	-	x
0580	SKEX14BAS	Å13		N5820.2	E1102	20101007	1530	117		21 2	13.0	1025	0030	x -x-----	10	x	x	-	x	x	x	x	x	-	x	-	-	-	x
0581	SKEX15BAS	Å14		N5819	E1056.5	20101007	1612	114		22 1	12.5	1026	0010	x -----	10	-	-	-	-	-	-	-	-	-	-	-	-	-	x
0582	SKEX16BAS	Å15		N5817.7	E1051	20101007	1700	137		22 1	12.1	1026	0030	x --x-----	12	x	x	-	x	x	x	x	x	-	x	-	-	-	x
0583	SKEX17BAS	Å16		N5816	E1043.5	20101007	1755	215		99 1	11.9	1026	9990	x -----	13	-	-	-	-	-	-	-	-	-	-	-	-	-	x
0584	SKEX18BAS	Å17		N5816.5	E1030.8	20101007	1955	327		99 1	12.0	1027	9990	x --xx----	14	x	x	x	-	x	x	x	x	x	-	-	-	-	x
0585	KAEX29BAS	ANHOLT E		N5640.0	E1207.0	20101008	1445	59	8	07 9	11.0	1028	2730	x -xxxx--	10	x	x	x	-	x	x	x	x	x	x	-	-	-	x
0586	BPSH05BAS	HANÖBUKTEN		N5537	E1452	20101009	0845	81	9																				

Date: 2010-11-24
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Ser no	Stat code	P r o j	Station-----	Lat-----	Lon-----	Date yyyymmdd	Time hhmm utc	Bottom depth m	Secchi depth m	Wind di ve	Air temp C	Air pres hPa	WCSI elec aoae tu hd	C t	PPCPZZT Hrhhhoor Cilyooa motPBw PrPl	No de	T e a l p i n	P h x	O x 2	H o o	P t n	N n n	N t o	A t k	S h o	L u i	P m g	P t n	C o c		
0617	BPWX00EKO		7SE ÖLANDS SÖDRA GRUND	N5716.76	E1718.64	20101019	2120	62		22 10	8.4	995	9990	x	-----P	9	x	x	-	x	-	-	-	-	-	-	-	-	-	-	x
0618	BPWX00EKO		22SW HOBURG	N5645.53	E1737.96	20101020	0645	86		22 3	8.9	995	2730	x	-----P	12	x	x	-	x	x	-	-	-	-	-	-	-	-	-	x
0619	BPWX00EKO		19SW STORA KARLSÖ	N5705.37	E1734.77	20101020	0950	110		20 3	8.2	995	2730	x	-----P	14	x	x	-	x	x	-	-	-	-	-	-	-	-	-	x
0620	BPWX00EKO		13SE HÖGBY	N5656.56	E1716.80	20101020	1310	70		12 3	8.3	994	2830	x	-----P	10	x	x	-	x	x	-	-	-	-	-	-	-	-	-	x
0621	BPWX00EKO		8NE BLÅSINGE HAMN	N5637.59	E1651.29	20101020	1740	50		34 12	6.1	995	6990	x	-----P	8	x	x	-	x	-	-	-	-	-	-	-	-	-	-	x
0622	BPWX00EKO		6NE SEGERSTAD	N5627.63	E1646.25	20101020	2100	58		36 12	5.6	996	9990	x	-----P	9	x	x	-	x	-	-	-	-	-	-	-	-	-	-	x
0623	BPSB00EKO		2S KLIPPBANKEN	N5545.67	E1531.92	20101021	0631	61		33 12	3.3	1006	2840	x	-----P	9	x	x	-	x	-	-	-	-	-	-	-	-	-	-	x
0624	BPSH00EKO		19ENE STENSHUVUD	N5539.42	E1453.48	20101021	1255	65		24 7	6.4	1009	1130	x	-----P	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x
0625	BPSH00EKO		23SE HANÖ	N5538.24	E1509.48	20101021	1715	74		22 13	7.5	1006	9990	x	-----P	11	x	x	-	x	-	-	-	-	-	-	-	-	-	-	x
0626	BPSE00EKO		13NE SÖDRA MIDSJÖBANKEN	N5547.53	E1741.82	20101025	0640	55		03 8	7.4	1003	8830	x	-----P	9	x	x	-	x	-	-	-	-	-	-	-	-	-	-	x
0627	BPSE00EKO		16ESE NORRA MIDSJÖBANKEN	N5606.12	E1750.38	20101025	1225	63		32 9	5.8	1009	2840	x	-----P	10	x	x	-	x	-	-	-	-	-	-	-	-	-	-	x
0628	BPSE00EKO		43SE HOBURG	N5615.33	E1844.13	20101025	1815	101		29 6	6.8	1012	9990	x	-----P	13	x	x	-	x	x	-	-	-	-	-	-	-	-	-	x
0629	BPEX00EKO		19S HOBURG BANK	N5620.24	E1827.54	20101025	2044	50		30 6	7.2	1012	9990	x	-----P	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x
0630	BPWX00EKO		30SE KAPELLUDDEN	N5625.18	E1720.29	20101026	0540	50		33 7	5.8	1016	1120	x	-----P	8	x	x	-	x	-	-	-	-	-	-	-	-	-	-	x
0631	BPWX00EKO		11E SEGERSTAD	N5622.93	E1653.64	20101026	0850	62		32 8	4.0	1018	0020	x	-----P	9	x	x	-	x	x	-	-	-	-	-	-	-	-	-	x
0632	BPSE00EKO		MIDSJÖHÅLET	N5556.28	E1701.44	20101026	1238	45		27 6	6.7	1020	0020	x	-----P	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x
0633	BPSSE00EKO		26SE ÖLANDS SÖDRA GRUND	N5551.21	E1647.23	20101026	1514	41		28 8	8.3	1021	0030	x	-----P																