BALANCE Interim Report No. 14

Intercalibration of sediment data from the Archipelago Sea

Title Intercalibration of sediment data from the Archipelago Sea					BALANCE Interim Report No.14			
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Revisi	Description	By	Checked	Approved	Date
1	Final report	AK	JYR	JYR	19/8-06
0	Draft report	AK	AR	JYR	19/5-06
	Front page illustration Box corer sample from the Archipelago Sea, *Image: GTK, 2005*				

Key words	Classification
BALANCE; sediment classification & harmonization, Archipelago Sea	☒ Open ☐ Internal ☐ Proprietary

Distribution	No of copies
BALANCE Secretariat	3 + pdf
BALANCE partnership	20 + pdf
BSR INTERREG IIB Joint Secretariat	1
Archive	1

CONTENTS

0 PREFACE

Marine geological data from numerous national and international sources has been used in production of the BALANCE Marine Landscapes for the Baltic Sea. This data was first harmonised to one classification scheme according to the predicted surficial material. These BALANCE sediment classes are:

1. Hard bottom, Bedrock (crystalline and sedimentary), Bedrock covered with boulders.
2. Hard bottom, Complex, patchy hard surface, coarse sand (sometimes also clay*)* to boulders.
3. Sand, fine to coarse sand (with gravel exposures)
4. Hard clay, sometimes/often/possibly exposed or covered with a thin layer of sand/gravel
5. Mud, gyttja-clay to gyttja-silt.

In this document we examine, how the harmonisation of Finnish marine geological data has been succeeded in the Archipelago Sea, BALANCE pilot area 3 (Figure 1). Do the predicted benthic substrates in BALANCE sediment map correspond to that observed through sampling?
Intercalibration was performed at local scale (1: 20 000) and at detailed scale. Collaboration between a numbers of authorities was also tested in the field inventories. Present study was done jointly between European BALANCE- and national VALKO- projects, because they share the same interests in the Archipelago Sea. The VALKO -project is part of the Finnish Inventory Programme for the Underwater Marine Environment (VELMU). The main aim of VALKO –project is to develop a collaboration model for the implementation of the geological and biological field inventories. Harmonization of survey methodology and data classification is an essential part of both projects.

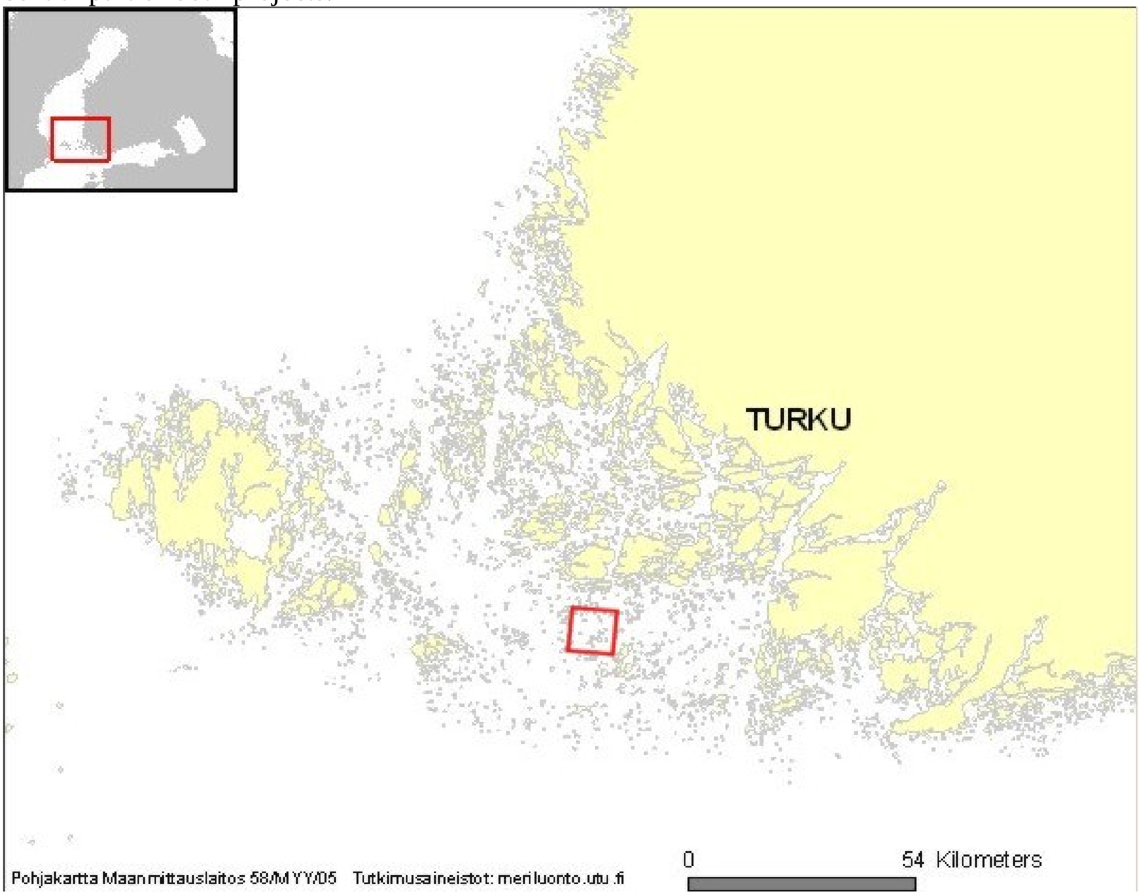

Fig. 1. *Study area in the Archipelago Sea (red square), Ormskär area (map page 103210).*

1 STUDY AREA

The field investigations were conducted in Ormskär area (map page 103210) (Figure 1), in the Archipelago Sea (Kotilainen et al., 2006; Kotilainen & Reijonen, 2006). Comparison between BALANCE sediment maps and sediment data was examined at local scale (1: 20 000) (Figure 2), as well as at detailed scale (in small area around Storlandet islands) (Figure 2, Figure 3).

The variable topography and the patchy nature of sedimentation are typical for the Archipelago Sea (Häkkinen, 1990). In the outer archipelago, in more open environment, the seabed erosion is more extensive than in the middle and the inner archipelago. Bedrock outcrops are common, which is distinct also in the study area. The water depth, exposure of the shore, sea bottom type and many other environmental factors vary even within small areas. Consequently, high diversity in sediment types is observed especially in the detailed studied area (Storlandet islands) with its sheltered coasts and relatively large open water areas.

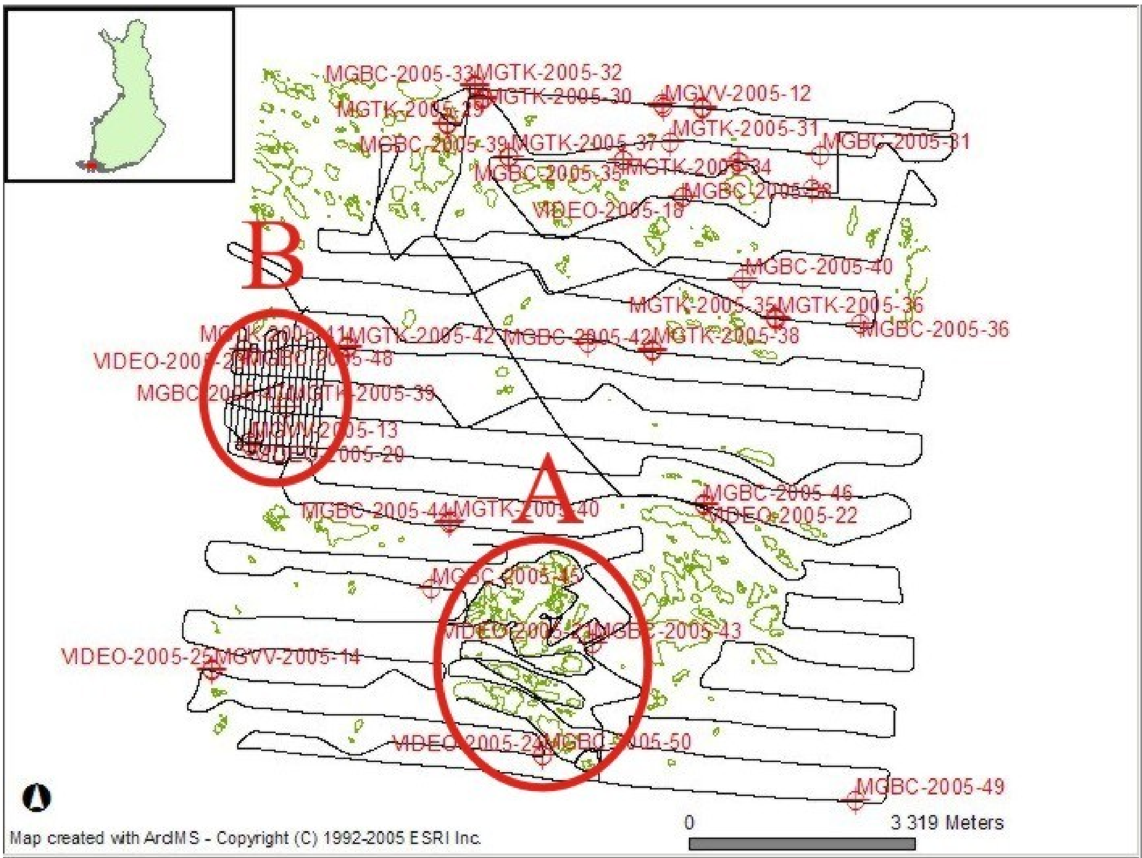

Fig. 2. Survey lines (black lines) and sampling sites (red dots) in Ormskär area (map sheet 1032 10). Red ellipse with A indicates the detailed study area in the vicinity of Storlandet islands. B indicates the detailed survey area not studied in the present work.

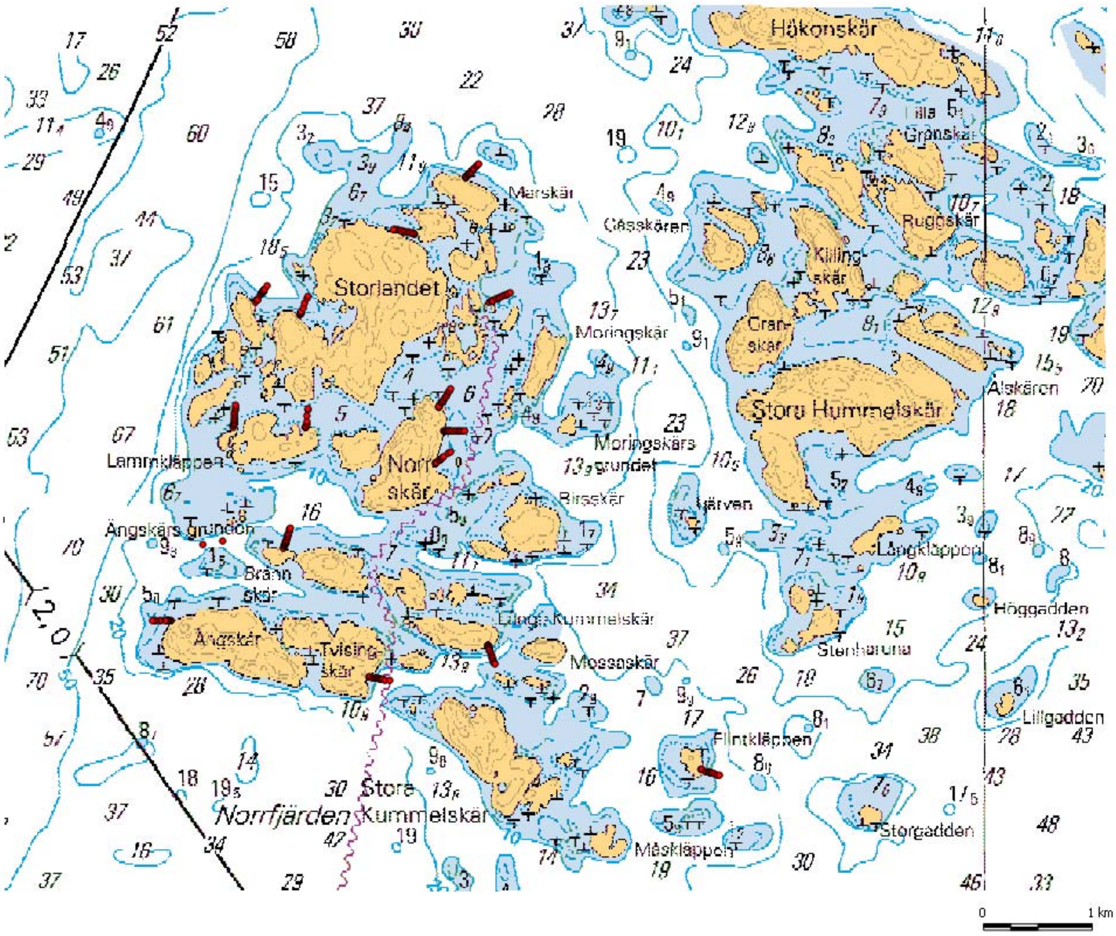

Fig. 3. Bathymetry in the vicinity of Storlandet islands. Red lines indicate diving transects.

2 METHODS

Comparison between BALANCE sediment maps and sediment data (intercalibration) was made on the basis of the existing data. The local scale (Ormskär) and detailed scale (Storlandet) study areas were surveyed in summer 2005 by the research vessels Kaiku, Geomari and Geola (Kotilainen et al. 2006; Kotilainen & Reijonen, 2006). In the local scale area the acoustic-seismic survey lines are designed to have 500 m spacing. Considering detail scale the acoustic-seismic soundings were planned to cover Storlandet area extensively, unfortunately in places it was too shallow for research vessels to operate (Figure 2). The Geological Survey of Finland (GTK) sampled surface sediments from the Ormskär area during the joint BALANCE and VALKO cruise in the summer 2005 (Kotilainen & Reijonen, 2006). Samples were used not only in the production of the marine geological map but also for the verification of the BALANCE sediment classification. In VALKO –project the GTK has also co-operated with biologists in mapping the underwater environment (Kotilainen et al., 2006). In this context Alleco Ltd has done SCUBA diving and remote video census in Storlandet area. These fine-scale methods were targeted at Storlandet area using the marine geological maps produced by GTK. Besides underwater flora and fauna Alleco Ltd has documented also the bottom sediment from the SCUBA diving lines (Figure 3). This sediment data was used in intercalibration and verification process of the detailed area. In addition, the SCUBA diving was made by biologists, who observed sediments from a biological prospective. This gave also an opportunity to compare the sediment categories between various organisations that conduct marine habitat mapping (e.g. GTK, SYKE, Alleco Ltd, Metsähallitus).

Table 1. The BALANCE sediment classes, Marine geological sediment classes and the predicted surface sediments

Balance substrate classes, harmonisation Finnish data		
Balance category	**Predicted surficial material**	**Marine Geological map, GTK 1: 20 000 categories**
1. Hard bottom, Bedrock (crystalline and sedimentary), Bedrock covered with boulders.	Bedrock, boulders	Crystalline bedrock
		Sedimentary bedrock
2. Hard bottom, Complex, patchy hard surface, coarse sand (sometimes also clay) to boulders.	Complex, almost everything	Till
		Glacioaquatic sediment
3. Sand	Fine to coarse sand (gravel)	Sand and gravel
		Secondary sand or silt
4. Hard clay	Thin layer of sand, clay, clay with coarse sed. (varved clay, glacial clay)	Glacial clay and silt
5. Mud, Gyttja	Mud, gyttja clay to silt	Clay (sulphide)
		Gyttja clay or clayey gyttja (litorina)
		Recent gyttja, gyttja clay or clayey gyttja (litorina)

The intercalibration process was adapted from Mattisson (2005). It was initiated by predicting the surface material of different marine geological sediment classes and by harmonising the marine geological data of the Ormskär and the Storlandet accordingly to BALANCE sediment classes (Table 1). Afterwards the predicted surface sediments were compared to those actually documented from the sea bottom by sampling and diving. The level of prediction accuracy of the BALANCE sediments in the surveyed areas was calculated as a proportion of the number of correct reclassifications divided by the number of incorrect reclassifications for each category.

2.1 Local scale

During the joint BALANCE and VALKO cruise in the summer 2005 (Kotilainen & Reijonen, 2006) special emphasis was put on predicting the surface sediment on geologically different bottom types. We took 22 Box corer and 3 vanVeen samples from the study area during the cruise (Figure 2, Figure 4). Samples were used in interpretation of soundings and geological mapping of the area. The sampling locations, from water depths between 15 – 78 m, were selected carefully using acoustic-seismic profiles. It was expected that on sampling sites the preliminary geological interpretation was correct, which was verified indeed. Thus it was possible to use sediment sample data also to verify BALANCE categories. The purpose here is not to study the accuracy of the map but to verify the predicted surface sediments in certain BALANCE category. Comparison between surface sediment samples and misinterpreted sediment areas would not reflect the accuracy of prediction but the accuracy of geological interpretation. However, a few errors were revealed in process; on the map there were bedrock areas while samples indicated softer sediments. The soundings were checked from these areas and they were corrected accordingly. In an area as diverse as the Archipelago Sea, there are numerous small bedrock outcrops and interpreter might unite small bedrock outcrops occurring in small area (matter of scale). The study consists in visual examination of sediment samples, which were compared to predicted surface materials. Visual observations of the grain size were recorded according to the geotechnical classification (Korhonen et al., 1974).

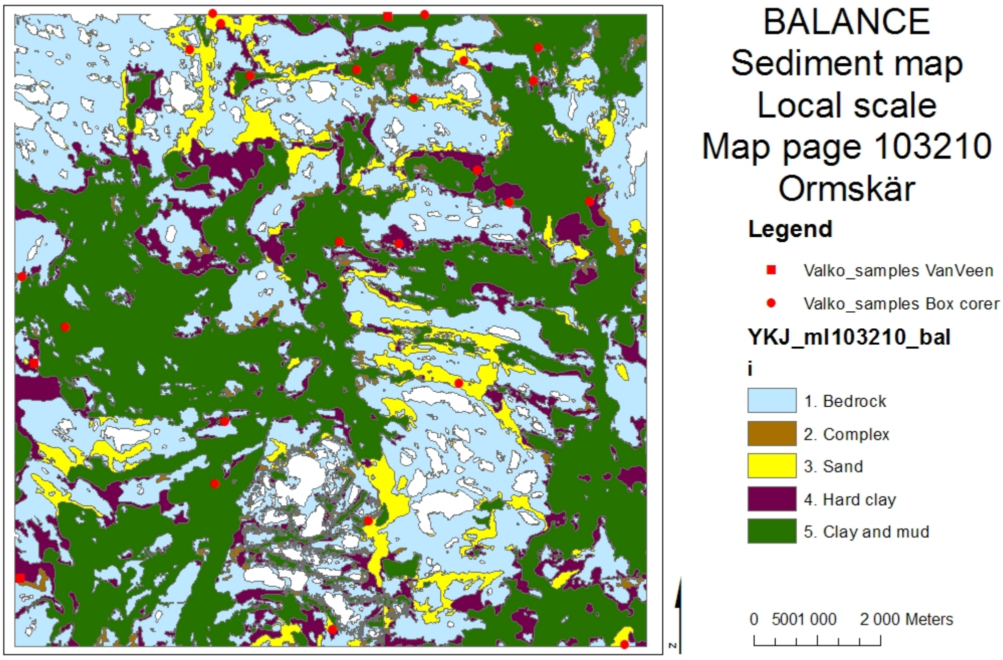

Fig. 4. *The local scale marine geological map of and the sampling sites.*

2.2 Detailed scale

Alleco Ltd conducted SCUBA diving in Storlandet area during summer 2005. Altogether 15 dive lines were studied. Data was collected from both sides of the dive lines at every changing depth meters, sediment types, dominant species or at least by 10 m intervals (Figure 3, Figure 5). Sediments were marked by coverage percentages using the geotechnical classification (Korhonen et al. 1974). In this study we compared the main grain size reported to predicted sediment. If there were considerable materials that were coarser or finer than main grain size we took it into account. If bedrock was observed (no matter what percentage) it was considered as main sediment type. This is reasoned because e.g. in the EUNIS system it is stated (Davies and Moss 2004) that non-mobile rock (here: bedrock) which is overlain by some deposited sediments then follow the path non-mobile (hard, bedrock).

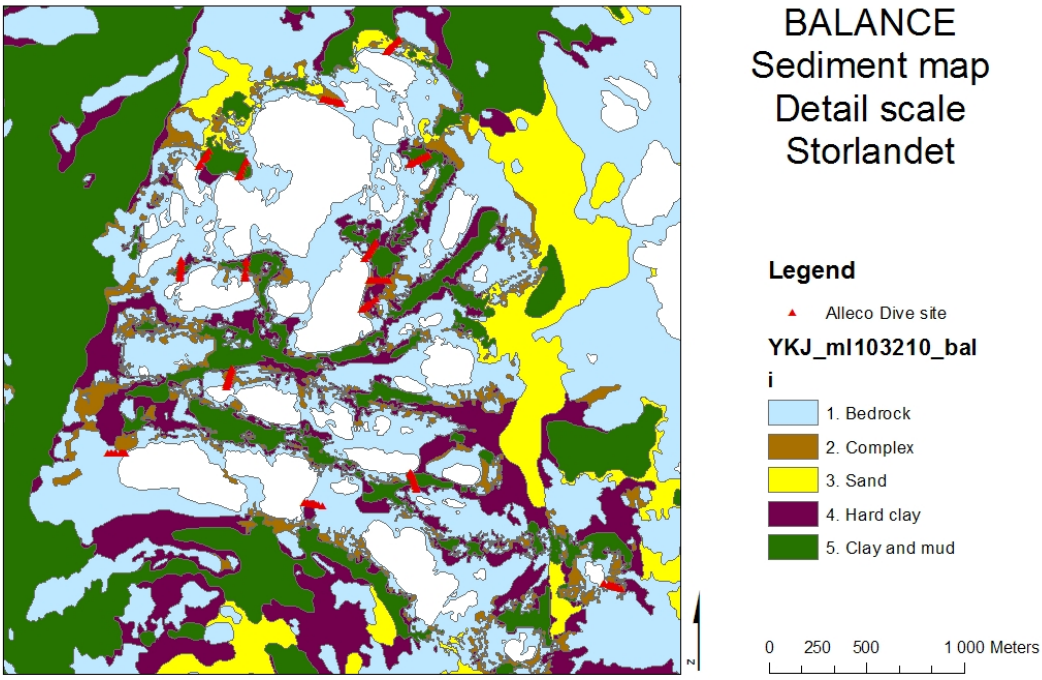

Fig. 5. *The Alleco Ltd dive sites on the top of marine geological map.*

3 RESULTS

There were 25 surface sediment samples from the Ormskär area and altogether 213 diving sites from the Storlandet area where we had information on bottom sediments. The results and proportion of accurate predictions for each of the BALANCE categories are found in Table 2 and Table 3, and in Figures 6 and 7.

Table 2. BALANCE sediment category, predicted surficial material, number of surface samples from the joint VALKO and BALANCE cruise and the proportion of correct prediction for each category from the Ormskär area.

BALANCE map	Predicted surface sediment	Number of sites	Correct (number)	Wrong (number)	Proportion of correct classification
1. Hard bottom, Bedrock	Bedrock, boulders	0			
2. Hard bottom, Complex	Complex, almost everything	1	1	0	1.0
3. Sand	Fine to coarse sand (gravel)	5	5	0	1.0
4. Hard clay	Thin layer of sand, clay, clay with coarse sed. (varved clay, glacial clay)	7	7	0	1.0
5. Clay and mud	Mud, gyttja clay to silt	12	12	0	1.0

Table 3. BALANCE sediment category, predicted surficial material, number of SCUBA diving sites (by Alleco Ltd) and the proportion of correct prediction for each category from the Storlandet area.

BALANCE map	Predicted surface sediment	Number of sites	Correct (number)	Wrong (number)	Proportion of correct classification
1. Hard bottom, Bedrock	Bedrock, boulders	73	52	21	0.7
2. Hard bottom, Complex	Complex, almost everything	40	31	8	0.8
3. Sand	Fine to coarse sand (gravel)	7	1	6	0.1
4. Hard clay	Thin layer of sand, clay, clay with coarse sed. (varved clay, glacial clay)	41	24	17	0.6
5. Clay and mud	Mud, gyttja clay to silt	52	26	26	0.5

4 DISCUSSION

4.1 Local Scale

The prediction accuracy of BALANCE surface sediments shows an excellent level for clay and mud, sand and hard clay. Sand samples were mainly sand with gravel (3 sites). The majority of hard clay samples were clay with coarser grains (3 sites) and also one sample that was completely covered with iron-manganese concretions (Fe-Mn nodules) was revealed. Clay and mud areas were covered mainly by gyttja (8 sites). Surface sediments found on these BALANCE classes fall to the accepted sediment range (Figure 6). Thus the harmonization of Finnish local scale marine geological maps has succeeded well for those sediment types. However, the amount of samples in each category is rather low, which deteriorates the reliability.

There were no samples from the bedrock areas and only one sample from complex area (that was Sand with clay). The accuracy of these areas could not be examined with confidence. The sampling devices used enable sampling of soft bottom but not coarser seabed. Bedrock and boulder areas should be studied *inter alia* by underwater video. Complex seabed is relatively rare in the study area and in addition they are often situated to very shallow areas that are difficult to operate by survey vessel.

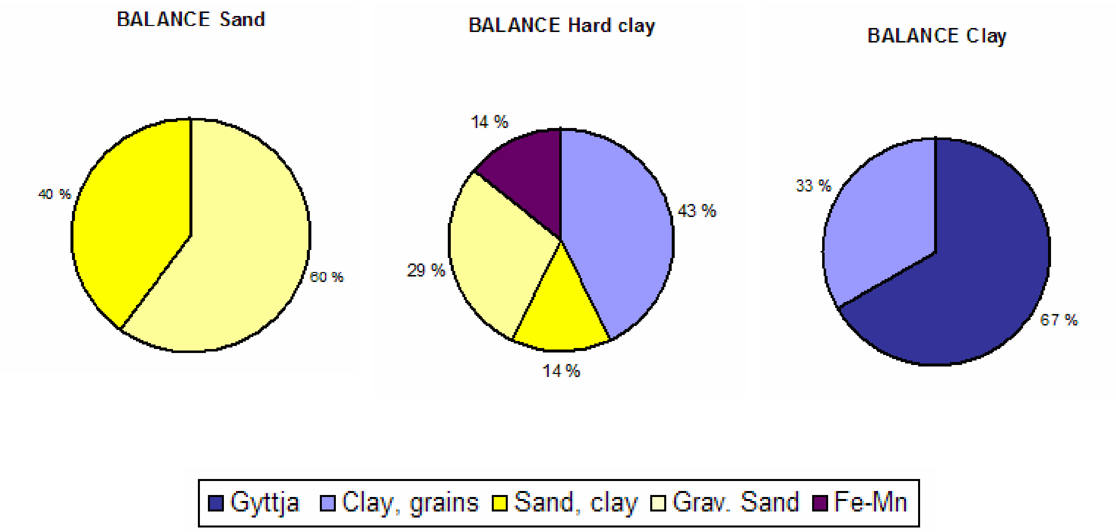

Fig. 6. *The distribution of different surface sediments in BALANCE sediment classes according to joint VALKO BALANCE cruise. Note that also the Fe-Mn concretions were classified here.*

4.2 Detailed scale

The detailed study complex sediments revealed the highest prediction accuracy (0.8). One has to take into account that here also the accepted sediment types variety is largest. Complex sediments are mixtures of different sediments; therefore all surface sediments other than bedrock and gyttja were accepted (Figure 7). Bedrock was excluded because it was treated as immobile, gyttja because it usually occurs in homogeneous conditions above clay. We had altogether 40 sites from complex sediment areas.

Bedrock areas had the second highest prediction accuracy (0.7). Most sites (73) were from bedrock areas and the results can be regarded reliable. There were a variety of sediments found from bedrock areas, gravel was found from 7 sites (10 %) and both stones and grained clay were found from 4 (5%) sites (Figure 7). The number of other sediments is small.

The prediction accuracy for hard clay was 0.6. There were 41 samples from these areas; hence the results can be regarded reliable. Bedrock was found in 16 sites (40 %) (Figure 7), and this could be explained by inaccurate positioning and errors in interpretation of marine geological map. Bedrock outcrops should be quite clearly defined from seismic data.

We had 52 sites of Clay and mud areas but only in 26 sites the predicted surficial material was right. The results are not very complimentary; in 17 sites the actual surface sediment was bedrock (Figure 7). Again, inaccurate positioning and errors in interpretation of marine geological map cause difficulties in assessing the results.

There were seven samples from sand areas and only one of them had similar material as expected. This is hardly a sufficient number of sites to calculate accuracy. In addition, the sand was rarely found as surface sediment.

The results do not show very high prediction accuracies. Besides incorrect sediment prediction, inaccurate positioning of both r/v Kaiku and diver might cause errors. Also the different background of the scientists may result to some differences in sediment categories. Different individuals made the diving observations and geological interpretations from acoustic-seismic profiles. The diving observations by biologists and profile interpretations by geologists from same surface sediments (and their combinations) might differ slightly, which would have a negative impact on the results. There was no acoustic-seismic data from each diving line and the vessel could not operate in the shallowest locations. A geological interpretation in the detailed study area was based mainly on the single profiling lines, not parallel (Figure 2). At these places the geologist may have made misjudgments on how the sediments are located, which descends the accuracy (Figure 5). In fact, the results gained here tell about the accuracy/reliability of geological map used in shallow coastal areas.

Considering the prediction accuracy according to the results from detailed area, they cannot be treated as reliable, but indicative. The accuracies can be kept as sufficient, except for sand. The amount of samples from sand areas is very low and therefore the results are not reliable. In future studies it is recommended that the diving lines situate in areas where there occur also acoustic-seismic data to keep results reliable. Also effort should be put into positioning and sediment interpretation. On this detailed scale errors of one or two meters make a big difference.

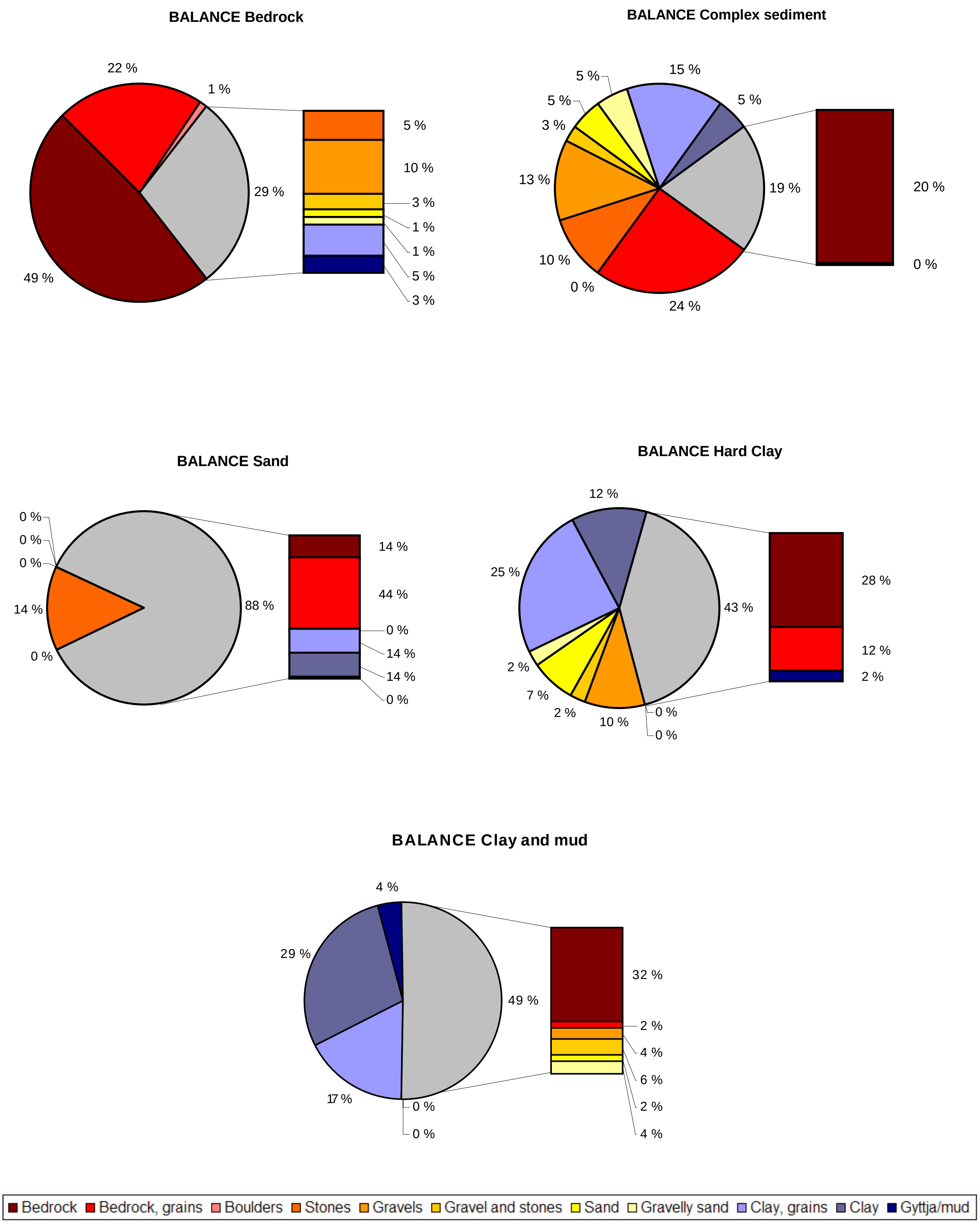

Fig. 7. *The distribution of different surface sediments documented by Alleco Ltd in BALANCE sediment classes.*

5 CONCLUSIONS

Altogether 25 surface sediment samples and recordings from 15 diving lines were used to verify the BALANCE sediment classes. The results from the local scale study (map page 103210, Ormskär) show that the harmonization of Finnish Marine geological local scale data to BALANCE classification has succeeded well. The surface sediments were correctly predicted regarding sand, hard clay and clay and mud. According to the diving observations made in detail study area surficial material was in most cases predicted in sufficient level. Highest reliabilities were gained to bedrock and complex areas. Collaboration between a numbers of authorities collecting seafloor data from the same area was tested successfully in the Archipelago Sea study area. This cooperation is essential to provide reliable information on the marine habitats at more cost-efficient level.

In some places the inaccurate positioning of divers or surveying vessel as well as false interpretation/prediction of sediment area weakens the prediction accuracies. In future studies the importance of correct positioning and reliability of sediment map/data should be emphasized. This study also shows the problems with shallow water areas. In those areas more effort should be made to produce more reliable information on the seafloor. Remote sensing methods like aerial photographs are helpful in some of those areas.

The results shown here indicate that in areas where Geological Survey of Finland has modern, local scale sediment data, and it has been used to produce BALANCE sediment (and marine landscape) maps, the predicted surface sediments are reliable. However, these results do not indicate the reliability (successful harmonization) of the entire BALANCE sediment map that was collated from data of various sources and different scales nor the confidence of the sediment maps. That validation has to be implemented using other methods

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APPENDIX I: SURFACE SAMPLES FROM THE JOINT BALANCE-VALKO CRUISE

Surface samples from the joint BALANCE-VALKO cruise, summer 2005

ID	DEVICE	LATN_WG	LONE_WG	X_YKJ	Y_YKJ	Map page	DEPTH_M	DIR_DEGF	DATE_	Surface_GTK	Surface_Bal	BALANCE
MGBC-2005-28	Box corer	60 03.018	21 39.108	6671864	3202408	103211C1	49	67	9.8.2005	ljSa	Gyttja	Clay
MGBC-2005-29	Box corer	60 02.736	21 35.103	6671645	3198655	103210B4	17	72	9.8.2005	kiHk	Grav. Sand	Sand
MGBC-2005-30	Box corer	60 02.957	21 35.641	6672013	3199187	103210B4	32	81	9.8.2005	ki/srHk	Grav. Sand	Hard clay
MGBC-2005-31	Box corer	60 02.722	21 41.035	6671171	3204150	103210D4	78	58	10.8.2005	ljSa	Gyttja	Clay
MGBC-2005-32	Box corer	60 02.441	21 40.954	6670657	3204033	103210D4	67	53	10.8.2005	ljHk	Sand, clay	Hard clay
MGBC-2005-34	Box corer	60 02.622	21 39.764	6671081	3202957	103210D2	35	152	11.8.2005	lj/saHk	Sand, clay	Sand
MGBC-2005-35	Box corer	60 02.549	21 37.940	6671083	3201256	103210D2	34	206	11.8.2005	ljsiSa	Clay, grains	Clay
MGBC-2005-36	Box corer	60 01.409	21 41.882	6668675	3204739	103210D3	73	216	12.8.2005	hkljSa	Clay, grains	Hard clay
MGBC-2005-37	Box corer	60 01.410	21 40.517	6668779	3203473	103210D3	42	233	12.8.2005	ljSa	Gyttja	Clay
MGBC-2005-38	Box corer	60 02.297	21 38.917	6670543	3202123	103210D2	20	231	12.8.2005	siljSa	Clay, grains	Clay
MGBC-2005-39	Box corer	60 02.505	21 36.126	6671139	3199568	103210B4	24	239	12.8.2005	siljSa	Clay, grains	Clay
MGBC-2005-40	Box corer	60 01.688	21 39.977	6669335	3203014	103210D2	31	258	13.8.2005	siljSa	Clay, grains	Hard clay
MGBC-2005-41	Box corer	60 01.085	21 37.617	6668395	3200735	103210D1	50	307	13.8.2005	siljSa	Clay, grains	Clay
MGBC-2005-42	Box corer	60 01.064	21 38.623	6668280	3201665	103210D1	28	255	13.8.2005	Fe-Mn	Fe-Mn	Hard clay
MGBC-2005-43	Box corer	59 58.704	21 38.075	6663949	3200801	103210C1	15	289	14.8.2005	ljSa Hk	Sand, clay	Complex
MGBC-2005-44	Box corer	59 59.564	21 35.646	6665726	3198676	103210A4	36	315	14.8.2005	hk/si ljSa	Clay, grains	Hard clay
MGBC-2005-45	Box corer	59 59.035	21 35.464	6664760	3198427	103210A4	46	322	14.8.2005	ljSa	Gyttja	Clay
MGBC-2005-46	Box corer	59 59.872	21 39.640	6665995	3202429	103210C2	25	322	14.8.2005	kiljsaHk	Grav. Sand	Sand
MGBC-2005-47	Box corer	60 00.381	21 32.948	6667446	3196297	103210B1	39	213	16.8.2005	ljSa	Gyttja	Clay
MGBC-2005-48	Box corer	60 00.813	21 32.214	6668303	3195683	103210B1	22	242	16.8.2005	ljsa	Gyttja	Clay
MGBC-2005-49	Box corer	59 57.631	21 42.400	6661636	3204658	103210C3	59	310	17.8.2005	ljsiHk	Sand, clay	Sand
MGBC-2005-50	Box corer	59 57.787	21 37.436	6662298	3200069	103210C1	19	314	17.8.2005	ki sr/Hk	Grav. Sand	Sand
MGVV-2005-12	vanVeen	60 03.005	21 38.485	6671887	3201829	103210D2	37	80	9.8.2005	ljSa	Gyttja	Clay
MGVV-2005-13	vanVeen	60 00.073	21 32.413	6666917	3195754	103210A2	18	70	13.8.2005	ljSa	Gyttja	Clay
MGVV-2005-14	vanVeen	59 58.249	21 32.131	6663559	3195212	103210A1	24	323	17.8.2005	kiHk	Grav. Sand	Hard clay

APPENDIX II: ***IMAGES FROM SURFACE SAMPLES.***

MBGC-2005-29 BALANCE sediment Sand

MGBC-2005-32 BALANCE sediment Hard clay

MGBC-2005-41 BALANCE sediment Clay and mud

About the BALANCE project

This report is a product of the BSR INTERREG IIIB project "BALANCE".

The BALANCE project aims to provide a transnational marine management template based on zoning, which can assist stakeholders in planning and implementing effective management solutions for sustainable use and protection of our valuable marine landscapes and unique natural heritage. The template will be based on data sharing, mapping of marine landscapes and habitats, development of the blue corridor concept, information on key stakeholder interests and development of a cross-sectoral and transnational Baltic zoning approach. BALANCE thus provides a transnational solution to a transnational problem.

The BALANCE partnership is composed of the following institutions based in 10 countries: The Danish Forest and Nature Agency (Lead), The Geological Survey of Denmark and Greenland, The National Environmental Research Institute/University of Aarhus, The Danish Institute for Fisheries Research, WWF Denmark, WWF Germany, Institute of Aquatic Ecology at University of Latvia, Estonian Marine Institute at University of Tartu, Coastal Research and Planning Institute at Klaipeda University, Metsähallitus Natural Heritage Service, The Finnish Environment Institute, The Geological Survey of Finland, WWF Finland, The Swedish Environmental Protection Agency, The National Board of Fisheries – Department of Research and Development, The Geological Survey of Sweden, County Administrative Board of Stockholm, Department of Marine Ecology at Gothenburg University and WWF Sweden.

The following institutes contribute as consultants to the partnership: The Geological Survey of Norway, Norwegian Institute for Water Research, DHI Water & Environment, The Leibniz Institute of Marine Sciences, The Sea Fisheries Institute, The Finnish Game and Fisheries Research Institute, Metria Miljöanalys and The Nature Conservancy.

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