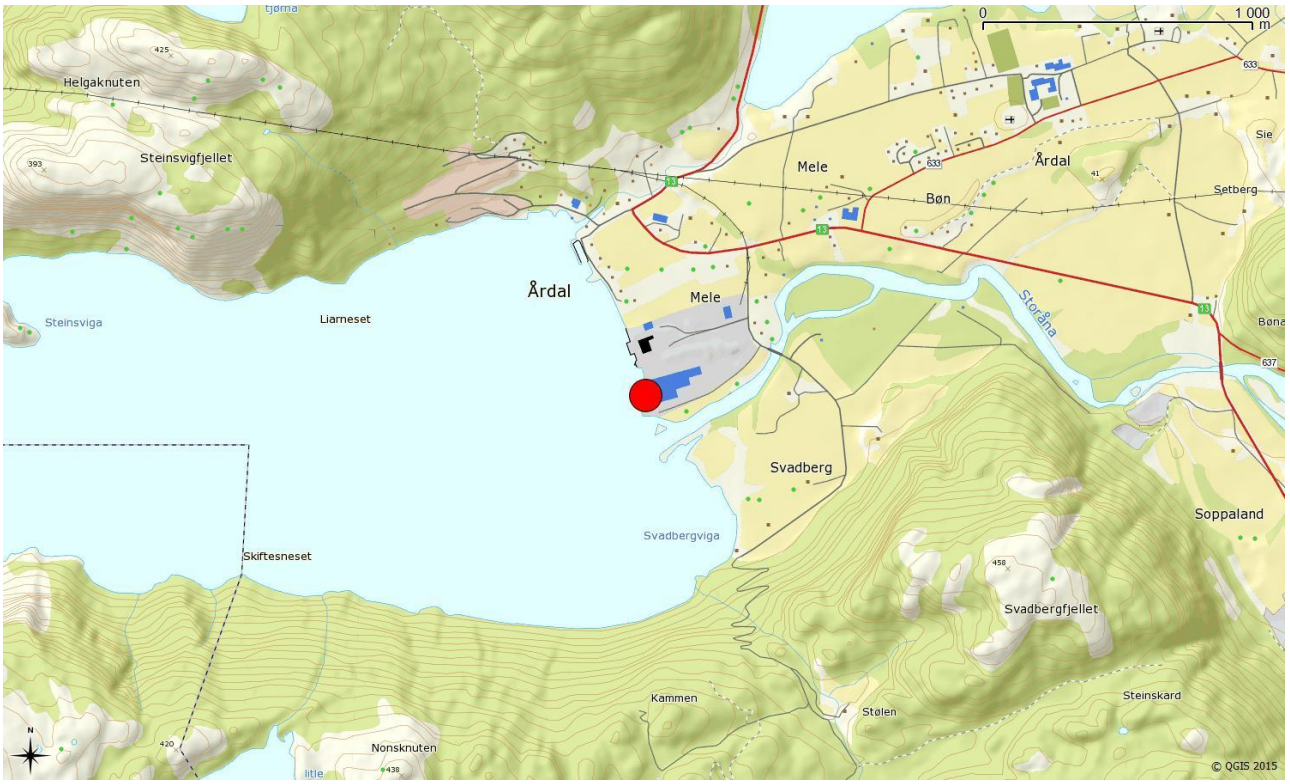
Risk assessment of sediments by Monier's quay in Årdal



Dredging area, Hjelmeland kommune

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CONTENT

1 PREFACE **1**
2 SUMMARY **2**
3 INTRODUCTION **3**
4 DESCRIPTION OF THE AREA **4**
5 DESIRED ENVIRONMENTAL CONDITION **7**
6 RISK ASSESSMENT, STEP 1 ..... **7**
6.1 METHODS 7
6.2 RESULTS 9
7 CONCLUSION **14**
8 REFERENCES **15**
9 APPENDIX **16**

1 PREFACE

Ecofact has conducted environmental surveys of sediment layers from the seafloor at a specified locality outside Monier's quay in Årdal (Hjelmeland municipality). This was requested by IPP Ingenieurgesellschaft (Georgina Holmes) on behalf of Monier, since there are plans to dredge the outside of the quay. In that context it is necessary to determine whether contaminants are present, the extent of their presence and the possible risk this entails. Ecofact would like to thank the involved partners for the cooperation.

August 2015

Sina Thu Randulff

2 SUMMARY

Description of the assignment

The reason for the environmental survey is the plans of dredging the area outside the quay of Monier. Ecofact has earlier reported elevated levels of the organic contaminant tributyltin (TBT) in the upper sediment layer. In order to clarify the extent of the contamination this survey investigates the concentrations of contaminants deeper down the sediment layers. This information is useful when determining further actions.

Data basis

Data collection of the mid and lower sediment layer was conducted the 15.07.15. Eurofins has analysed the samples. The upper layer was collected 20.02.15 and the results were given by Ecofact, 17.07.2015 (OKL-02166).

Results

The investigated sediment layers are not exceeding the limit values for ecological risk (given in TA-2802) for metals or the organic pollutants PCBs and PAHs. Based on the results from this and the former survey we conclude that the upper (0-10 cm) and mid layer (10-30 cm) do not reach the desired environmental condition for TBT, due to the presence of a point source. The lower sediment layer (30-50 cm) is not contaminated and considered to be no risk.

3 INTRODUCTION

Ecofact has conducted environmental surveys of the seabed at a specified locality outside Monier's quay in Årdal (Hjelmeland municipality), as requested by Akkar (Jostein Salte), on behalf of Monier. There are plans to dredge the outside of the quay, and it is therefore necessary to determine whether contaminants are present and the possible risk this entails. Another survey was conducted by Ecofact on the top layer (0-10 cm) of the sediments (OKL-02166, 17.07.2015), and showed elevated tributyltin (TBT) values. In order to reveal the extent of the TBT-contamination this survey investigates the contaminant levels deeper down in the sediment layer (10-30 cm and 30-50 cm). Field work was conducted the 15.07.2015, and sediment samples were analysed by the accredited laboratory Eurofins. The obtained sediment samples are analysed as given in the TA-2802 regulations of the Norwegian Environment Agency, and classified according to TA-2229.

4 DESCRIPTION OF THE AREA

The area in question is located in Årdalsfjord, just north of the Årdal River estuary (Figure 1 and 2). The quay facilities are located in a delta, and thus lie in an area of natural alluvial deposits which over years has settled natural reserves (Figure 3). Additionally the pile quay is formed by unintentional deposits from loading and unloading of ships. The depth is therefore significantly reduced and the developer wants to dredge loads as a result of this. Årdalsfjord is a relatively deep fjord, with a steep gradient towards the delta. This reduces the risk of resuspension of sediments. The seabed will only locally be affected by whirling from propellers. The area is frequented by ships and the developer says that it is a boat docked approximately 3 days a week.

The surrounding land area currently consists of Monier's industrial area, with mostly hard surfaces (Figure 3). It is thus potentially subjected to adverse runoff of surface water. There are landscaped an artificial promontory south of the area of measures, consisting of broken tiles and paving stones.

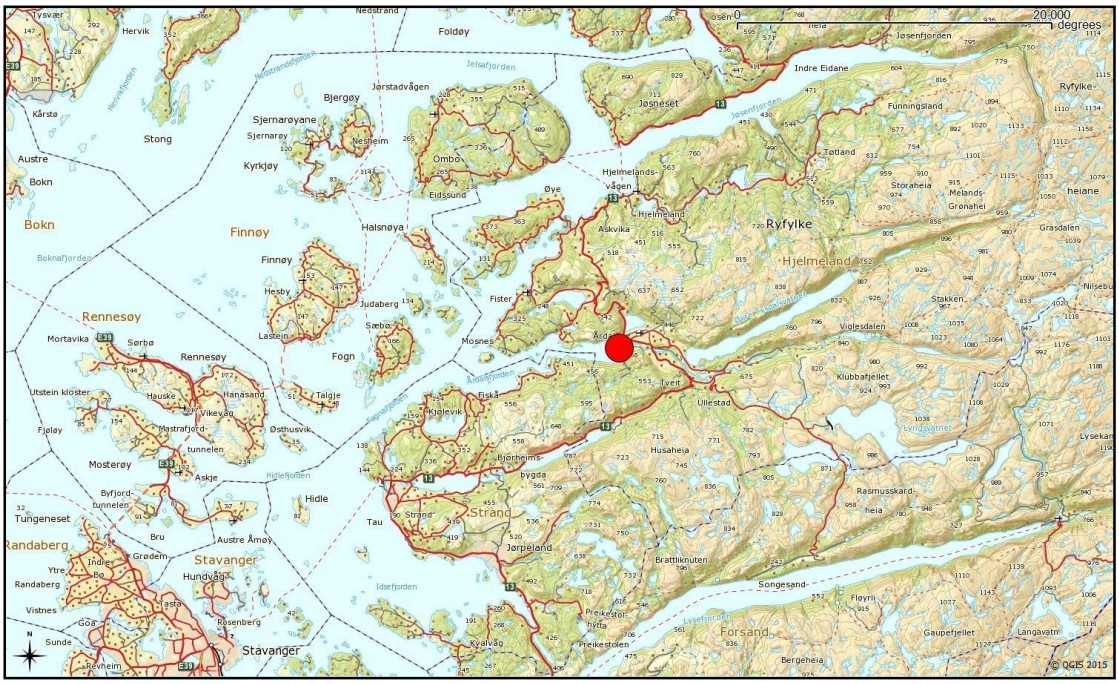

Figure 1. Regional localization of the study area; Årdal in Hjelmeland municipality.

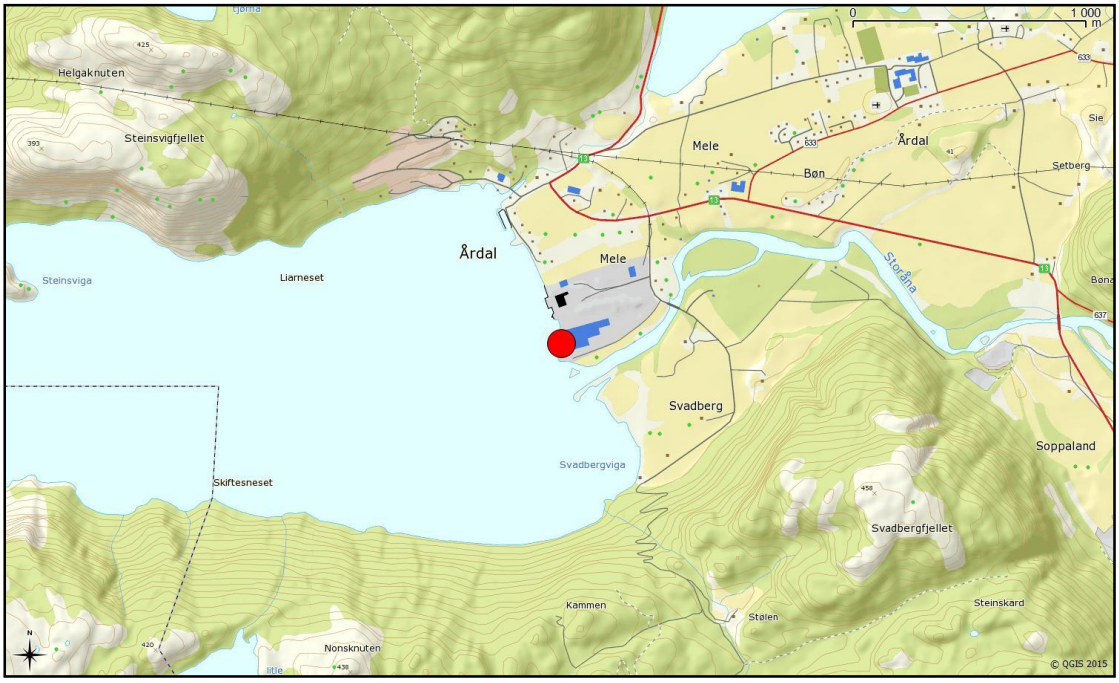

Figure 2. Local localization of the study area; in the end of the Årdal fjord.

Figure 3. The area of measures is marked with a black, dashed line outside Moniers quay facility. Red points shows the locations of the 4 subsamples for the upper 10 cm previously sampled.

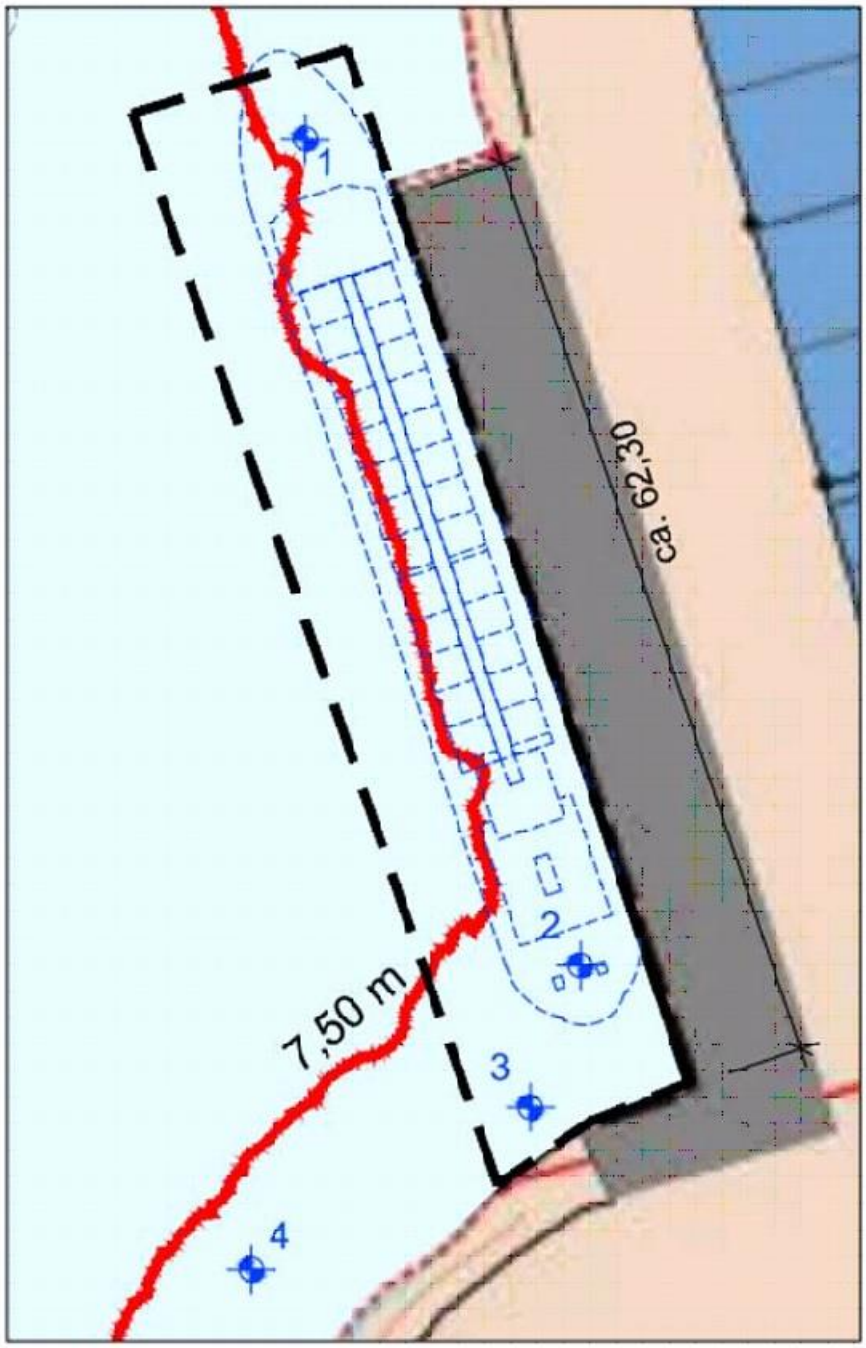

Figure 4. Sample location 1-4. Sample point 1-3 was samples for separate layers 10-20 cm and 20-50 cm. Sample point 4 was sampled in 3 separate layers; 0-10 cm, 10-30 cm and 30-50 cm.

5 DESIRED ENVIRONMENTAL CONDITION

This project aims to reach the environmental targets for stage 1, ecological conditions, based on the TA-2802 guide of the Norwegian Environment Agency (the former Climate and Pollution Agency).

Desired state of the environment: Below the limit specified in step 1 for TA-2802.

If contaminated soil is detected it must be considered removed or covered. It is recommended to use the Climate and Pollution Agency guide for handling contaminated soil, TA-2960, if measures are needed.

6 RISK ASSESSMENT, STEP 1

6.1 Methods

The method used in the survey is adapted the areas limited extent (1.5 ha). The method is originally designed for surveys in larger geographic areas such as fjords and larger basins. Since the range of the area of measure is so small, a mixed sample point consisting of four subsamples was considered to be an adequate coverage of the area. Toxicity test can normally be omitted in smaller surveys according to TA-2802.

Fieldwork was conducted 15.07.2015 by Ole K. Larsen and Sina T. Randulff. Sediments were sampled from 3 different layers of the seabed; upper layer (0-10 cm), mid layer (10-30 cm) and lower layer (30-50 cm). 4 subsamples were sampled to represent a mixed sample from the given layer of the seabed (Figure 3 and 4). As the upper layer has been sampled before, only one additional subsample was sampled from this layer. The concentrations of the 0-10 cm layer were therefore compared against the results given in OKL-02166, 17.07.2015, and only used to complement these.

The samples were obtained by pushing a sample tube (35 mm diameter) into the sediments. A cap created a vacuum and thereby retained the sediment inside by the tube for inspection and separation into different layers. No anoxic layers were included. The samples were placed in diffusion-tight bags prior to analysis at an accredited laboratory (Eurofins). Both metals (arsenic, cadmium, copper, chromium, mercury, nickel, lead and zinc) and organic pollutants (polyaromatic hydrocarbons (PAHs), polychlorinated byphenyls (PCBs) and TBT) were analysed. The detected concentrations of the contaminants were assessed towards their ecological status classes for TA-2229 (see Table 1) and the limit values specified in step 1 for TA-2802.

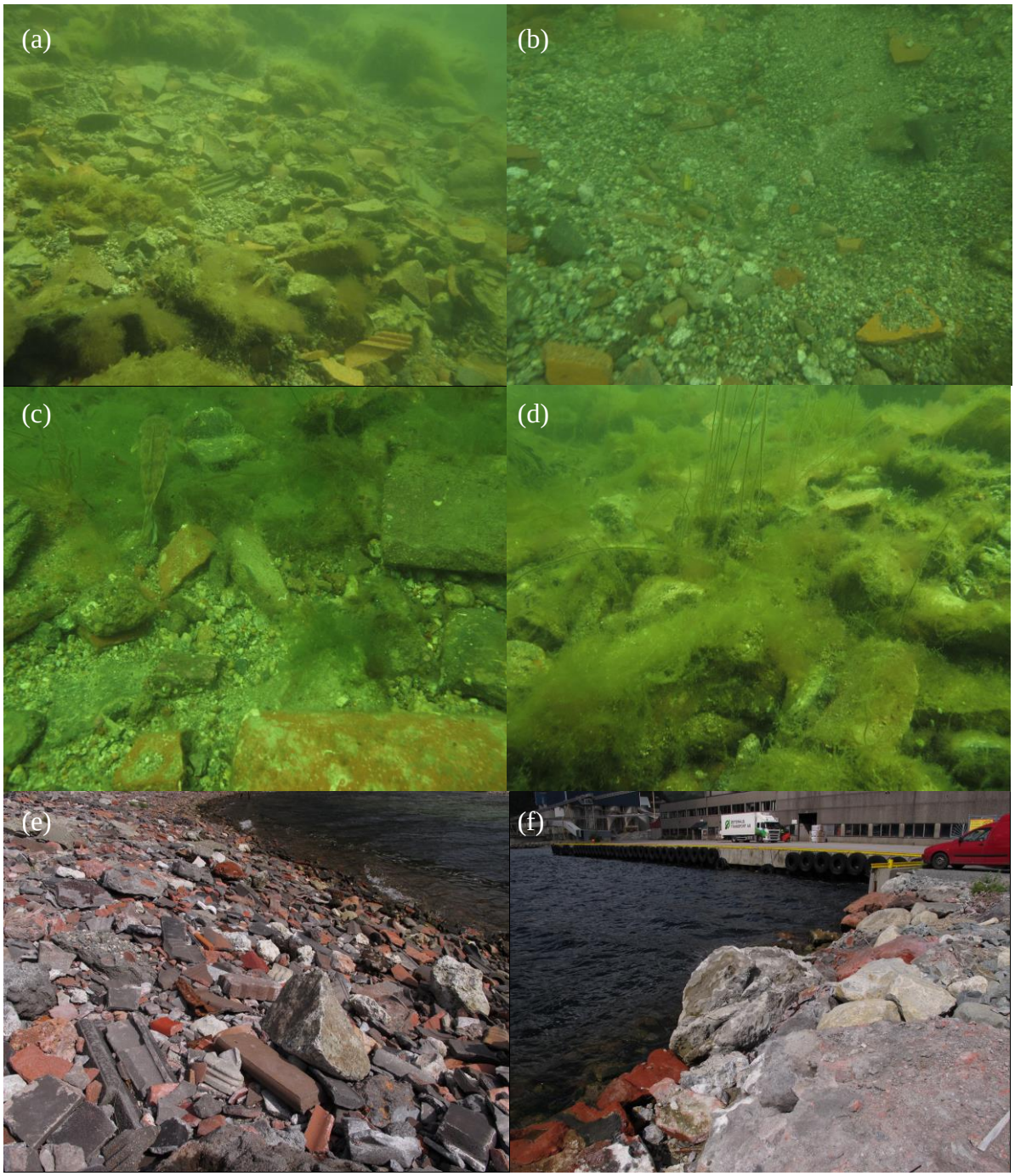

Figure 5: (a-d) The seafloor in the sample area varied in the size of the sediment composition and consist mainly of artificial material (tiles an paving stones)..
(d-e) The artificial promontory beside the quay was mainly consisting of broken tiles and paving stones.

Table 1. Classification of the environmental condition of sediments based on the content of metals and organic contaminants, as given in TA-2229/2007. Metals are given as mg/kg, the remaining contaminants as µg/kg.

Chemical status/ contaminant	**Class 1 Background**	**Class 2 Good**	**Class 3 Moderate**	**Class 4 Poor**	**Class 5 Bad**
***Metals** (mg/kg)*					
Arsenic (As)	<20	20-52	52-76	76-580	>580
Cadmium (Cd)	<0,25	0,25-2,6	2,6-15	15-140	>140
Copper (Cu)	<35	35-51	51-55	55-220	>220
Chromium (Cr)	<70	70-560	560-5900	5900-59000	>59000
Mercury (Hg)	<0,15	0,15-0,63	0,63-0,86	0,86-1,6	>1,6
Nickel (Ni)	<30	30-46	46-120	120-840	>840
Lead (Pb)	<30	30-83	83-100	100-720	>720
Zinc (Zn)	<150	150-360	360-590	590-4500	>4500
***PAHs** (µg/kg)*					
Naphthalene	<2	2-290	290-1000	1000-2000	>2000
Acenaphthylene	<1,6	1,6-33	33-85	85-850	>850
Acenaphthene	<4,8	4,8-160	160-360	360-3600	>3600
Fluoren	<6,8	6,8-260	260-510	510-5100	>5100
Phenanthrene	<6,8	6,8-500	500-1200	1200-2300	>2300
Anthracene	<1,2	1,2-31	31-100	100-1000	>1000
Fluoranthene	<8	8-170	170-1300	1300-2600	>2600
Pyrene	<5,2	5,2-280	280-2800	2800-5600	>5600
Benzo[*a*]anthracene	<3,6	3,6-60	60-90	90-900	>900
Chrysene	<4,4	4,4-280	280-280	280-560	>560
Benzo[*b*]fluorantren	<46	46-240	240-490	490-4900	>4900
Benzo[*k*]fluorantren		<210	210-480	480-4800	>4800
Benzo[*a*]pyrene	<6	6-420	420-830	830-4200	>4200
Indenopyren	<20	20-47	47-70	70-700	>700
Dibenzoantracen	<12	12-590	590-1200	1200-12000	>12000
Benzoperylen	<18	18-21	21-31	31-310	>310
ΣPAH_{16}	<300	300-2000	2000-6000	6000-20000	>20000
ΣPCB_7	<5	5-17	17-190	190-1900	>1900
TBT-effect based		<0,002	0,002-0,016	0,016-0,032	>0,032
TBT- administrative	<1	1-5	5-20	20-100	>100

6.2 Results

The detected concentrations of the contaminants are given as max and median of the subsamples in table 2 for the upper layer, table 3 for the mid layer and table 4 for the lower layer. The concentrations measured in the upper layer in the former survey are also given in the results here, while the concentrations found in the complementary subsample are given in appendix, table 1. PCBs and PAHs were below the limit of quantification for all samples from all layers. As shown in table 3-4, none of the detected mean sediment concentrations from the mid and lower sediment layer exceeded the level 1 limit values given in TA-2802. However, the highest TBT concentration (23µg/kg) detected in one subsample from the mid-layer exceeded the level 1 limit value. The subsample with elevated TBT levels (23 µg/kg) was in contrast to the other 3 subsamples (<1.9 µg/kg).

For the mid and lower layer the TA-2229/2007 classification of the contaminants indicated that the state of the contamination belonged to Class 1 Background for all the detected contaminants except from TBT (table 5). TBT were not found in the upper layer in this survey (Table 1, appendix), but was detected in substantial amounts in the former survey (Table 2). The TBT concentration detected in the mid layer were classified as moderate (Class 3), and the lower layer as good (Class 2) (table 5). The subsample with elevated TBT levels (10-30 cm) falls within the class 4 (bad).

Table 2. Detected contaminant levels from of the upper sediment layer sampled the 20.02.2015 outside Monier's quay. The levels are compared to level 1 limit values, TA-2802. Concentrations are given as mg/kg for metals and µg/kg for organic pollutants. The results belong to the former survey, OKL-02166.

	Detected sediment concentration (0-10 cm)			**Level 1 limit values (mg/kg)**	**Detected sediment concentration (0-10 cm) compared to level 1 limit values (mg/kg) (number of times):**	
Contaminant	Number of samples	$C_{sed,\ max}$ (mg/kg)	$C_{sed,\ median}$ (mg/kg)		**Max**	**Median**
Arsenic (As)	1	1,7	1,7	52		
Lead (Pb)	1	7,6	7,6	83		
Cadmium (Cd)	1	0,005	0,005	2,6		
Copper (Cu)	1	15	15	51		
Chromium (Cr)	1	10	10	560		
Mercury (Hg)	1	0,0005	0,0005	0,63		
Nickel (Ni)	1	7,9	7,9	46		
Zinc (Zn)	1	41	41	360		
Naphthalene	1	0,005	0,005	0,29		
Acenaphthylene	1	0,005	0,005	0,033		
Acenaphthene	1	0,005	0,005	0,16		
Fluoren	1	0,005	0,005	0,26		
Phenanthrene	1	0,005	0,005	0,50		
Anthracene	1	0,005	0,005	0,031		
Fluoranthene	1	0,005	0,005	0,17		
Pyrene	1	0,005	0,005	0,28		
Benzo[*a*]anthracene	1	0,005	0,005	0,06		
Chrysene	1	0,005	0,005	0,28		
Benzo[*b*]fluorantren	1	0,005	0,005	0,24		
Benzo[*k*]fluorantren	1	0,005	0,005	0,21		
Benzo[*a*]pyrene	1	0,005	0,005	0,42		
Indenopyren	1	0,005	0,005	0,047		
Dibenzoantracen	1	0,005	0,005	0,59		
Benzoperylen	1	0,005	0,005	0,021		
PCB 28	1	0,00025	0,00025			
PCB 52	1	0,00025	0,00025			
PCB 101	1	0,00025	0,00025			
PCB 118	1	0,00025	0,00025			
PCB 138	1	0,00025	0,00025			
PCB 153	1	0,00025	0,00025			
PCB 180	1	0,00025	0,00025			
ΣPCB_7	1	*1,75E-03*	*1,75E-03*	*0,017*	*0,10*	*0,10*
Tributyltin (TBT-ion)	1	0,021	0,021	0,035		

nd = not detected

Table 3. Detected contaminant levels in mid sediment layer outside Monier's quay compared to level 1 limit values, TA-2802. Concentrations are given as mg/kg for metals and µg/kg for organic pollutants.

Contaminant	Detected sediment concentration (10-30 cm)			Level 1 limit values (mg/kg)	Detected sediment concentration (10-30 cm) compared to level 1 limit values (mg/kg) (number of times):	
	Number of samples	$C_{sed,\ max}$ (mg/kg)	$C_{sed,\ median}$ (mg/kg)		Max	Median
Arsenic (As)	4	2.50	1.35	52		
Lead (Pb)	4	7.3	5.7	83		
Cadmium (Cd)	4	0.054	0.027	2.6		
Copper (Cu)	4	12.0	7.9	51		
Chromium (Cr)	4	13.0	9.3	560		
Mercury (Hg)	4	0.002	0.002	0.63		
Nickel (Ni)	4	9.0	6.9	46		
Zinc (Zn)	4	47	36	360		
Naphthalene	4	<0.010	<0.010	0.29		
Acenaphthylene	4	<0.010	<0.010	0.033		
Acenaphthene	4	<0.010	<0.010	0.16		
Fluoren	4	<0.010	<0.010	0.26		
Phenanthrene	4	<0.010	<0.010	0.50		
Anthracene	4	<0.010	<0.010	0.031		
Fluoranthene	4	<0.010	<0.010	0.17		
Pyrene	4	<0.010	<0.010	0.28		
Benzo[*a*]anthracene	4	<0.010	<0.010	0.06		
Chrysene	4	<0.010	<0.010	0.28		
Benzo[*b*]fluorantren	4	<0.010	<0.010	0.24		
Benzo[*k*]fluorantren	4	<0.010	<0.010	0.21		
Benzo[*a*]pyrene	4	<0.010	<0.010	0.42		
Indenopyren	4	<0.010	<0.010	0.047		
Dibenzoantracen	4	<0.010	<0.010	0.59		
Benzoperylen	4	<0.010	<0.010	0.021		
PCB 28	4	<0.0005	<0.0005			
PCB 52	4	<0.0005	<0.0005			
PCB 101	4	<0.0005	<0.0005			
PCB 118	4	<0.0005	<0.0005			
PCB 138	4	<0.0005	<0.0005			
PCB 153	4	<0.0005	<0.0005			
PCB 180	4	<0.0005	<0.0005			
ΣPCB_7	4	nd	nd	0.017		
Tributyltin (TBT-ion)	4	0,023	0,006725	0,035		

nd = not detected

Table 4. Detected contaminant levels in lower sediment layer outside Monier's quay compared to level 1 limit values, TA-2802. Concentrations are given as mg/kg for metals and µg/kg for organic pollutants.

Contaminant	Detected sediment concentration (30-50 cm)			Level 1 limit values (mg/kg)	Detected sediment concentration (30-50 cm) compared to level 1 limit values (mg/kg) (number of times):	
	Number of samples	$C_{sed,\ max}$ (mg/kg)	$C_{sed,\ median}$ (mg/kg)		Max	Median
Arsenic (As)	4	2.70	1.43	52		
Cadmium (Cd)	4	8.1	5.8	83		
Copper (Cu)	4	0.071	0.029	2.6		
Chromium (Cr)	4	12.0	7.2	51		
Mercury (Hg)	4	15.0	8.4	560		
Nickel (Ni)	4	0.002	0.001	0.63		
Lead (Pb)	4	9.4	6.1	46		
Zinc (Zn)	4	51	35	360		
Naphthalene	4	<0.010	<0.010	0.29		
Acenaphthylene	4	<0.010	<0.010	0.033		
Acenaphthene	4	<0.010	<0.010	0.16		
Fluoren	4	<0.010	<0.010	0.26		
Phenanthrene	4	<0.010	<0.010	0.50		
Anthracene	4	<0.010	<0.010	0.031		
Fluoranthene	4	<0.010	<0.010	0.17		
Pyrene	4	<0.010	<0.010	0.28		
Benzo[*a*]anthracene	4	<0.010	<0.010	0.06		
Chrysene	4	<0.010	<0.010	0.28		
Benzo[*b*]fluorantren	4	<0.010	<0.010	0.24		
Benzo[*k*]fluorantren	4	<0.010	<0.010	0.21		
Benzo[*a*]pyrene	4	<0.010	<0.010	0.42		
Indenopyren	4	<0.010	<0.010	0.047		
Dibenzoantracen	4	<0.010	<0.010	0.59		
Benzoperylen	4	<0.010	<0.010	0.021		
PCB 28	4	<0.0005	<0.0005			
PCB 52	4	<0.0005	<0.0005			
PCB 101	4	<0.0005	<0.0005			
PCB 118	4	<0.0005	<0.0005			
PCB 138	4	<0.0005	<0.0005			
PCB 153	4	<0.0005	<0.0005			
PCB 180	4	<0.0005	<0.0005			
ΣPCB_7	4	nd	nd	0.017		
Tributyltin (TBT-ion)	4	0,0013	0,001075	0,035		

nd = not detected

Table 5. TA-2229/2007 classification of the concentrations of contaminants from the different sediment layers outside Monier's quay. The upper sediment layer (0-10 cm) were sampled 15.02.15 (OKL-02166).

Station/ contaminants	**Upper layer (0-10 cm)**	**Mid layer (10-30 cm)**	**Lower layer (30-50 cm)**
***Metals** (mg/kg)*			
Arsenic (As)	1,7	1.35	1.43
Lead (Pb)	7,6	5.7	5.8
Cadmium (Cd)	<0,10	0.027	0.029
Copper (Cu)	15	7.9	7.2
Chromium (Cr)	10	9.3	8.4
Mercury (Hg)	<0,001	0.002	<0.001
Nickel (Ni)	7,9	6.9	6.1
Zinc (Zn)	41	36	35
***PAHs** (µg/kg)*			
Naphthalene	<10	<10	<10
Acenaphthylene	<10	<10	<10
Acenaphthene	<10	<10	<10
Fluoren	<10	<10	<10
Phenanthrene	<10	<10	<10
Anthracene	<10	<10	<10
Fluoranthene	<10	<10	<10
Pyrene	<10	<10	<10
Benzo[*a*]anthracene	<10	<10	<10
Chrysene	<10	<10	<10
Benzo[*b*]fluorantren	<10	<10	<10
Benzo[*k*]fluorantren	<10	<10	<10
Benzo[*a*]pyrene	<10	<10	<10
Indenopyren	<10	<10	<10
Dibenzoantracen	<10	<10	<10
Benzoperylen	<10	<10	<10
ΣPAH_{16}	nd	nd	nd
***PCBs** (µg/kg)*			
ΣPCB_7	nd	nd	nd
TBT *(µg/kg)*	21	6.73	1.08

nd = not detected

7 CONCLUSION

The absence of detectable levels of PCBs and PAHs, and the low concentrations of metals indicates that the state of contamination of these compounds is very good. The TA-2229/2007 classification of these contaminants showed that they were detected in background concentrations. This is in accordance with what was found in the upper layer in the former survey. Because the former survey detected elevated levels of TBT, this study was conducted to reveal the extent of this contamination. The TBT levels do show a tendency to decrease down the sediment layers. The classification of the TBT concentrations indicates moderate levels (class 3) for the mid sediment layers and good levels for the lower sediment layer (class 2). The concentrations that were detected in this study did exceed the level 1 limit values for TA-2802 for the mid-layer, as one subsample had highly elevated levels. This indicates the presence of a point source.

The sediments can be declared as not contaminated and considered to be no risk if:

- The mean concentration of each contaminant in all samples are below the level 1 limit value, *and*
- The concentrations of the subsamples are below 2x the limit value *and*
- The subsamples are TA-2229/2007 classified below class 4 (bad).

The mid-sediment layer (10-30 cm) cannot be declared as not contaminated of TBT. Based on the results from this and the former survey we conclude that the upper and mid layer do not reach the desired environmental condition. The subsamples indicates that the contamination in the mid-layer consist in a hot-spot. The lower sediment layer (30-50 cm) is not contaminated and considered to be no risk.

TBT is a highly persistent and toxic contaminant for a range of marine organisms, with the dog whelk being very vulnerable (Bryan et al., 1986). TBT can cause sterility as a result of imposex, which is the development of masculine characteristics on the females. This has led to total collapses of some populations. The biocide has since the 50s been applied to the hulls of vessels for its anti-fouling properties, commonly known as bottom paint. The use was limited throughout the 90s, and a total ban was introduced in 2008. Nevertheless, shipping is still an active source, as TBT may be present on older ships. Elevated levels of TBT are also usual to find in sediments by old marinas and trafficked harbours, because the compound binds to suspended matter and to sediments (Evans et al., 1995). The long half-life makes it persist in the sediments, where it can be released even 30 years later. By dredging the quay area TBT will be removed from the local environment. This process may also cause spreading of the contaminant, and the process should therefore be performed with caution.

8 REFERENCES

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9 APPENDIX

Table 1. Detected contaminant levels from the compementary sample of the upper sediment layer outside Monier's quay compared to level 1 limit values, TA-2802. Concentrations are given as mg/kg for metals and µg/kg for organic pollutants.

Contaminant	Detected sediment concentration (0-10 cm)			Level 1 limit values (mg/kg)	Detected sediment concentration (0-10 cm) compared to level 1 limit values (mg/kg) (number of times):	
	Number of samples	$C_{sed,\ max}$ (mg/kg)	$C_{sed,\ median}$ (mg/kg)		Max	Median
Arsenic (As)	1	1.50	1.50	52		
Lead (Pb)	1	6.00	6.00	83		
Cadmium (Cd)	1	0.043	0.043	2.6		
Copper (Cu)	1	10.0	10.0	51		
Chromium (Cr)	1	9.9	9.9	560		
Mercury (Hg)	1	0.002	0.002	0.63		
Nickel (Ni)	1	8.00	8.00	46		
Zinc (Zn)	1	43.00	43.00	360		
Naphthalene	1	<0.010	<0.010	0.29		
Acenaphthylene	1	<0.010	<0.010	0.033		
Acenaphthene	1	<0.010	<0.010	0.16		
Fluoren	1	<0.010	<0.010	0.26		
Phenanthrene	1	<0.010	<0.010	0.50		
Anthracene	1	<0.010	<0.010	0.031		
Fluoranthene	1	<0.010	<0.010	0.17		
Pyrene	1	<0.010	<0.010	0.28		
Benzo[*a*]anthracene	1	<0.010	<0.010	0.06		
Chrysene	1	<0.010	<0.010	0.28		
Benzo[*b*]fluorantren	1	<0.010	<0.010	0.24		
Benzo[*k*]fluorantren	1	<0.010	<0.010	0.21		
Benzo[*a*]pyrene	1	<0.010	<0.010	0.42		
Indenopyren	1	<0.010	<0.010	0.047		
Dibenzoantracen	1	<0.010	<0.010	0.59		
Benzoperylen	1	<0.010	<0.010	0.021		
PCB 28	1	<0.0005	<0.0005			
PCB 52	1	<0.0005	<0.0005			
PCB 101	1	<0.0005	<0.0005			
PCB 118	1	<0.0005	<0.0005			
PCB 138	1	<0.0005	<0.0005			
PCB 153	1	<0.0005	<0.0005			
PCB 180	1	<0.0005	<0.0005			
ΣPCB_7	1	nd	nd	0.017		
Tributyltin (TBT-ion)	1	<1.00	1.00	0.035		

nd = not detected

Table 2. TA-2229/2007 classification of the concentrations of contaminants from the different sediment layers outside Monier's quay.

Contaminant	**Upper layer (0-10 cm)**
***Metals** (mg/kg)*	
Arsenic (As)	1.50
Lead (Pb)	6.0
Cadmium (Cd)	0.043
Copper (Cu)	10.0
Chromium (Cr)	9.9
Mercury (Hg)	0.002
Nickel (Ni)	8.0
Zinc (Zn)	43
PAH (µg/kg)	
Naphthalene	<0.010
Acenaphthylene	<0.010
Acenaphthene	<0.010
Fluoren	<0.010
Phenanthrene	<0.010
Anthracene	<0.010
Fluoranthene	<0.010
Pyrene	<0.010
Benzo[*a*]anthracene	<0.010
Chrysene	<0.010
Benzo[*b*]fluorantren	<0.010
Benzo[*k*]fluorantren	<0.010
Benzo[*a*]pyrene	<0.010
Indenopyren	<0.010
Dibenzoantracen	<0.010
Benzoperylen	<0.010
ΣPAH_{16}	nd
***PCBs** (µg/kg)*	
ΣPCB_7	nd
TBT *(µg/kg)*	<1