BALANCE Interim Report No. 23

The modelling of *Furcellaria lumbricalus* habitats along the Latvian coast

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CONTENTS

1 PREFACE

This report describes the modelling of habitats shaped by *Furcellaria lumbricalis* at the Latvian Baltic Proper coast. Presence or absence of *Furcellaria lumbricalis,* the only macroalgae species adapted to the high wave exposure along the almost linear shoreline, shapes the characteristics of hard bottom habitats on the underwater slope. The modelling activities were conducted by the Latvian Institute of Aquatic Ecology and are a product of the BSR INTERREG IIIB co-financed project "BALANCE".

Detailed video survey information on benthic vegetation and bottom sediment type from a 35 km long coastal stretch were combined with depth data and modelled wave exposure to calibrate generalized additive models of presence/absence of *Furcellaria* stands. In the model calibration area, the most successful model correctly reflected 75 % and 94 % of *Furcellaria* stand presences and absences, respectively. Model extrapolation to the entire Latvian Baltic Proper coastline was limited by the quality of bottom type and depth information available from published maps.

Further information on the BALANCE project and electronic copies of this report can be obtained at www.balance-eu.org. Information about the BSR INTERREG Neighbourhood Programme can be obtained at www.bsrinterreg.net.

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2 INTRODUCTION

This report describes the application of generalized additive models to describe the distribution of reefs along the Latvian Baltic Proper coast, which are in this area expressed as *Furcellaria lumbricalis* stands on rocky substrates. The EU Habitat Directive lists reefs in its Annex I and requires their adequate protection within the NATURA 2000 network (Directive 92/43/EEC Treaty of Accession 2003). For the purpose of the directive, reefs are defined as “Submarine, or exposed at low tide, rocky substrates and biogenic concretions, which arise from the sea floor in the sublittoral zone but may extend into the littoral zone where there is an uninterrupted zonation of plant and animal communities. These reefs generally support a zonation of benthic communities of algae and animals species including concretions, encrustations and corallogenic concretions” (Interpretation Manual of European Union Habitats, 2003). Further, the manual lists belts of filamentous algae, *Fucus vesiculosus* and perennial red algae as the characteristic plant components of northern Baltic reefs and mussel beds and hard bottom invertebrates as fauna typically found on reefs.

High wave exposure is believed to constrain the occurrence of *Fucus vesiculosus* at the exposed south-eastern Baltic coast. Instead, macrophyte stands are composed almost exclusively of the perennial red algae *Furcellaria lumbricalis* (Bučas et al. 2007). To correspond to the reef definition of the Interpretation Manual of European Union Habitats we therefore aim to model the occurrence of *Furcellaria* stands on rocky substrates associated with hard bottom fauna, which is – along the Latvian Baltic Proper coast - dominated by the blue mussel, *Mytulis edulis*.

Detailed observations with precise spatial coordinates of macrophyte communities, the associated hard bottom fauna, together with information on sediment type, were available from a coastal strip in the southern part of the Latvian Baltic Proper coast, extending approximately 35 km along the coast. This area was used to calibrate general additive models of *Furcellaria* distribution. Further, these models were applied to predict the probability of presence/absence of *Furcellaria* stands for the entire Latvian Baltic Proper coast.

3 MODEL DEVELOPMENT

The model was developed to predict the location of *Furcellaria lumbricalis* habitats along the Latvian coast.

3.1 Study area

The study area is located in the south-eastern Baltic Proper, along the Latvian coast (Fig. 1). Models of *Furcellaria* distribution were calibrated in the southern tip of the study area (model calibration area) and then extrapolated to the entire coastline (model extrapolation area).

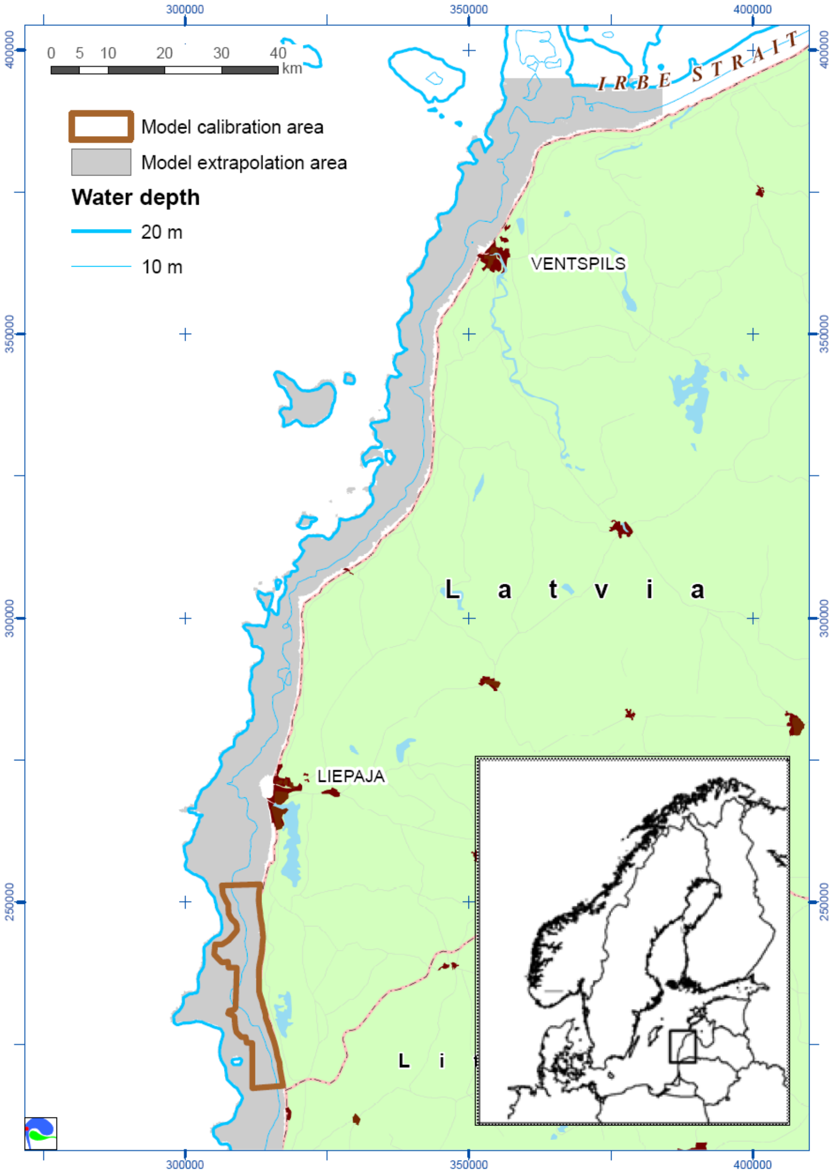

Fig. 1: Location of the model calibration area (brown polygon) and model extrapolation area (grey shaded area) on the Latvian Baltic Proper coast and the Baltic Sea region (map insert)

3.2 Available field data

Coverage by macroalgae, density of hard bottom mussels (*Mytilus edulis*) as well as bottom substrate properties by categories sand, stones and boulders were extracted from video observations in the model calibration area made with an underwater video camera lowered from a boat. The video survey was conducted during July/August 2006 at 566 stations on a regular grid, with 400 m distance between the observation sites. At each site 5 – 50 m^2 of bottom area were surveyed, depending on bottom and habitat complexity. Macroalgae and bottom sediment coverage were extracted from the video sequences on a semi-quantitative scale (0: absent, 1: < 20 %, 2: 20 – 60 %, 3: > 60 %). Rocks with diameters 10 – 50 cm were termed stones; larger than 50 cm boulders. Depth was measured by echo sounder. Wave energy was estimated by the 95 % percentile of squared orbital wave velocity at the bottom, calculated by a wave model (Seņņikovs et al. 2007).

3.3 Physical conditions in the model calibration area

The model calibration area stretches along the Latvian Baltic Proper coast from the Lithuanian border close to Nida along a distance of 35 km northwards to Bernāti (Fig. 2). The 15 m isobath, which is located 4 – 8 km offshore, roughly delineates its seaward boundary. Especially north of Pape the seafloor slopes gently towards the Eastern Gotland deep and exhibits a broad plateau with water depths 7 – 10 m (Fig. 2A). The 95 % percentile of wave energy (Fig. 2B) showed a maximum at approximately 5 m depth and quickly decreased in deeper waters. The seafloor was mostly covered by mixed substrates of boulders, stones and sand. Boulders (Fig. 2C) occurred everywhere in the study area except for the surf zone, which was dominated by sand. Bottoms without any sand cover occurred only in patches north of Pape and close to Jūrmalciems (Fig. 2D).

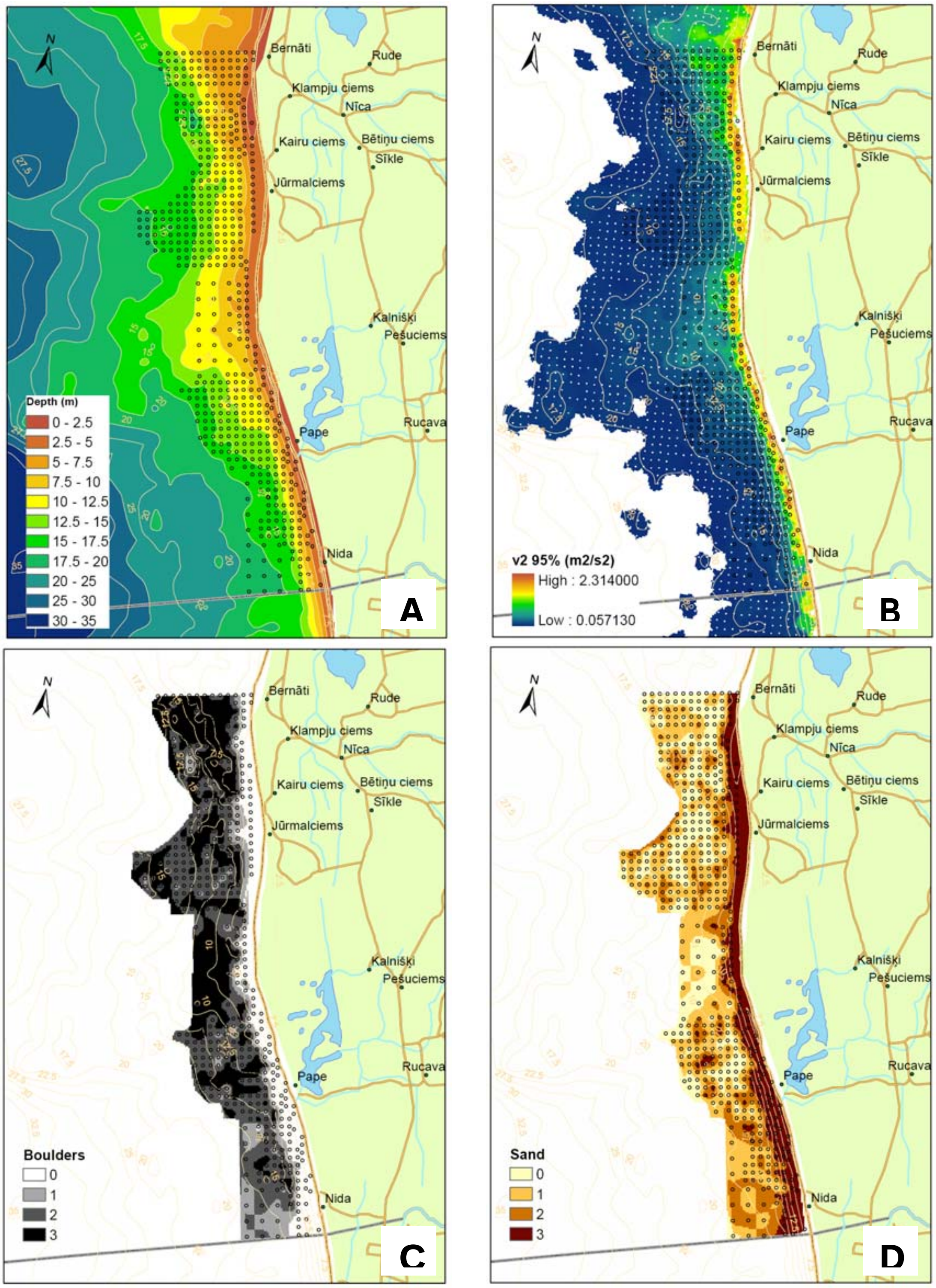

Fig. 2: Bottom depth (A), wave energy (95 % percentile of orbital velocity at bottom squared, B), boulder density (C) and sand coverage (D) in the model calibration area. Maps were generated by inverse distance squared interpolation between the video observation sites denoted by dots.

3.4 Macroalgae and associated fauna in the model calibration area

The dominant macroalgal species in the model calibration area was *Furcellaria lumbricalis*. In some locations, an overgrowth of epiphytic annual species, popularly termed “yellow algae” (*Pylaella* sp.) and “red algae” (*Ceramium* sp.) was noted. *Furcellaria* (Fig. 3A) was practically absent from the southern part of the area, but north of Pape it occurred in partially dense stands outside the surf zone up to approximately 12 m depth. *Mytilus edulis* was present in high densities at all sampling sites outside the surf zone, only at the very southern tip of the study area the *Mytilus* coverage was lower (Fig. 3B).

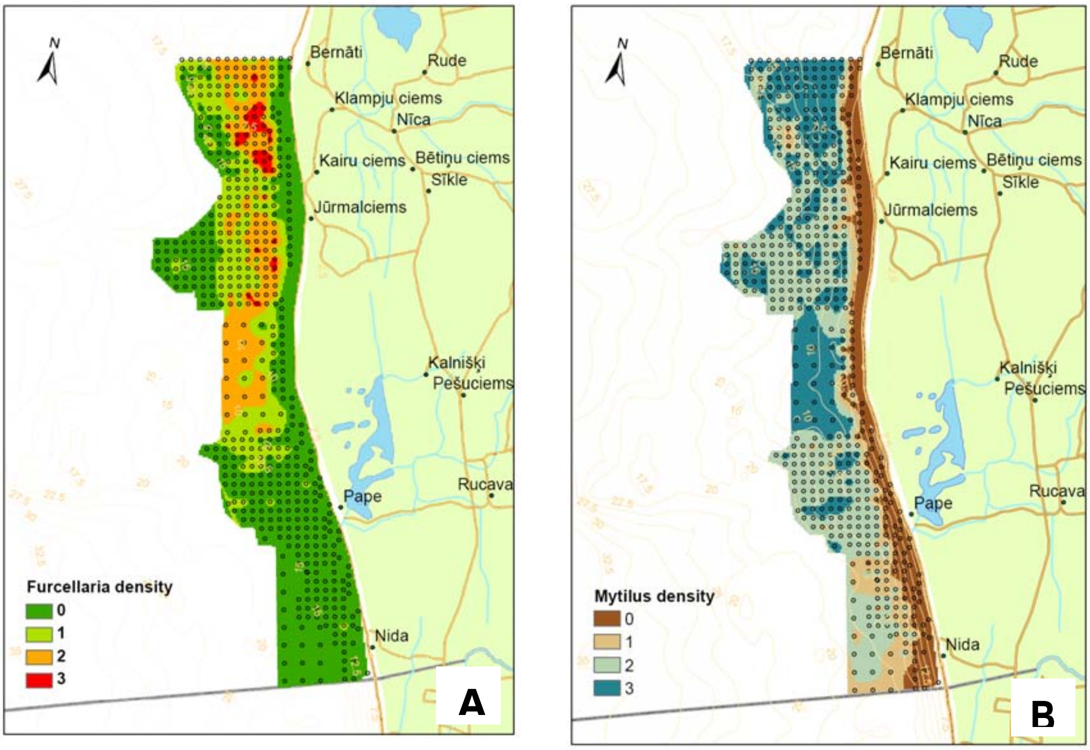

Fig. 3: *Biological communities in the model calibration area – Furcellaria lumbricalis (A) and Mytilus edulis (B)*

3.5 Statistical modeling

The main patterns in the distribution of macroalgae and *Mytilus edulis* were first examined by cluster analysis using Ward’s method. Ward’s method is a hierarchical agglomerative clustering scheme that attempts to minimize the data variance in each cluster formed and therefore tends to produce compact clusters with homogeneous properties (see for example Legendre and Legendre, 1998). Clustering was performed on a dataset describing the physical environment (depth, wave energy), sediment properties (sand, stones, boulders), as well as *Mytilus* and macroalgae coverage (“yellow algae”, “red algae”, *Furcellaria*). Continuous raw data were linearly transformed to the range covered by the semi-quantitative parameters and Euclidean distances were used as similarity measure.

According to the major data patterns extracted by cluster analysis, further statistical modelling focused on the occurrence of *Furcellaria* stands (defined as *Furcellaria* coverage 2 – 3, i.e. > 20 %), dependent on depth, wave energy, and two substrate descriptors – sand coverage (low: ≤ 20 %, high: > 20 %) and boulder presence/absence. In a second step, the model was refined to describe the occurrence of *Furcellaria* stands on boulders (defined as sites with *Furcellaria* coverage > 20 % and boulder presence), which was closer to the description of reefs in the Interpretation Manual of European Habitats. For models of boulder sites, also the effect of high *Mytilus* coverage (*Mytilus* > 2, i.e. > 60 %) on *Furcellaria* growth was investigated. It was not possible to specifically model conditions, under which *Furcellaria* was able to “outcompete” *Mytilus* (e.g. *Furcellaria* coverage > 60 %, *Mytilus* coverage ≤ 60 %), because the dataset contained only four cases with these conditions.

The presence/absence of *Furcellaria* stands and the presence/absence of *Furcellaria* stands on boulders was modelled by a suite of generalized additive models (GAM), using a bionomial distribution for the response variable with a logit link function. A GAM (Hastie and Tibshirani, 1986) attempts to describe the response variable as a combination of factors, linear predictors, and smooth functions (regression splines) of one or several covariates. The R package mgcv (Wood, 2006, 2007) was used for model fitting, which provides routines for optimum selection of the degree of smoothness of the regression splines. R^2, Akaike’s information criterion (AIC, Akaike 1973), and the receiver-operating characteristics determined by the number of true/false positive and negative model outcomes were used to describe model performance. In a second step, a simple cross-validation was performed by splitting the dataset into calibration and validation sites (70 % and 30 % of cases, respectively).

3.6 Model extrapolation to entire Latvian Baltic Proper coast

The models developed for the presence/absence of *Furcellaria* stands were further applied to the entire Latvian Baltic Proper coast. Depth and wave energy were taken from Seņņikovs et al. 2007; sediment types were digitized from a recent lithological map of the Latvian coastal zone (Ulsts and Bulgakova, 1998). Boulder presence and sand dominance were attributed to the mapped sediment types as shown in table 1.

Table 1: Sand dominance and boulder presence categories assigned to the sediment types in the lithological map of the Latvian coast

Lithology	**Sand coverage**	**Boulder presence**
Silt	high	absent
Coarse sand and gravel with stones and boulders	low	present
Prequarternary sediments	low	absent
Fine sand	high	absent
Sandy silt and silty sand	high	absent
Sand, coarse sand with stones	high	absent
Medium and coarse sand	High	absent

4 RESULTS AND DISCUSSION

4.1 Major data patterns

Ward's clustering identified five major clusters in the video survey dataset (Fig. 4). Cluster 1 assembled relatively shallow sites (average depth 8.4 m) with rocky substrates (boulder coverage > 60 %). These bottoms support *Furcellaria* stands and dense *Mytilus* communities (coverage > 20 % and > 60 %, respectively). Wave energy at these sites is relatively high (average 0.71 m^2s^{-2}). Sites in cluster 2 are located at greater depth (average 12.8 m), but lower wave energy (average 0.35 m^2 s^{-2}). Bottom substrates in this cluster are mostly rocky (boulders and stones). *Mytilus* occurs in high densities, while *Furcellaria* growth varies from absence to coverages > 60 %. Cluster 3 represents the deepest sites in the analysis (average depth 15.7 m) with lowest wave energy (average 0.15 m^2 s^{-2}). Bottom substrates are dominated by stones and boulders. *Mytilus* coverage is high (> 20 %), while *Furcellaria* is absent. Cluster 4 is located at shallower depth and larger wave energy (averages 14.4 m and 0.22 m^2 s^{-2}, respectively). Bottoms are mixed substrates of sand, boulders and stones (coverages 20 % - > 60 %, 20 % – 60 %, and < 20 % - 60 %, respectively). Similar to cluster 3, *Mytilus* coverage is high (> 20 %), while *Furcellaria* is absent. Cluster 5 assembles the shallowest sites in the analysis with

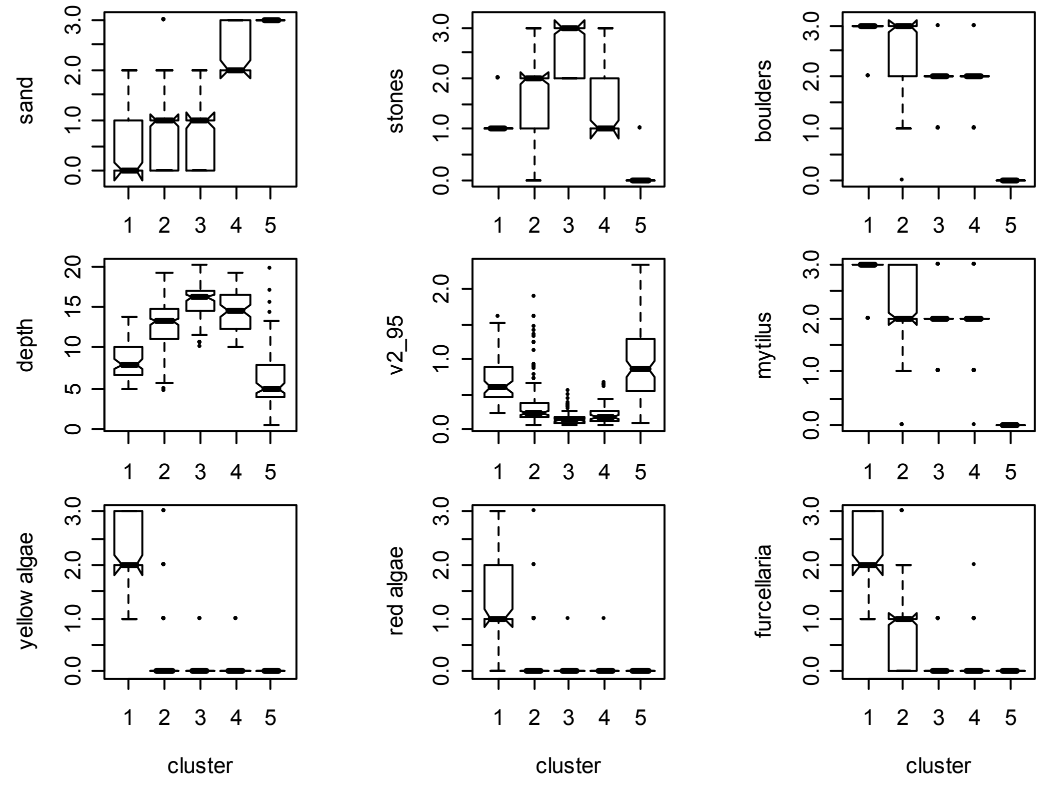

Fig. 4: *Major data patterns identified by Ward's clustering. Boxes and whiskers show the properties of sites in each of the five major clusters. Coverage data (sand, stones, boulders, mytilus, yellow algae, red algae and* Furcellaria*) are given on a semi-quantitative scale (0: absent, 1: < 20 %, 2: 20 – 60 %, 3: > 60 %), depth in m, and wave energy (95 % percentile of orbital velocity at bottom, v2_95) in* m^2s^{-2}.

largest wave energy (averages 6.2 m and 0.92 $m^2 s^{-2}$). At these sites bottoms are entirely covered by sand. Hard substrates are absent and neither *Furcellaria* nor *Mytilus* occur.

Thus highest coverage of *Furcellaria lumbricalis* occurred in clusters 1 and 2, which centered around 8.4 m (cluster 1) and 12.8 m (cluster 2) depth and were characterized by very low (cluster 1) to low (cluster 2) sand coverage and high density of boulders. *Furcellaria lumbricalis* did not occur in the deepest cluster 3, even though sand coverage was low and hard substrates were present, indicating that its growth was restricted by light. *Furcellaria* was also absent from the clusters 4 and 5, which were characterized by high sand coverage, even though in cluster 4 depth range and hard substrates overlapped with the *Furcellaria* sites in cluster 2. *Mytilus* occurred in all clusters except cluster 5, which lacked hard substrates completely. This suggests that two major factors structure the sessile communities in the study area: Low sand coverage, which coincided in the dataset with presence of hard substrates (boulders), together with a light limit for growth, determine the occurrence of *Furcellaria*, whereas *Mytilus* occupies all hard substrates irrespective of depth and is only absent from sites with pure sand coverage.

4.2 GAM models

4.2.1 Furcellaria stands

The combination of explanatory variables, that were tested to model *Furcellaria* stands (*Furcellaria* coverage > 20 %) and model performance characteristics (R^2, AIC, counts of true and false positive and negative classifications) are listed in table 2. Best model performance in terms of R^2 and AIC was achieved by models which explained the presence/absence of *Furcellaria* stands (*Furcellaria* > 20 %) as a function of the factors sand coverage (≤20 %/>20 %) and boulder presence and smooth functions of depth and wave energy:

Furcellaria stands ~ sand coverage + boulder presence + s(depth) + s(wave energy), link = logit (model 7)

Furcellaria stands ~ sand coverage + boulder presence + s(depth, wave energy), link = logit (model 8)

Best performance in terms of R^2 and AIC (table 2) was reached by model 7, which together with model 8 also achieved the highest number of correctly classified sites. Both models correctly classified 90 % of the sampling sites, and performed better for the absence than for the presence of *Furcellaria* stands (94 % of absences and 75 % of presences identified correctly). Model performance in the cross-validation experiment was similar, where models 7 and 8 correctly classified 88 % of the validation sites (93 % of absences and 70 % of presences identified correctly).

In general, differences between individual model performances were small and any combination of one or two factors describing sediment properties (sand coverage and/or boulder presence) with any one or two smooth functions characterizing the physical environment (depth and/or wave energy) reflected the data reasonable well. Model performance dropped however, if substrate properties were omitted completely (model 0, model0depth). Boulder presence was not a statistically significant factor in any of the parameter combinations and the GAM results indicate that sand coverage was a better descriptor for *Furcellaria* stands in the model calibration area.

Table 2: GAM performance for occurrence of sites with Furcellaria lumbricalis *stands dependent on factors sand coverage and boulder presence, as well as smooth functions of depth and wave energy. Performance is measured by* R^2*, AIC and counts of true/false positive and negative classifications. Values given for each factor/smooth function represent approximate significance levels (n.s.:>.1)*

Model	sand coverage	boulder presence	depth	wave energy	R^2	AIC	true positive	true negative	false positive	false negative
#0depth	-	-	<.001	-	.29	385.4	40	416	36	73
#0	-	-	<.001	<.001	.38	349.6	61	428	24	52
#1	-	n.s.	<.001	-	.45	305.6	84	407	45	29
#2	<.001	-	<.001	-	.49	303.2	86	419	33	27
#3	-	n.s.	-	<.001	.44	316.5	83	407	45	30
#4	<.001	-	-	<.001	.45	327.5	83	421	31	30
#5	<.001	-	<.001	<.001	.52	286.0	84	423	29	29
#6	-	n.s.	<.001	<.001	.44	292.4	80	415	37	33
#7	<.001	n.s.	<.001	<.001	.54	270.2	85	423	29	28
#8	<.001	n.s.	<.001		.53	273.2	85	423	29	28
#9	<.001	-	<.001		.52	288.5	83	423	29	30
#10	-	n.s.	<.001		.48	295.2	82	410	42	31

If the physical environment is characterized by a single smooth function in the GAM models (i.e. depth or wave energy alone), the smoothing splines show an optimum at intermediate values (Fig. 5, top): Shallow waters are unfavorable for *Furcellaria* growth because of the high wave impact, while deep waters are unfavorable because of the low light availability. Vice versa, *Furcellaria* is absent from environments with low wave energy, because they are located at depths with low light, and missing from locations with high wave energy. GAM models using both depth and wave energy as independent variables produce almost linear smoothing splines for both variables that correspond well to the biological effect of each physical factor on macroalgae growth. The depth smooth linearly decreases with water depth, capturing the reduced light availability, while the probability of dense *Furcellaria* growth declines almost linearly with increasing wave energy, reflecting the physical damage of wave shear on macrophytes (Fig. 6). Despite the strong covariance between depth and wave energy (Fig. 5, bottom), both smooth functions are statistically significant ($p < 0.001$ in models 6 and 7) and the GAM model is able to separate the effects of the two counteracting parameters.

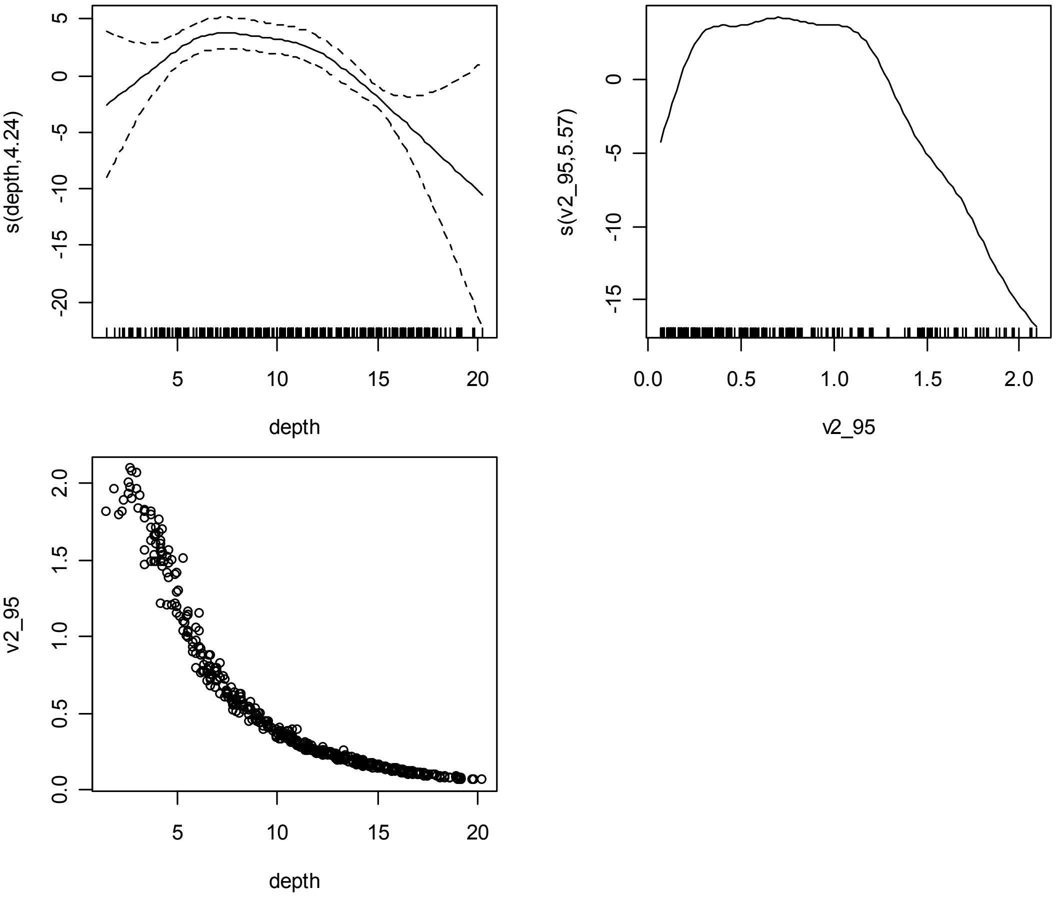

Fig. 5: *Depth and wave energy smooth functions in models using only a single descriptor of the physical environment (top left: depth smooth in model 2, top right: wave energy smooth in model 4), bottom panel shows wave energy dependency on depth in the model calibration area*

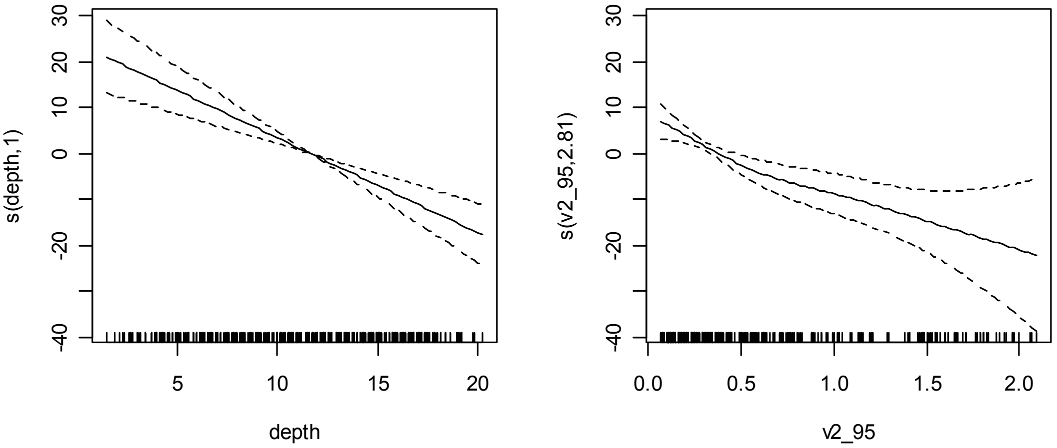

Fig. 6: *Smooth functions in GAM model 7 using both depth (left panel) and wave energy (right panel) as descriptors of the physical environment*

4.2.2 **Furcellaria** *stands on boulders*

When restricted to describe *Furcellaria* stands on boulders, model performance patterns (table 3) were similar to formulations for *Furcellaria* presence/absence on all substrates. High coverage of *Mytulis edulis* (> 60 %) depressed *Furcellaria* growth in a statistically significant way, indicating that both species compete for space, and resulted in slightly better model performance.

Best performance in terms of R^2 and AIC was reached by model 16, which includes sand coverage and *Mytilus* dominance (coverage > 20 % and > 60 %, respectively) as factors and smooth functions of depth and wave energy (model 16, table 3). In total, 90 % of cases were classified correctly (87 % of presences and 91 % of absences).

Furcellaria stands on boulders ~ sand coverage + *Mytilus* dominance + s(depth) + s(wave energy), link = logit (model 16)

Table 3: *GAM performance for occurrence of sites with* Furcellaria *stands on boulders dependent on factors sand coverage and Mytilus dominance as well as smooth functions of depth and wave energy. Performance is measured by R^2, AIC and counts of true/false positive and negative classifications. Values given for each factor/smooth function represent approximate significance levels (n.s.:>.1)*

Model	**Sand coverage**	***Mytilus* dominance**	**depth**	**wave energy**	**R^2**	**AIC**	**true positive**	**true negative**	**false positive**	**false negative**
#11	-	-	<.001	-	.41	303.6	84	293	45	29
#12	-	-	<.001	<.001	.45	290.3	80	301	37	33
#13	-	-	<.001		.44	293.4	82	296	42	31
#14	<.001	-	<.001		.50	270.9	84	309	29	29
#15	<.001	-	<.001	<.001	.51	268.3	84	309	29	29
#16	<.001	<.01	<.001	<.001	.52	262.3	86	307	31	27
#17	-	<.001	<.001	-	.45	288.9	79	305	33	34
#18	-	<.001	<.001	<.001	.48	281.5	79	305	33	34
#19	-	<.001	<.001	<.001	.48	277.7	79	305	33	34

4.2.3 *Misclassified sites*

The spatial distribution of misclassified sites (Fig. 7) for the best models of *Furcellaria* stands (model 7) and *Furcellaria* stands on boulders (model 16) showed a distinct pattern: Most false negative and false positive model outcomes were located at the edge of areas with dense *Furcellaria* growth and are thus associated with the transition between *Furcellaria* absence and presence. An exception is a cluster of false positive model outcomes slightly north of Pape, where the model falsely predicts presence of *Furcellaria* stands at approximately 10 m water depth. These sites are located at much greater depth than the wave-impact determined upper limit of the *Furcellaria* distribution. It therefore seems unlikely that peculiarities of the wave field (wave focusing) had prevented the growth of *Furcellaria* in this area. This leaves other factors not included in the model, for example higher turbidity caused by local eutrophication, toxic effects, or diseases as candidates to explain the lack of *Furcellaria* growth at these sites. Video observations made in 1998 in the Pape area (Finnish Institute of Marine Research, 1998) during the Environmental Impact Assessment for the Butinge Oil Terminal, which was later build south of Pape, still found dense *Furcellaria* coverage in the area, confirming that the physical conditions were suitable for its growth.

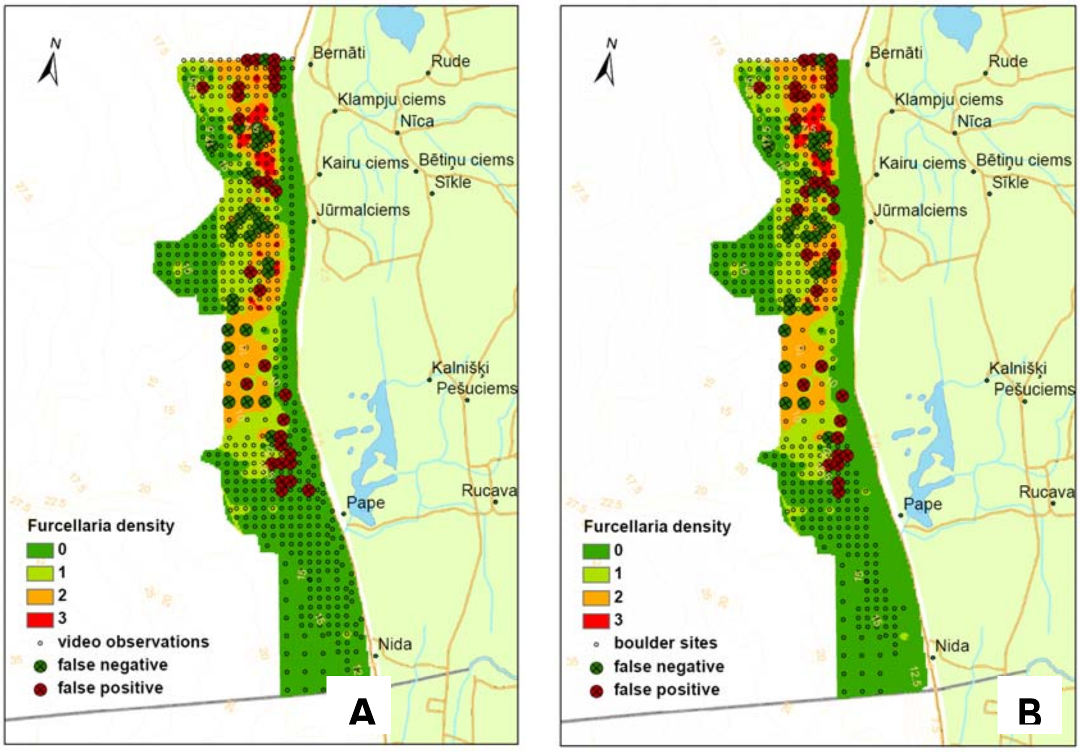

Fig. 7: *Misclassified sites for best model of Furcellaria stands (model 7, A) and Furcellaria stands on boulders (model 16, B)*

4.3 Model extrapolation along the Latvian Baltic Proper coast

The lithological information available for the Latvian Baltic Proper coast (Fig. Appendix I-1) is rather schematic, compared to the fine mosaic of sandy and rocky bottoms (see Fig. 2) documented in the video survey of the model calibration area. For example, the video observations used for this study documented boulders throughout the model calibration area, whereas the lithological map depicts boulders only in the southern tip of the model calibration region (Fig. 8). To test the sensitivity of different GAM model formulations against the quality of the sediment input data, we compared model performance in the calibration area, using both the sediment type information from the video surveys (“calibration lithology”) as well as sediment type information from the lithological map (“extrapolation lithology”). Two models of the presence/absence of *Furcellaria* stands, model 5 and model 7, were selected for performance testing. Model 7, which used sand coverage and boulder presence as factors describing sediment properties, as well as smooth functions of depth and wave energy, performed best for the model calibration data. Model 5, which differ from model 7 only by not using boulder presence, performed almost equally well for the calibration data. Therefore, when used with the detailed sediment type information from the video surveys, both models predicted a similar distribution pattern of *Furcellaria* stands in the model calibration area (Fig. 9A and 9C), which represented the data well (see Fig. 3A). Based on the sediment types from the lithological map the same model formulations generated widely differing

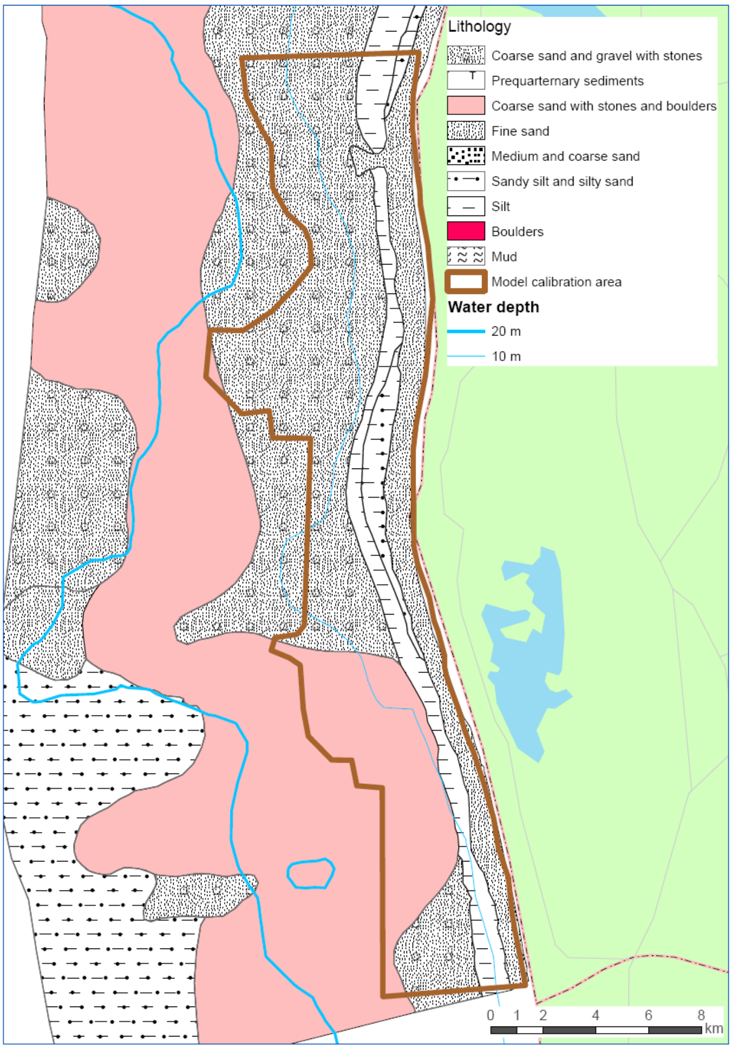

Fig. 8: *Sediment types in the model calibration area according to the lithological map of the Latvian coastal zone (Ulsts and Bulgakova, 1998)*

predictions (Fig. 9B and 9D). Model 7 now predicted *Furcellaria* stands only in the southern tip of the calibration area, corresponding to the boulder presence derived from the lithological map. Model 5 on the other hand overestimated *Furcellaria* occurrence. However, *Furcellaria* distribution is predicted within a realistic depth range and the *Furcellaria* stands identified in the video survey are mostly located within the region where model 5 predicts more than 75 % occurrence probability. Also when applied to the entire Latvian Baltic Proper coast (Figs. Appendix I-2 and Appendix I-3), model 7 only predicts the occurrence of *Furcellaria* stands at isolated rocky patches, whereas model 5 generates high occurrences probabilities along large stretches of the coastline. The occurrence pattern generated by model 5 corresponds better to the data presented in the Butinge Oil Terminal Environmental Impact Assessment (Finnish Institute of Marine Research, 1998), which indicate that *Furcellaria* is present along large regions of the Latvian Baltic Proper coast. Therefore using a simpler representation of sediment type, as is the case with replacing the boulder presence/sand coverage parameterization in model 7 by the simpler sand coverage description in model 5, seems to lead to a more robust model that performs better when detailed bottom type information is unavailable.

Taken to the extreme of model performance when sediment type information is completely unavailable, model0depth, which relies entirely on depth information, also generates a distribution of *Furcellaria* stands along the entire coast within its optimum depth range, but does not generate occurrence probabilities larger than 0.6 (Fig. Appendix I-4).

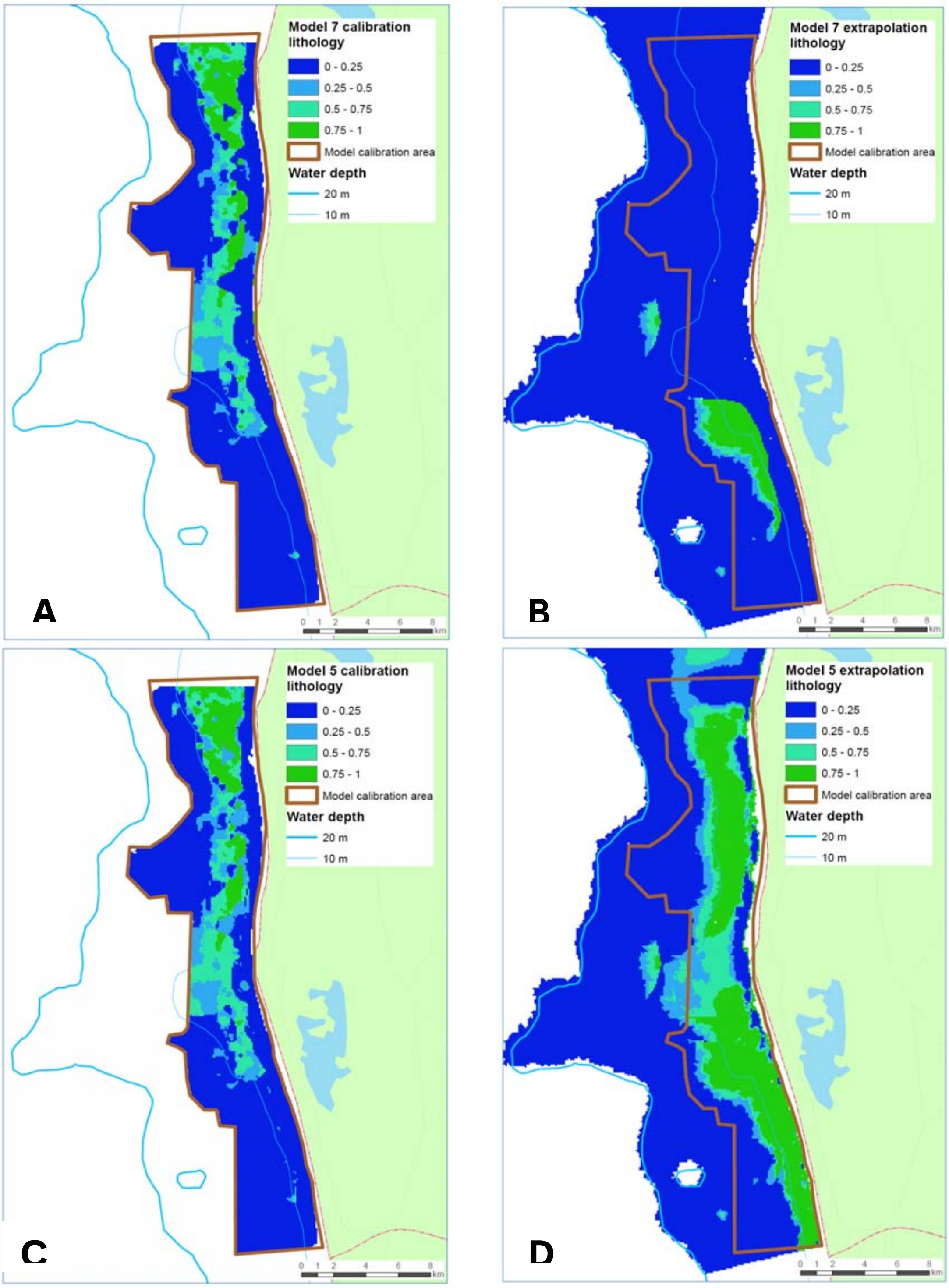

Fig. 9: Probability of presence of Furcellaria stands predicted by model 7 based on calibration lithology (A) and extrapolation lithology (B), compared to predictions from model 5 based on calibration lithology (C) and extrapolation lithology (D)

5 CONCLUSIONS

GAM provides a highly sensitive modelling tool that was able to identify the physical effects of the strongly co-varying predictors' depth and wave energy on *Furcellaria* occurrence. A rough representation of *Furcellaria* presence can be derived from physical parameters alone, i.e. depth or wave energy, or their combination. Inclusion of bottom type information increases the ability of the model to identify sites where the occurrence of *Furcellaria* is highly likely and extends its growth outside the optimum depth and wave energy range when substrate conditions are suitable. Models which rely on very detailed bottom type information, e.g. sand coverage and boulder presence, do not perform well when used with less detailed input data, while models which use a coarser description of bottom type generate more robust occurrence predictions. However, in order to use modelling as a tool to designate the protected areas described by Annex 1 of the EU Habitat directive, depth and bottom type information is required on a finer scale than provided by the maps currently available for the entire Latvian Baltic Proper coast.

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7 APPENDIX: EXPLANATION OF FURCELLARIA OCCURRENCE

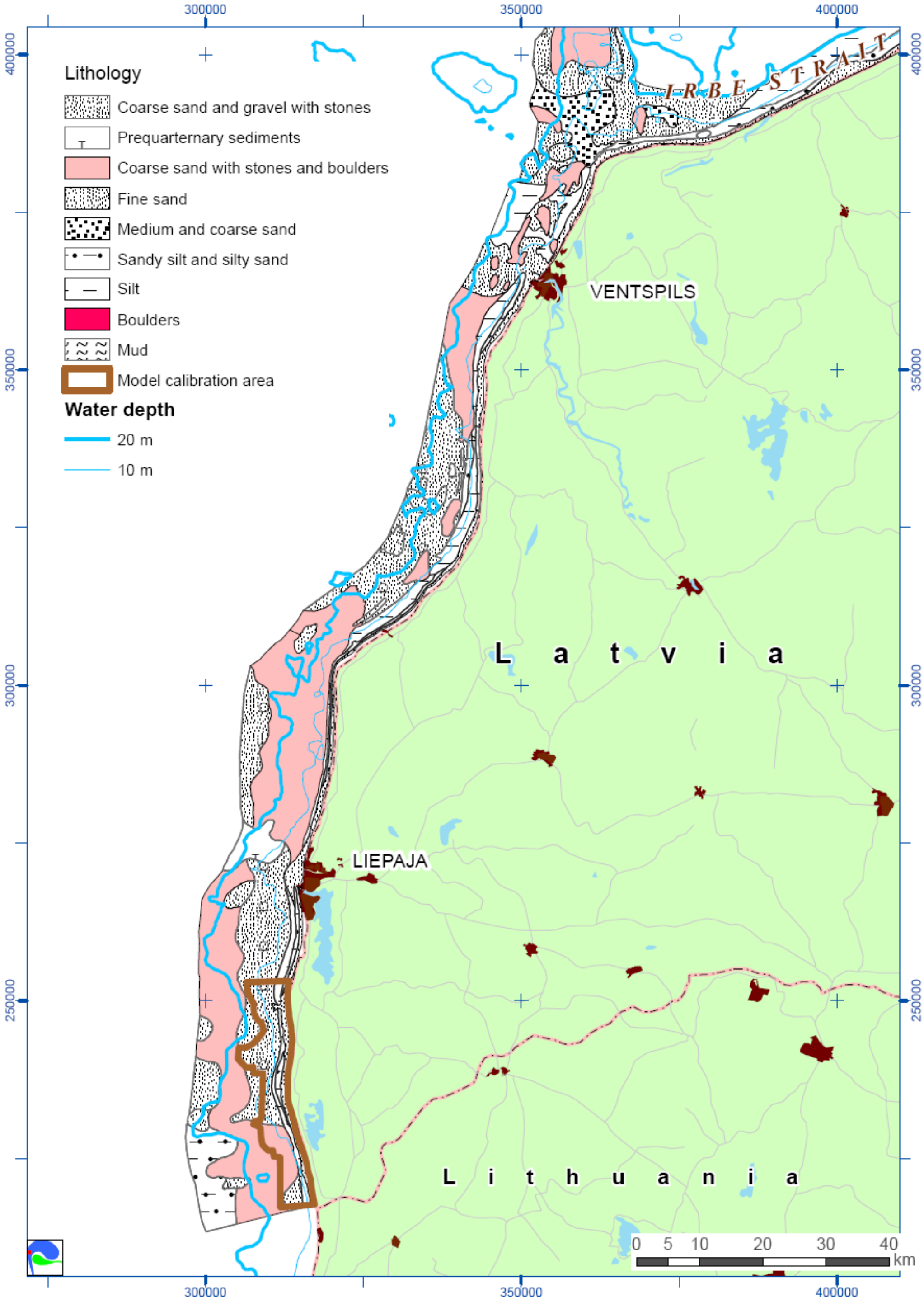

Fig. Appendix I-1: Lithology in the model extrapolation area; bottom types where boulders are present are marked in pink

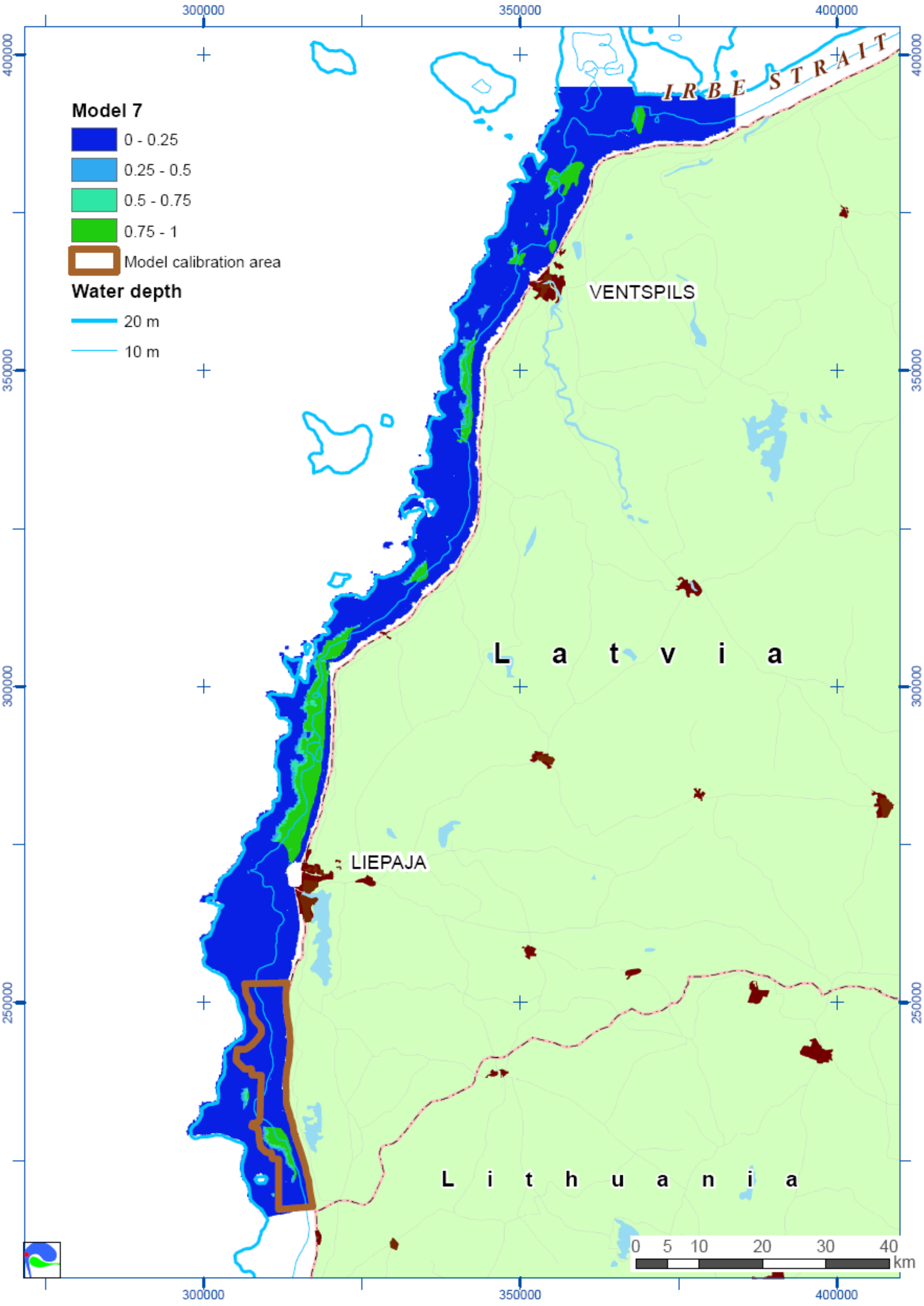

Fig.Appendix I-2: *Probability of presence of* Furcellaria *stands predicted by model 7 (factors sand coverage and boulder presence, smooth functions of depth and wave energy)*

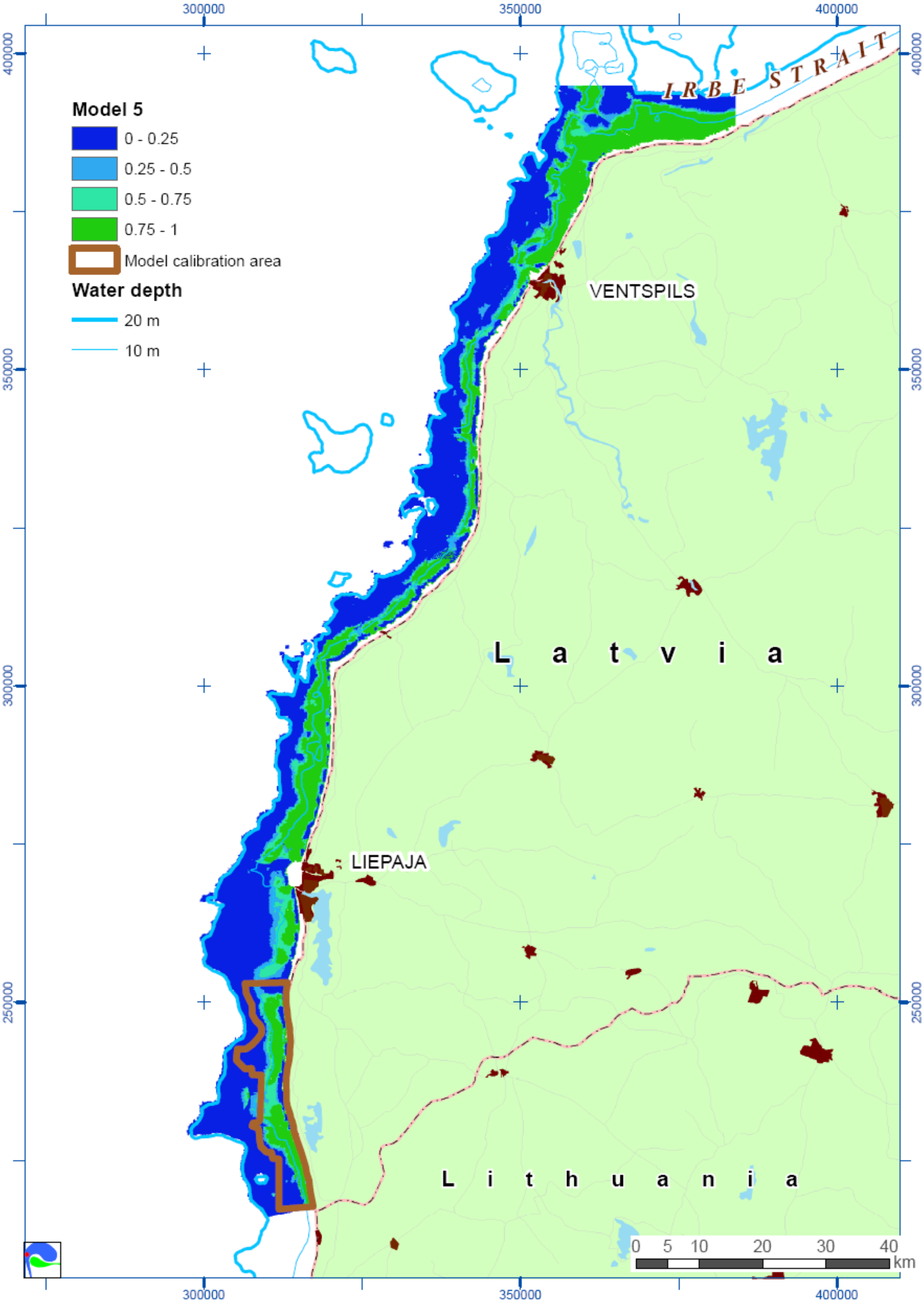

Fig.Appendix I-3: *Probability of presence of* Furcellaria *stands predicted by model 5 (factor sand coverage, smooth functions of depth and wave energy)*

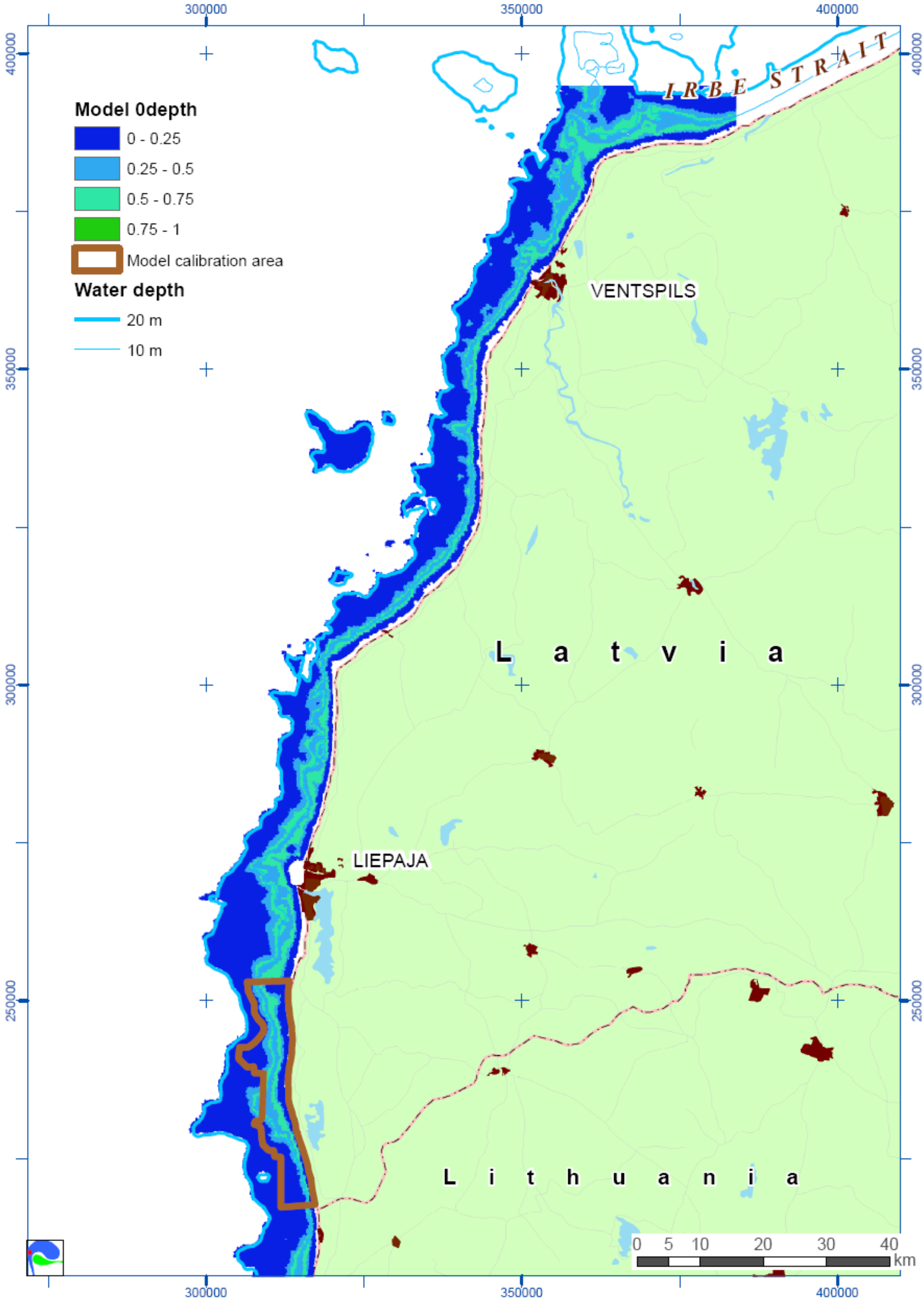

Fig. Appendix I-4: *Probability of presence of* Furcellaria *stands predicted by model 0depth (smooth function of depth)*

About the BALANCE project:

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 work is part financed by the European Union through the development fund BSR INTERREG IIIB Neighbourhood Programme and partly by the involved partners. For more information on BALANCE, please see www.balance-eu.org and for the BSR INTERREG Neighbourhood Programme, please see www.bsrinterreg.net

The **BALANCE Report Series** includes:

BALANCE Interim Report No. 1	"Delineation of the BALANCE Pilot Areas"
BALANCE Interim Report No. 2	"Development of a methodology for selection and assessment of a representative MPA network in the Baltic Sea – an interim strategy"
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BALANCE Interim Report No. 6	"BALANCE Cruise Report - The Archipelago Sea"
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BALANCE Interim Report No. 26	"What´s happening to our shores?"
BALANCE Interim Report No. 27	"Mapping and modelling of marine habitats in the Baltic Sea"
BALANCE Interim Report No. 28	"GIS tools for marine planning and management"
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BALANCE Interim Report No. 31	"Marine landscapes and benthic habitats in the Archipelago Sea"
BALANCE Interim Report No. 32	"Guidelines for harmonisation of marine data"
BALANCE Interim Report No. 33	"The BALANCE Conference"

In addition, the above activities are summarized in four technical summary reports on the following themes 1) Data availability and harmonisation, 2) Marine landscape and habitat mapping, 3) Ecological coherence and principles for MPA selection and design, and 4) Tools and a template for marine spatial planning. The BALANCE Synthesis Report "Towards a Baltic Sea in balance" integrates and demonstrates the key results of BALANCE and provides guidance for future marine spatial planning.