RoxAnn Measurements and Video based Mussel Mapping from Øresund, Denmark: Data Report

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1 Data

Work is done on two historical datasets from Øresund, the sound between Denmark and Sweden.

One data set consists of video based ground truth information on the degree of mussel coverage. This data covers an area of approximately 31 by 19 km^2 (the rectangle described by $x_{UTM} \in [351,411;369,006]$ and $y_{UTM} \in [6,152,421;6,182,806]$). The original data set has 30,134 observations. However, some observations a copied in the original data set. When copies are removed we are left with 29,058 observations. The original values in the data have been transformed according to this table

Original value	Approximate coverage
0	0 %
4	15 %
3	35 %
2	65 %
1	90 %

These data are shown in Figure 1.

The other data set consists of RoxAnn measurements (E1,E2) from a smaller area of approximately 1.5 by 2.0 km^2. The E1 and E2 values lie between 0 and 2. Also these data contain copies, and in this case the removal of these reduces the number of observations from 20,478 to 17,292. Figures 2 and 3 show the RoxAnn data.

In the region of overlap between the two data sets ($x_{UTM} \in [358,000;360,000]$ and $y_{UTM} \in [6,161,000;6,162,500]$) we have 842 observations in the mussel coverage data. Figure 4 shows the mussel coverage in the region covered by RoxAnn data. The position of the region of overlap between the two data sets is shown with a rectangle in Figure 1.

Figure 5 shows 2-D histograms of E2 and E1 values before (left) and after logarithm transformations.

2 Spatial Structure

Figure 6 shows the 1-D isotropic semivariogram of the mussel coverage in the region of overlap before (left) and after logarithm transformation (before taking logs 0 % coverage is replaced by 1 % coverage). The lag distance is 5 m.

Figure 7 shows the 2-D semivariogram of the mussel coverage in the region of overlap before (left) and after logarithm transformation. The lag distance in both x- and y-directions is 50 m.

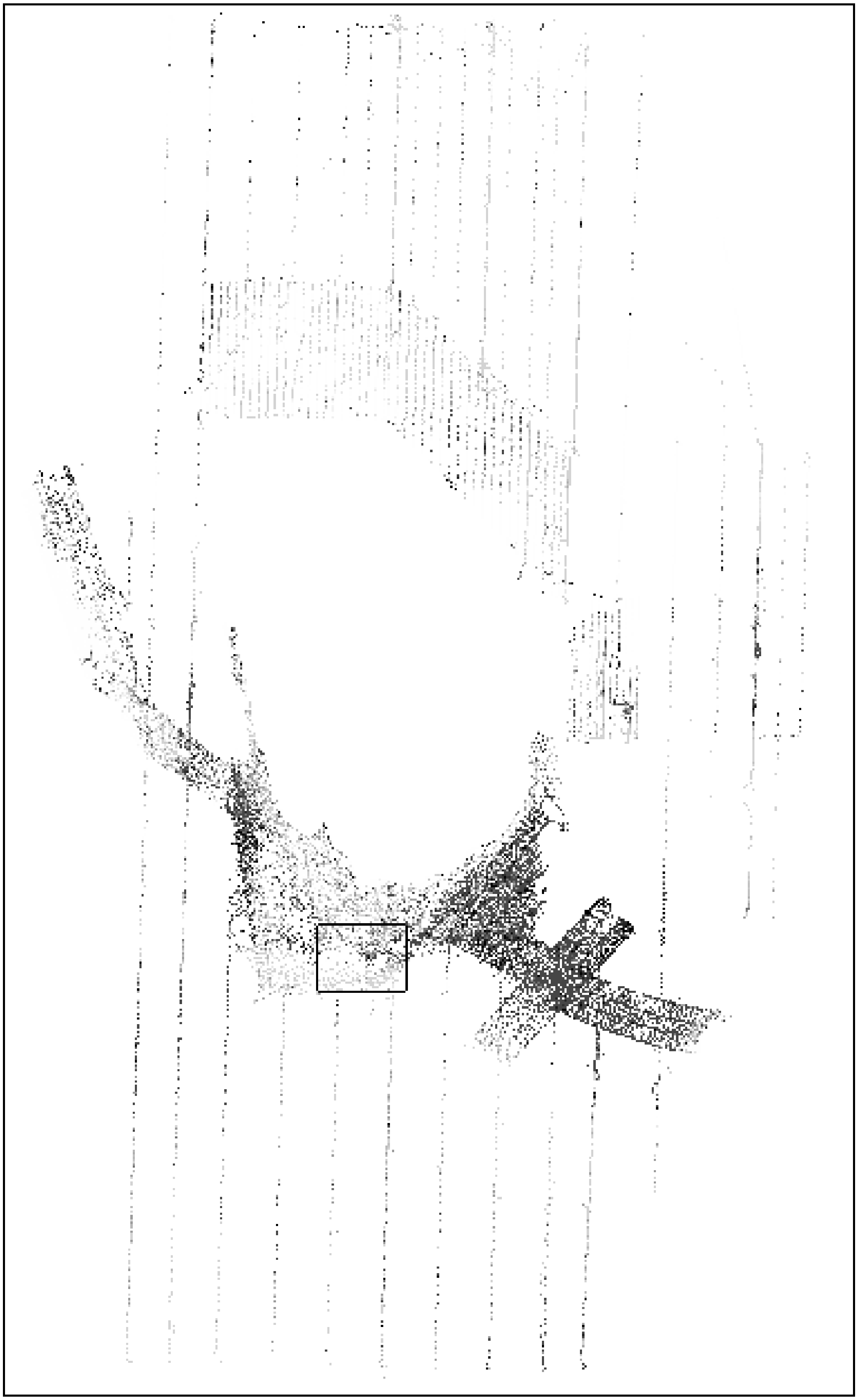

Figure 1. Mussel coverage

Figure 2. RoxAnn, E1

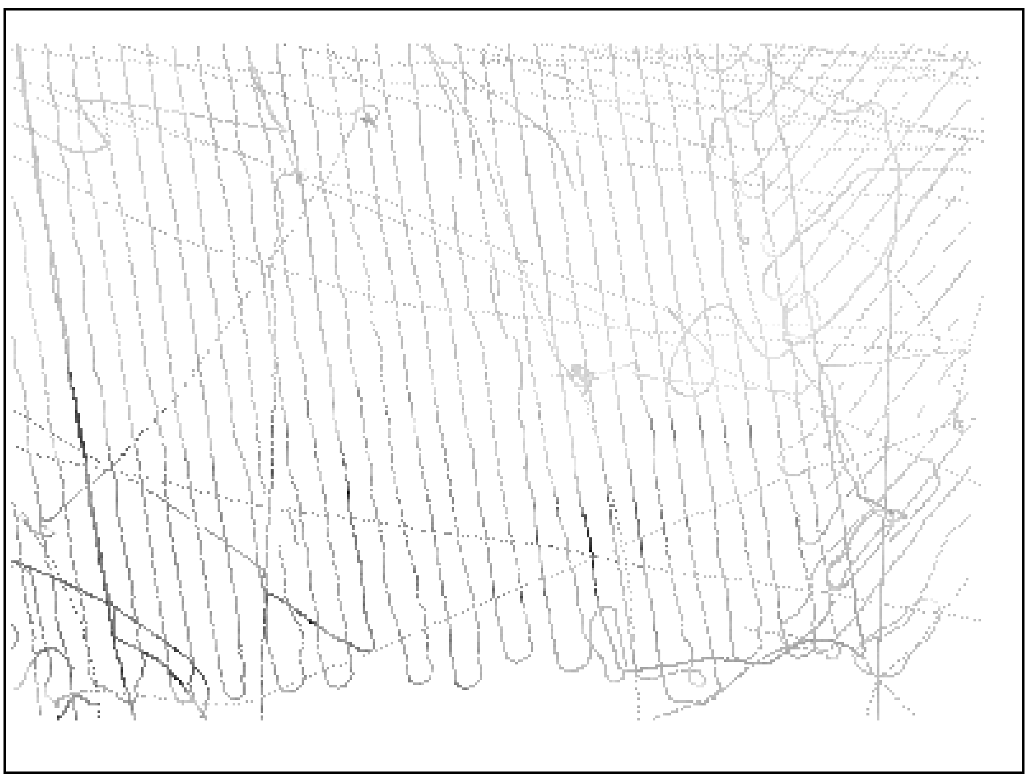

Figure 3. RoxAnn, E2

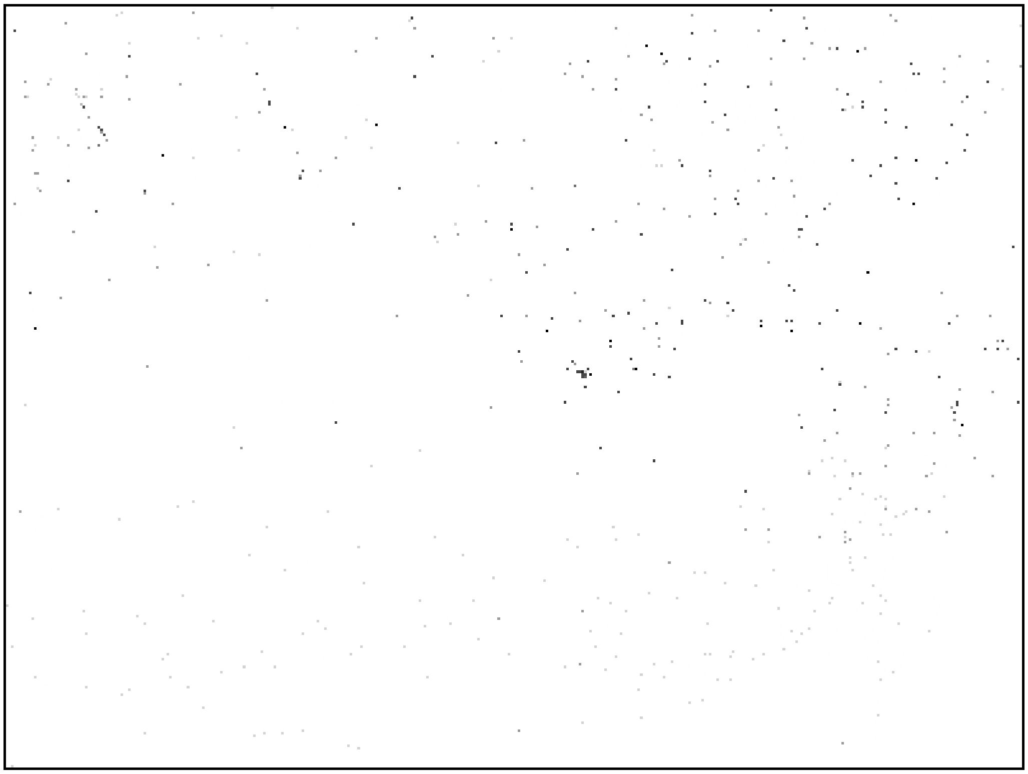

Figure 4. Mussel coverage in RoxAnn data region

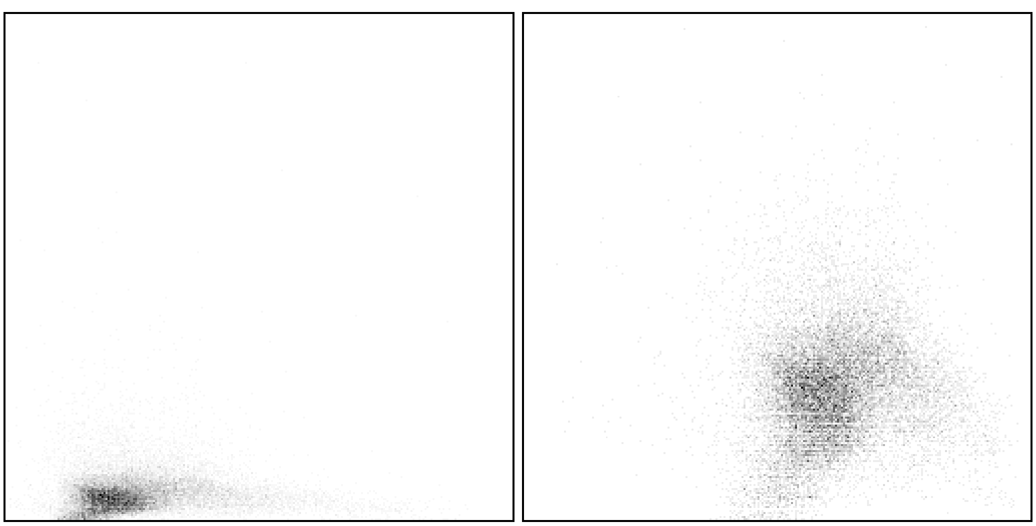

Figure 5. 2-D histograms of (E2,E1) (left) and ln(E2,E1)

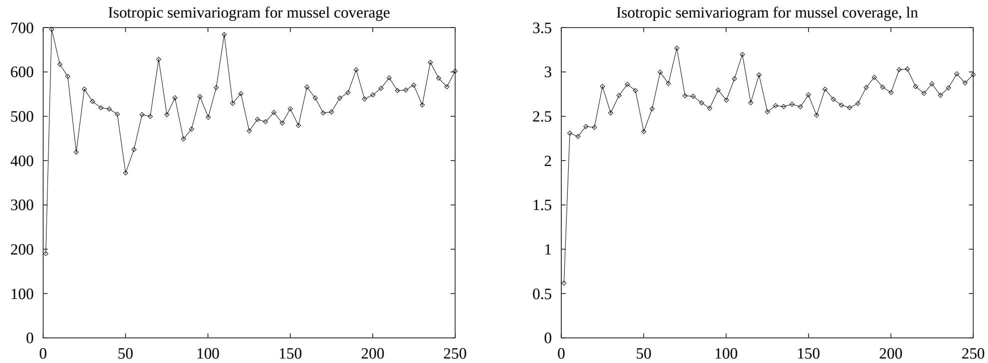

Figure 6. 1-D semivariograms of mussel coverage before (left) and after taking logarithms

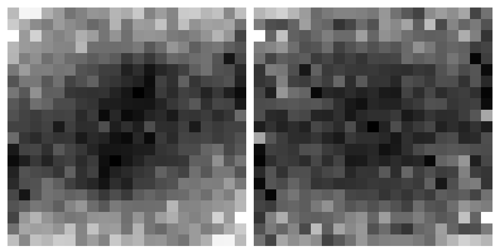

Figure 7. 2-D semivariograms of mussel coverage before (left) and after taking logarithms, 21×21 50×50 m^2 pixels

Figure 8 shows 1-D isotropic indicator semivariograms of the mussel coverage in the region of overlap. The lag distance is 5 m.

Figures 9 and 10 shows 2-D semivariograms of the mussel coverage in the region of overlap. In Figure 9 individual stretching is used, In Figure 10 a common stretch is used. The lag distance in both x- and y-directions is 50 m.

Figures 11 and 12 show 1-D isotropic semivariograms of E1 and E2 before (left) and after logarithm transformation. The lag distance is 5 m.

Figures 13 and 14 show 2-D semivariograms of E1 and E2 before (left) and after logarithm transformation. The lag distance in both x- and y-directions is 50 m.

The following table shows parameters for double spheric semivariogram models for the ln-transformed variables. The models are based on sample semivariograms with lag values up to 500 m.

	Short Range [m]	Long Range [m]	Nugget [$unit^2$]	Low Sill [$unit^2$]	High Sill [$unit^2$]
E1	8.882	539.5	0.03419	0.04243	0.08920
E2	18.95	$6.896\ 10^{13}$	0.02429	0.01844	$4.152\ 10^{9}$
Mussel	7.562	10780	0.000	2.545	10.88

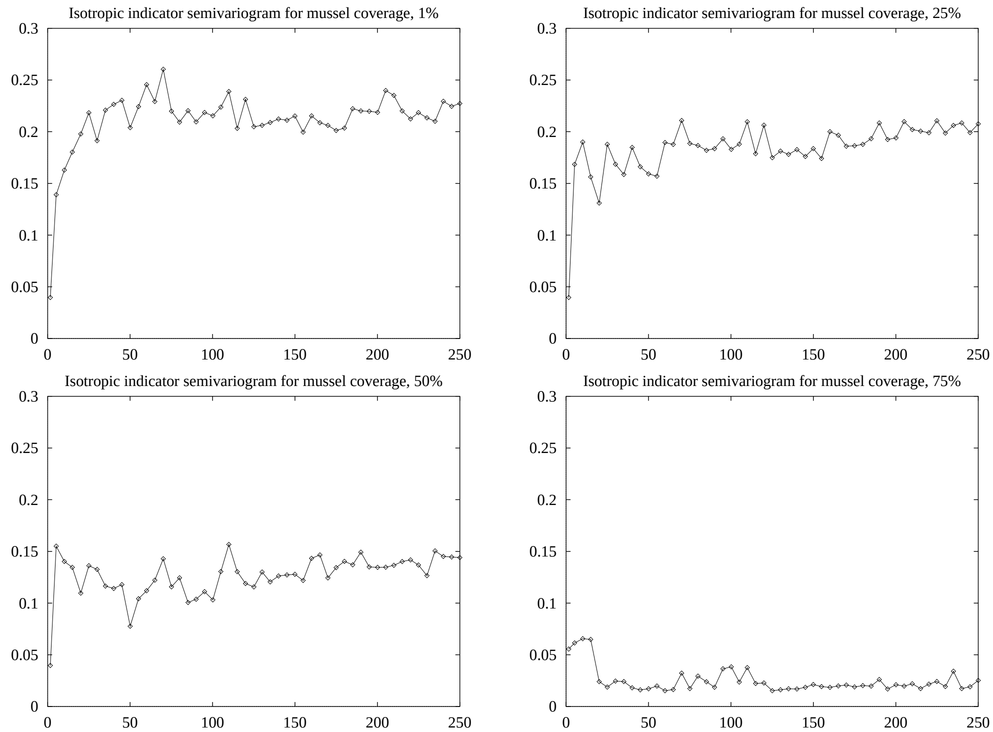

Figure 8. 1-D indicator semivariograms of mussel coverage, 1% cutoff (top-left), 25% cutoff (top-right), 50% cutoff (bottom-left), and 75% cutoff (bottom-right)

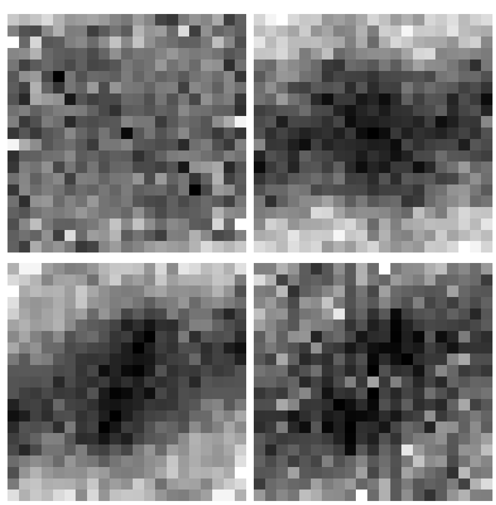

Figure 9. 2-D indicator semivariograms of mussel coverage, 1% cutoff (top-left), 25% cutoff (top-right), 50% cutoff (bottom-left), and 75% cutoff (bottom-right); 21×21 50×50 m^2 pixels, individual streching

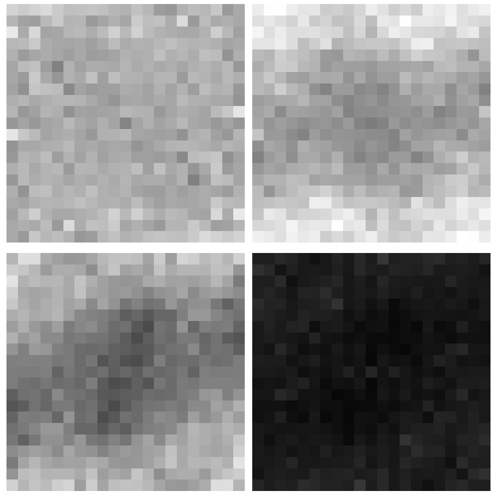

Figure 10. 2-D indicator semivariograms of mussel coverage, 1% cutoff (top-left), 25% cutoff (top-right), 50% cutoff (bottom-left), and 75% cutoff (bottom-right); 21×21 50×50 m^2 pixels, common streching

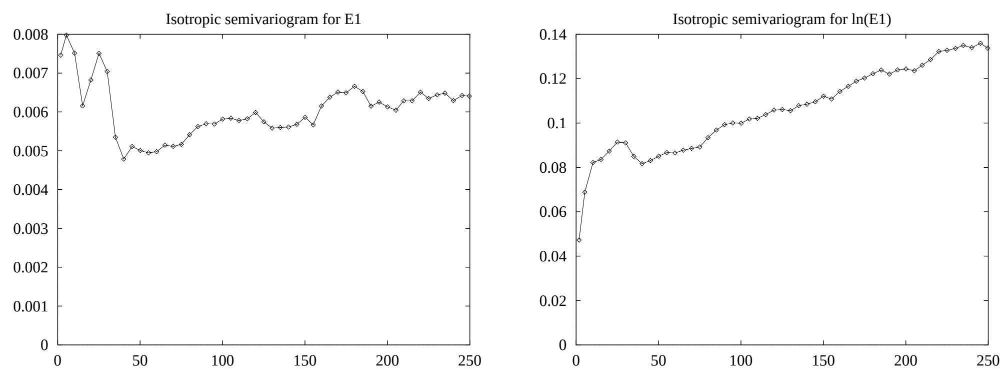

Figure 11. 1-D semivariograms of E1 (left) and ln(E1)

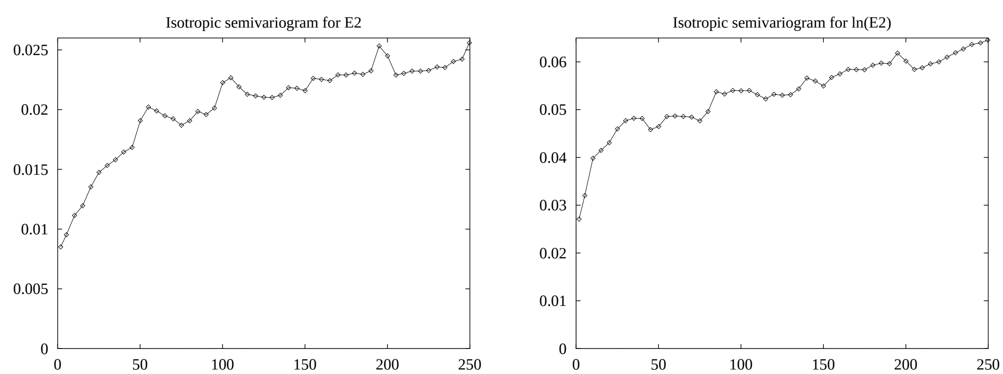

Figure 12. 1-D semivariograms of E2 (left) and ln(E2)

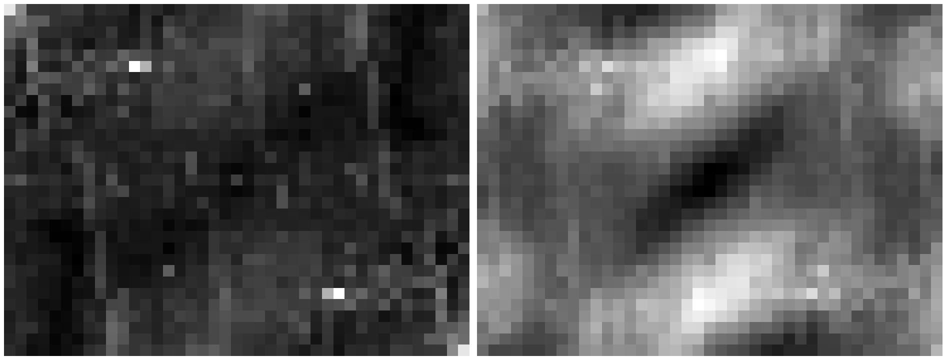

Figure 13. 2-D semivariograms of E1 (left) and ln(E1), 31×41 50×50 m^2 pixels

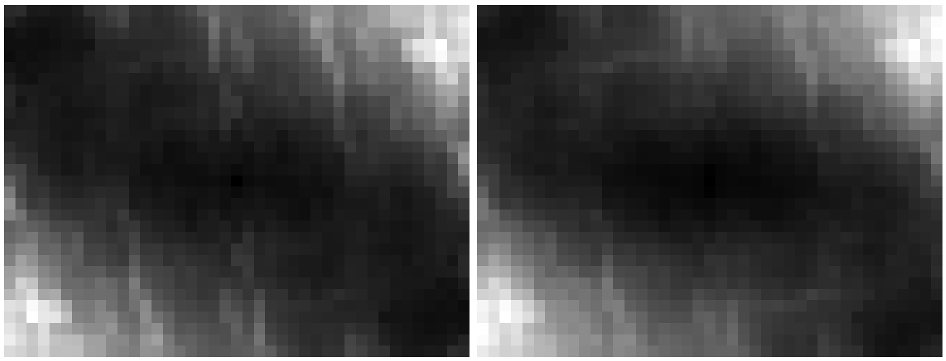

Figure 14. 2-D semivariograms of E2 (left) and ln(E2), 31×41 50×50 m^2 pixels

All subsequent work is done on logarithms of both RoxAnn and mussel coverage data.

3 Interpolation

A 10 meter grid is used for all interpolation schemes applied.

3.1 Weighted Means

Figure 15 shows interpolation of the mussel coverage, E1 and E2 by means of inverse distance weighting. The search radius is 1000 m and a maximum of 50 nearest neighbours are used.

3.2 Kriging

Kriged versions of the mussel coverage, E1 and E2 are shown in Figure 16. The semi-variogram models used are the ones listed above. The search radius is 1000 m and a

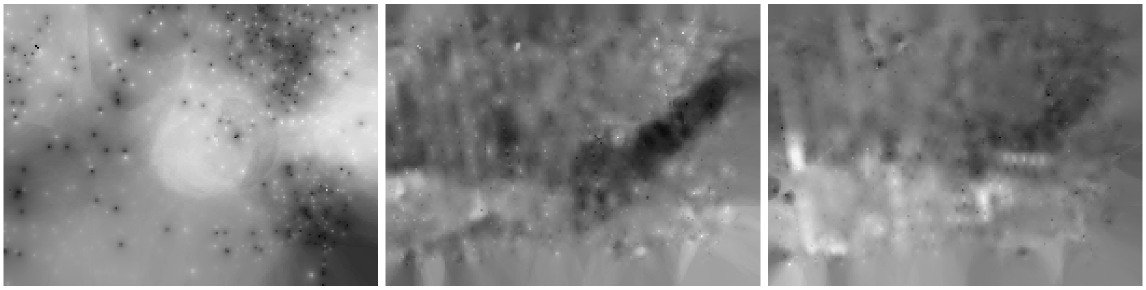

Figure 15. Inverse distance weighted mussel coverage (left), E1 (middle) and E2, ln

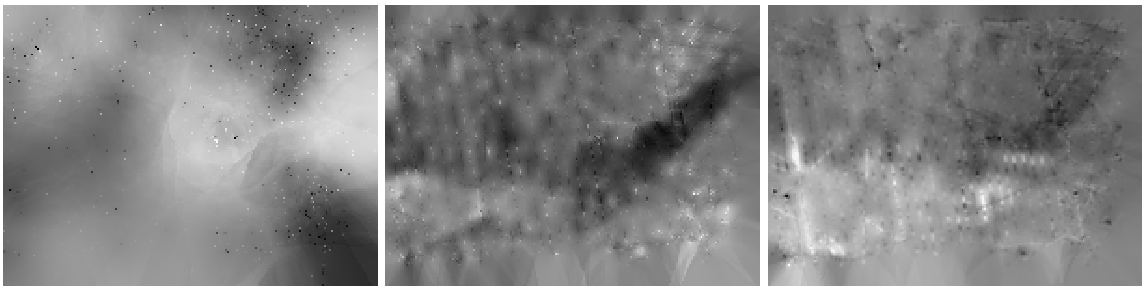

Figure 16. Kriged mussel coverage (left), E1 (middle) and E2, ln

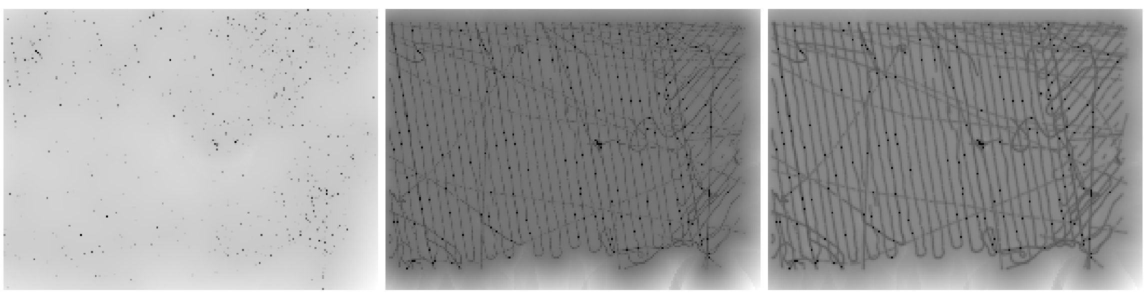

Figure 17. Kriging variances for mussel coverage (left), E1 (middle) and E2, ln

maximum of 50 nearest neighbours are used.

The corresponding kriging variances are shown in Figure 17.

The correlation matrix between the kriged variables is shown in the following table.

	Mussel	E1	E2
Mussel	1.00	–0.50	–0.26
E1	–0.50	1.00	0.27
E2	–0.26	0.27	1.00

3.3 Markov Random Fields

The irregularly sampled data have been interpolated by means of MRF techniques also. The optimisation problem involved is solved by means of iterated conditional modes (ICM) which in this case with one minimum only can reach that solution if iterations are not stopped too soon.

MRF/ICM interpolated versions of the mussel coverage, E1 and E2 are shown in Figures 18 to 20. The parameter α which lies between 0 and 1 determines the degree of smoothness of the interpolation. $1 - \alpha$ determines the degree of belief in the actually measured data.

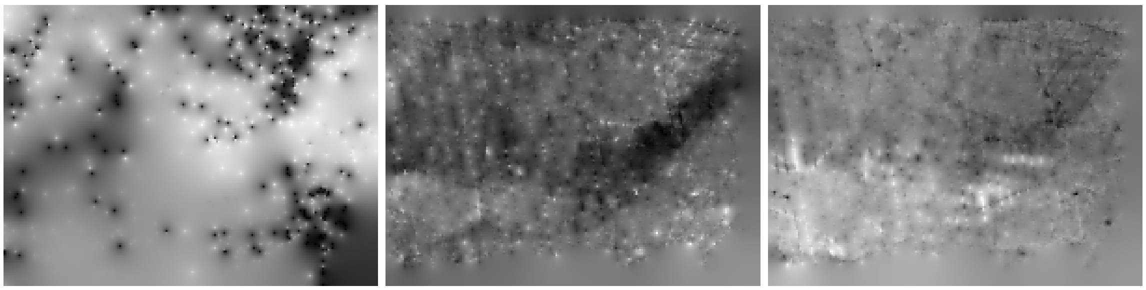

Figure 18. MRF/ICM (α=0.1) mussel coverage (left), E1 (middle) and E2, ln

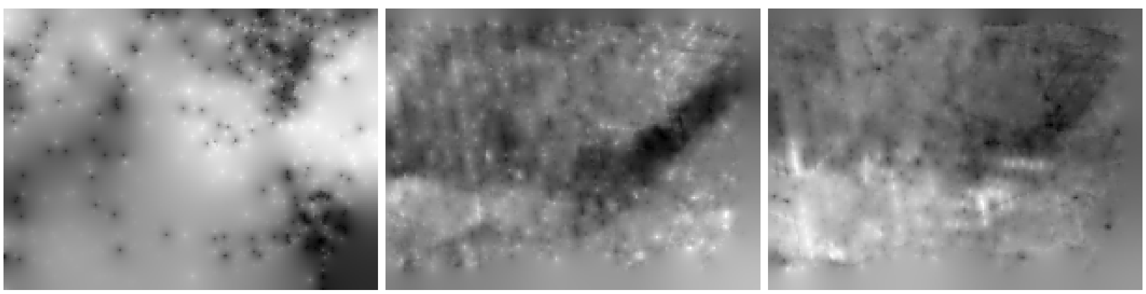

Figure 19. MRF/ICM (α=0.5) mussel coverage (left), E1 (middle) and E2, ln

Figure 20. MRF/ICM (α=0.9) mussel coverage (left), E1 (middle) and E2, ln

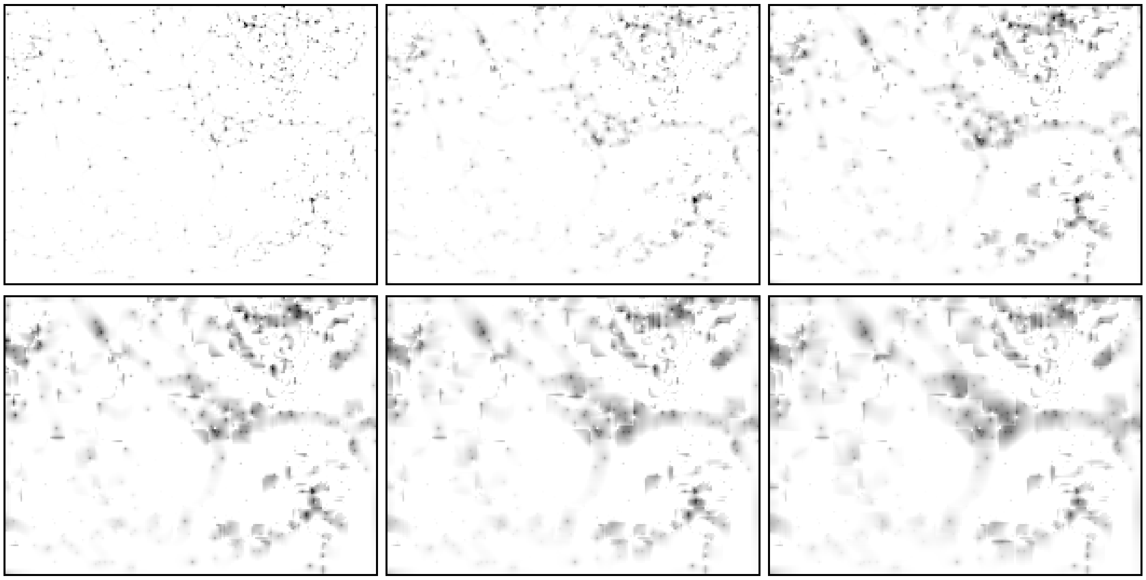

Figure 21. Tophat transformations of MRF/ICM (α=0.9) mussel coverage

4 Patchiness

As a first attempt to visualise patchiness in the mussel coverage a white tophat transformation is applied to the MRF/ICM ($\alpha = 0.9$) interpolated image. The (negated) results are shown for ever increasing structural elements in Figure 21. The basic structural element is a 3$\times$3 box.

5 Prediction of Mussel Coverage

As an example of prediction of mussel coverage from RoxAnn data a regression analysis based on the above kriged version of data is performed. This table summarises the results

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	2	3299.50227	1649.75114	5581.676	0.0001
Error	30348	8969.82255	0.29557		
C Total	30350	12269.32483			

Root MSE	0.54366	R-square	0.2689
Dep Mean	2.39660	Adj R-sq	0.2689
C.V.	22.68460		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
Intercept	1	0.152809	0.02179264	7.012	0.0001
E1	1	-1.124744	0.01223849	-91.902	0.0001
E2	1	-0.309184	0.01225278	-25.234	0.0001

This colour plate shows the the results from the different interpolation techniques as RGB plots. Mussel coverage is shown in red, E1 in green and E2 in blue (after taking logarithms). All left plots are scaled linearly between minimum and maximum. All middle plots are scaled linearly between mean value minus three standard deviations and mean value plus three standard deviations. All right plots are histogram equalised.

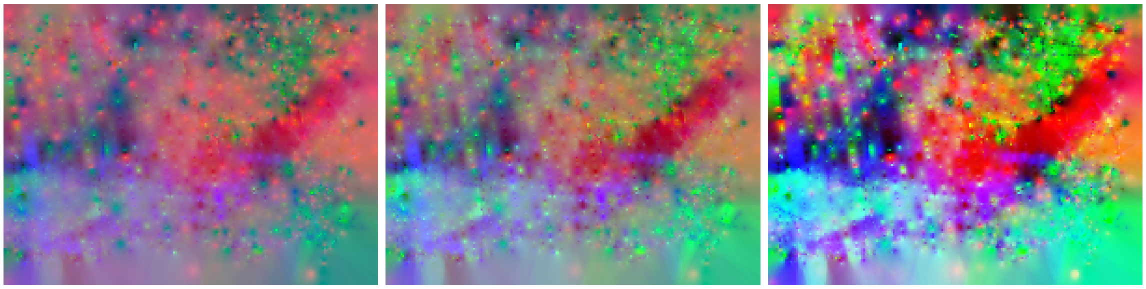

Figure 22. Inverse distance weighted mussel coverage, E1 and E2 as RGB, ln

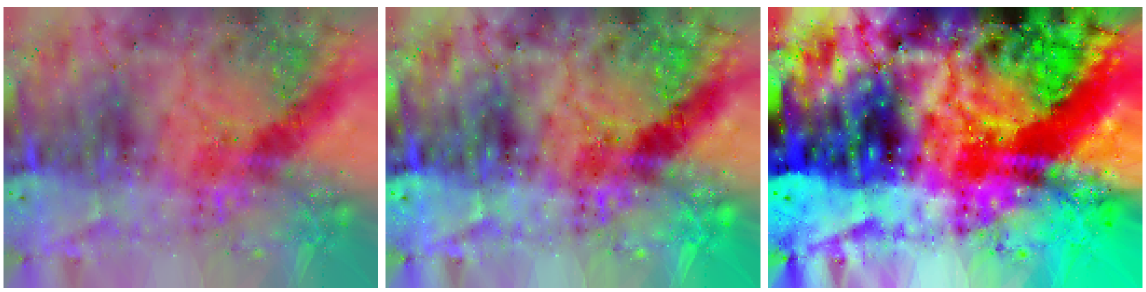

Figure 23. Kriged mussel coverage, E1 and E2 as RGB, ln

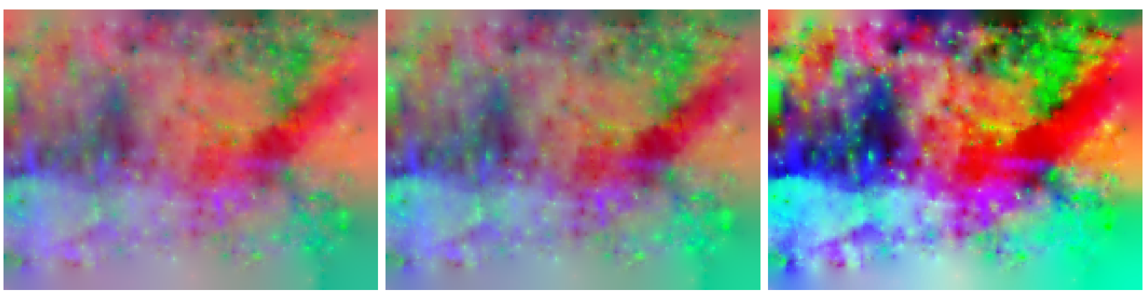

Figure 24. MRF/ICM (α=0.5) mussel coverage, E1 and E2 as RGB, ln