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Modelling Tidal Changes Within The Wash and Morecambe Bay During The Holocene

Volume 2

by

A.C. Hinton

**A Thesis submitted in partial fulfilment
of the requirements for the degree of
Doctor of Philosophy**

Geography Department

**The University of Durham
1992**



27 APR 1993

The results contained in this thesis are all my own work. Information derived from other sources is acknowledged at the appropriate point in the text. Work presented here has not been published elsewhere.

Signed

Anne C. Hinton

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The copyright of the bathymetric and label data for the Liverpool Bay and Morecambe Bay tidal models for present sea-level conditions, presented in Appendix 6.1, is held by the Proudman Oceanographic Laboratory, Birkenhead.

SYMBOLS USED IN THE TEXT

Symbol	Meaning (units)
a, b	Real and imaginary parts of a complex time-varying coefficient
c	Speed of progression of the tidal wave (metres per second)
c_g	Phase speed (radians)
C_D	Dimensionless drag coefficient
D	Total water depth ($h + \zeta$)
E	Matrix consisting of values of elements predicted from the model
f	Nodal factor - adjustment of tidal amplitude made for the 18.61 year nodal cycle of lunar declination
f_c	Coriolis parameter
f_e	Nodal factor of the Equilibrium Tide at time zero
F	Stress in the x direction
F_B	Bottom stress in the x direction
g	Gravitational constant ($6.67 \times 10^{-11} \text{Nm}^2\text{kg}^{-2}$)
G_e	Phase lag of the Equilibrium Tide at Greenwich (radians)
G_y	Stress in the y direction
G_B	Bottom stress in the y direction
h	Mean water depth
h_{max}	Maximum bathymetric value in model (metres)
h_{ws}	Smallest model grid width
h_w	Model grid width
H	Tidal amplitude
H_e	Tidal amplitude of harmonic constituent e
HO	Matrix consisting of values of amplitude and phase of harmonic constituents
i, m	Number of points at which calculations are made in the latitudinal and longitudinal directions respectively
I	An unspecified harmonic constituent
j, k	Constants
l	Tidal wavelength
L	Length of bay from sea mouth to head
m_e	Mass of the earth ($5.97 \times 10^{24} \text{kg}$)
m_l	Mass of the moon ($7.35 \times 10^{22} \text{kg}$)
M	A point at the centre of the moon
n	Nodal angle - adjustment of tidal phase made for the 18.61 year nodal cycle of lunar declination
n_e	Nodal angle of the Equilibrium Tide at time zero
O	A point at the centre of the earth
P	Hydrostatic pressure
P_A	Atmospheric pressure on the water surface
P_{Z_d}	Hydrostatic pressure at a point at depth z_d metres below the water surface

Symbol	Meaning (units)
\mathbf{q}	Depth-mean current vector
R	Equatorial radius of the earth (6,378 kilometres)
R_l	Distance from the centre of the earth to the centre of the moon (384,400 kilometres)
s	Coefficient of bottom friction
s'	An element of space
t	Time
$T(t)$	Tidal level at time t
u	Latitudinal velocity
u_q	Component of the depth-mean current in the direction of increasing χ
U	A constant
v	Longitudinal velocity
v_q	Component of the depth-mean current in the direction of increasing ϕ
V_e	Phase angle of the Equilibrium Tide at time zero (radians)
x	Latitudinal distance
X, Y, Z	Points at the surface of the earth
y	Longitudinal distance
z	Sea surface elevation
z_d	Distance below water surface
z_0, Z_0	Mean sea-level
ΔS	Grid width
$\Delta t, \Delta T$	Timestep (seconds)
ζ	Displacement of water level from mean value
θ	North co-latitude ($90^\circ - \text{latitude}$)
λ	Wavelength of the progressive wave
ρ	Water density (1025kg/m^3)
σ	Angular frequency (of a tidal constituent)
σ_e	Angular frequency at time zero of a tidal constituent e
τ_b	Bottom stress
ϕ	Angle of latitude
χ	East longitude
ω	Angular frequency of the earth's rotation
Ω	Gravitational potential at the surface of the earth
Ω_Y	Gravitational potential at a point Y on the surface of the earth

Harmonic Constituents

Constituent	Speed	Meaning
M_2	28.9841	lunar semi-diurnal tidal constituent
M_3	43.4761	lunar third-diurnal tidal constituent
M_4	57.9682	lunar quarter-diurnal tidal constituent
M_6	86.9523	lunar sixth-diurnal tidal constituent
MS_4	58.9841	generated by the interaction of M_2 and S_2
$2MS_2$ (or Meu_2)	27.9682	in shallow water
S_2	30.0000	solar semi-diurnal tidal constituent

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Figures relating to Chapter 6

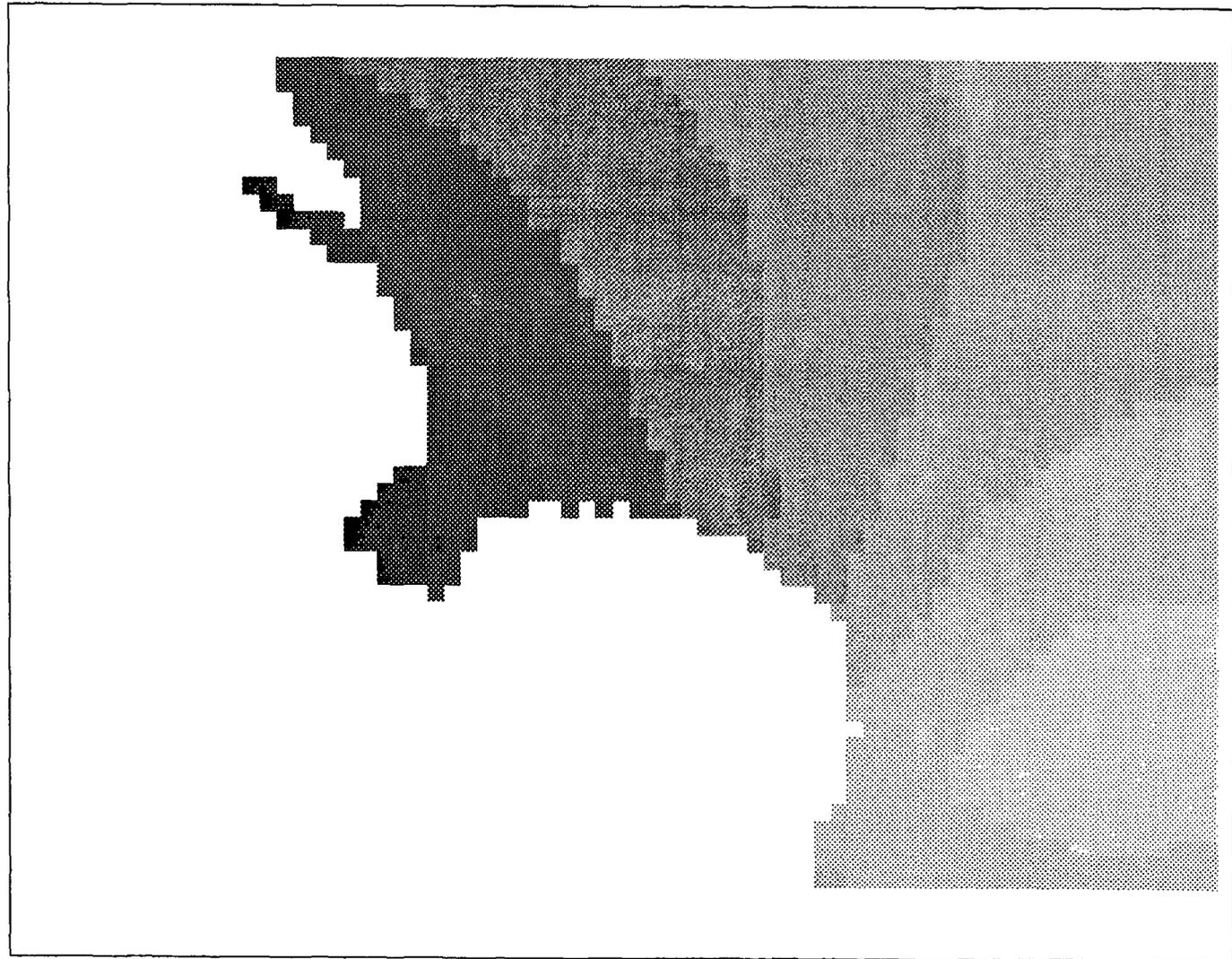
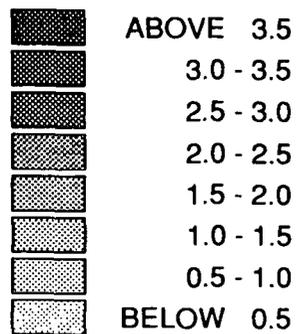
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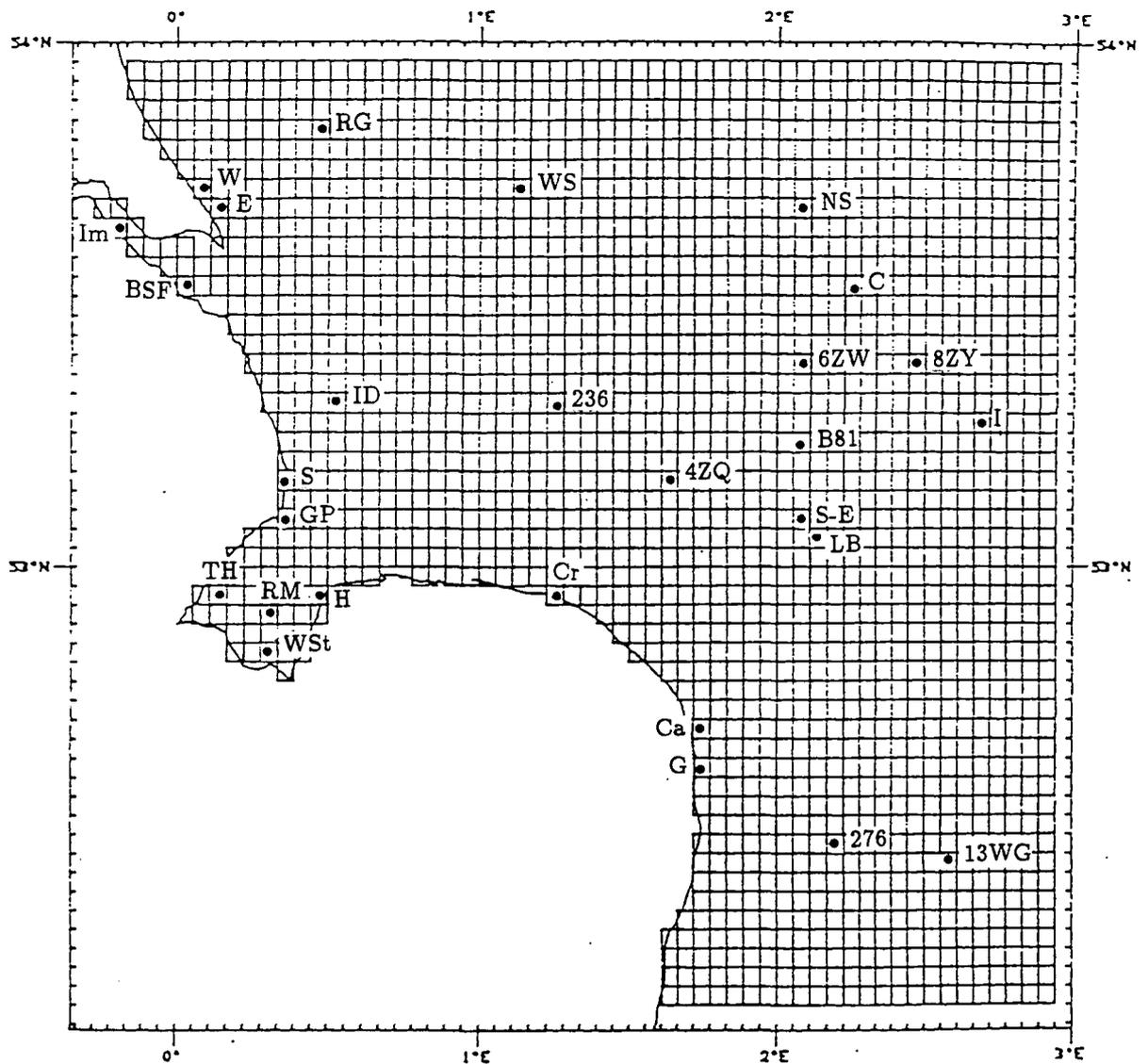


Figure 6.1. EAST COAST 3 MODEL

Maximum Tidal Altitudes (m.)
Present Sea-Level

2





Key

RG	Rough Gas Field	S	Skegness
NS	North Star Rig	4ZQ	4ZQ
W	Withernsea	S-E	Shell - Esso
WS	West Sole	GP	Gibraltar Point
Im	Immingham	LB	Leman Bight
E	Easington	TH	Tab's Head
236	OSTG 236	H	Hunstanton
BSF	Bull Sand Fort	Cr	Cromer
C	Conoco	RM	Roaring Middle
6ZW	6ZW	WSt	West Stones
8ZY	8ZY	Ca	Caister
ID	Inner Dowsing	G	Gorleston
I	Indefatigable	276	OSTG 276
B81	Station B81	13WG	13WG

Figure 6.2. EC3 Model Grid Showing the Locations from which the Data in Table 6.5 are taken.

Figure 6.3. EC3 Model Histogram: Present Sea-Level with data from Table 6.5.

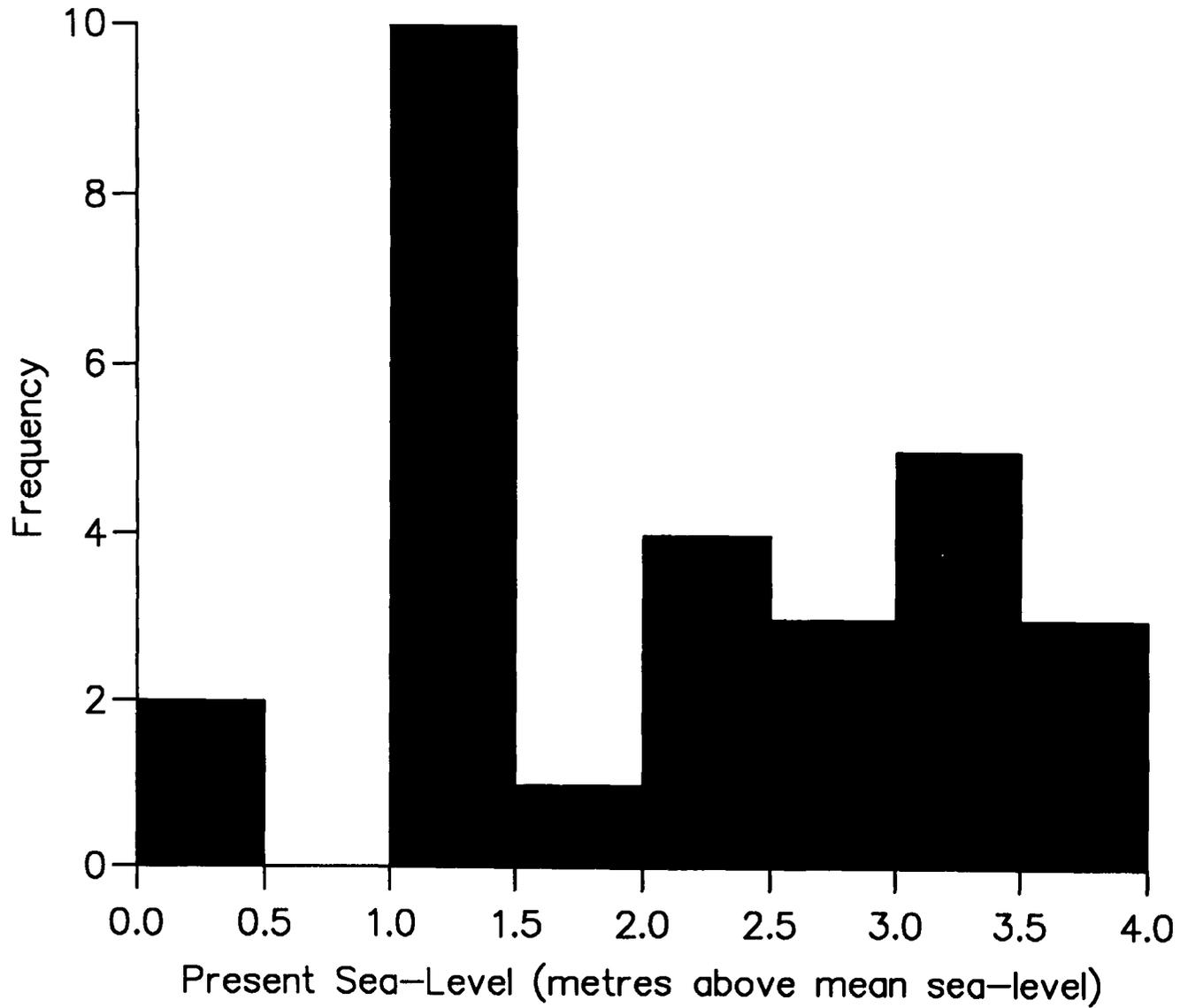


Figure 6.4. EC3 Model Data from Table 6.6. The bars represent the maximum and minimum extents of the data, whilst the line within each bar gives the standard deviation of the data about the mean value. The standard deviation is not shown to exceed the maximum or minimum value of the data, although this does occur in some cases.

Key

- 0 Present Sea-Level Simulation
- M1 Modification 1
- M2 Modification 2
- 2 -2 Metres Sea-Level Simulation
- 5 -5 Metres Sea-Level Simulation
- 10 -10 Metres Sea-Level Simulation
- 15 -15 Metres Sea-Level Simulation
- 3c 3,000 Years B.P. Coastline
- 3p 3,000 Years B.P. Palaeogeography
- 4c 4,000 Years B.P. Coastline
- 4p 4,000 Years B.P. Palaeogeography
- 5c 5,000 Years B.P. Coastline
- 5p 5,000 Years B.P. Palaeogeography

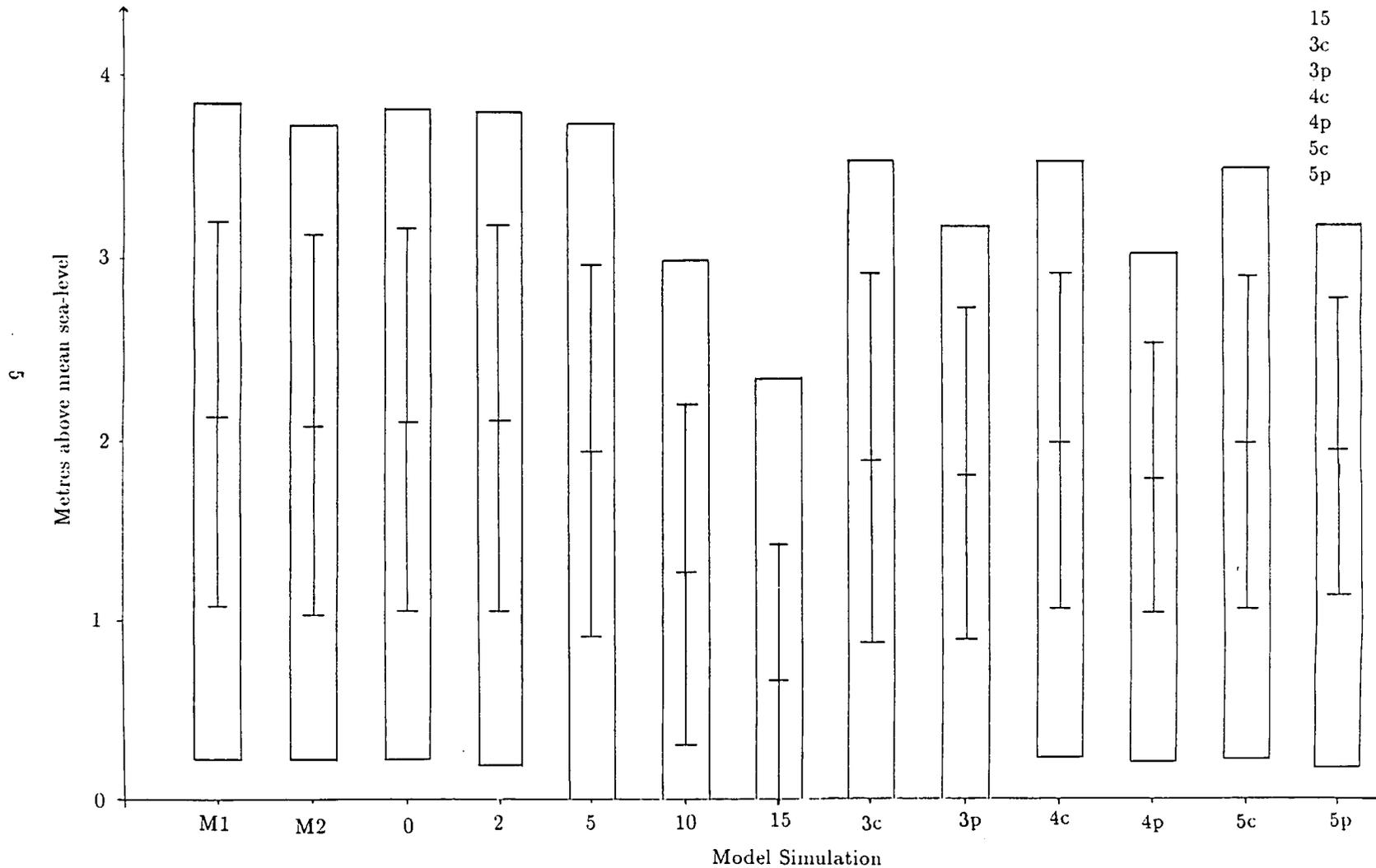
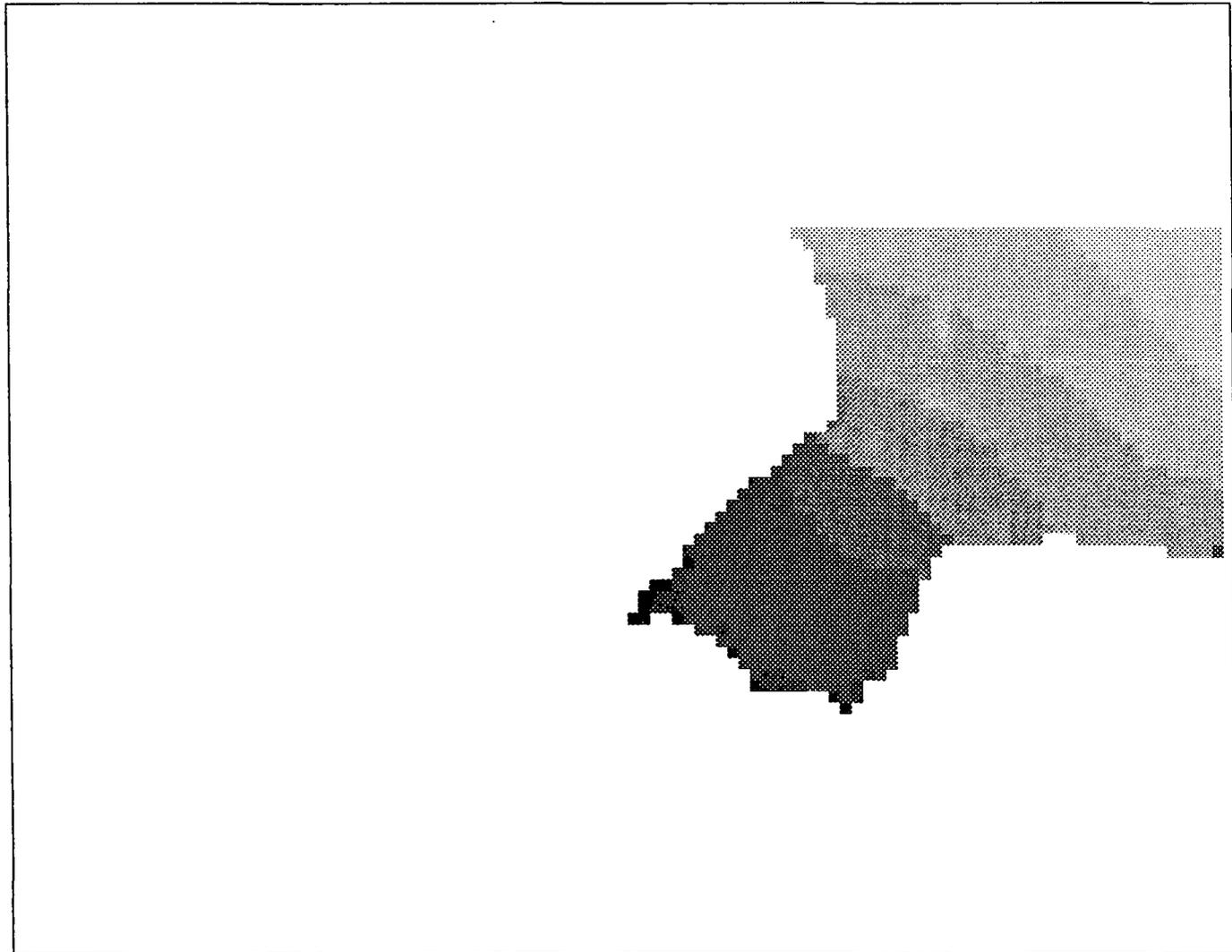
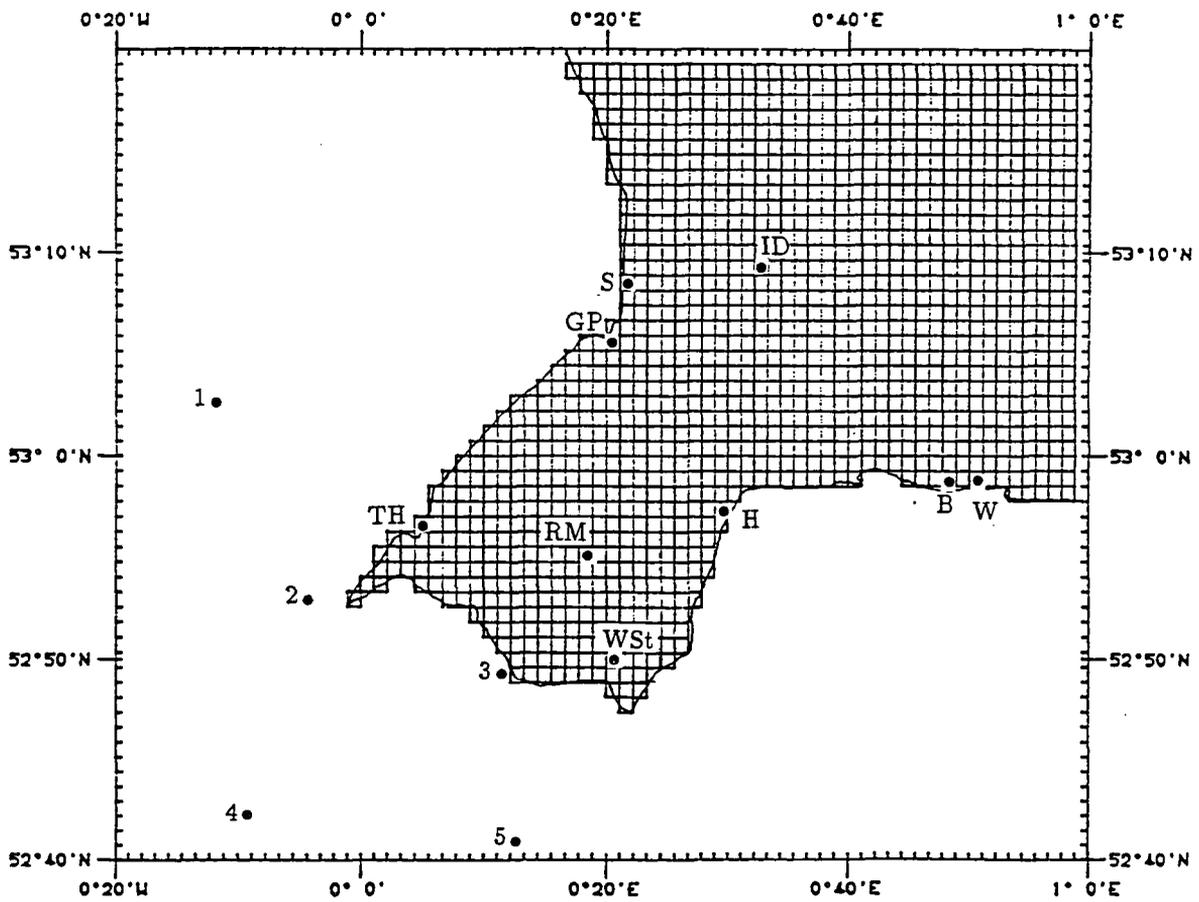


Figure 6.5. WASH MODEL Present Sea-Level

Maximum Tidal Heights (m.)



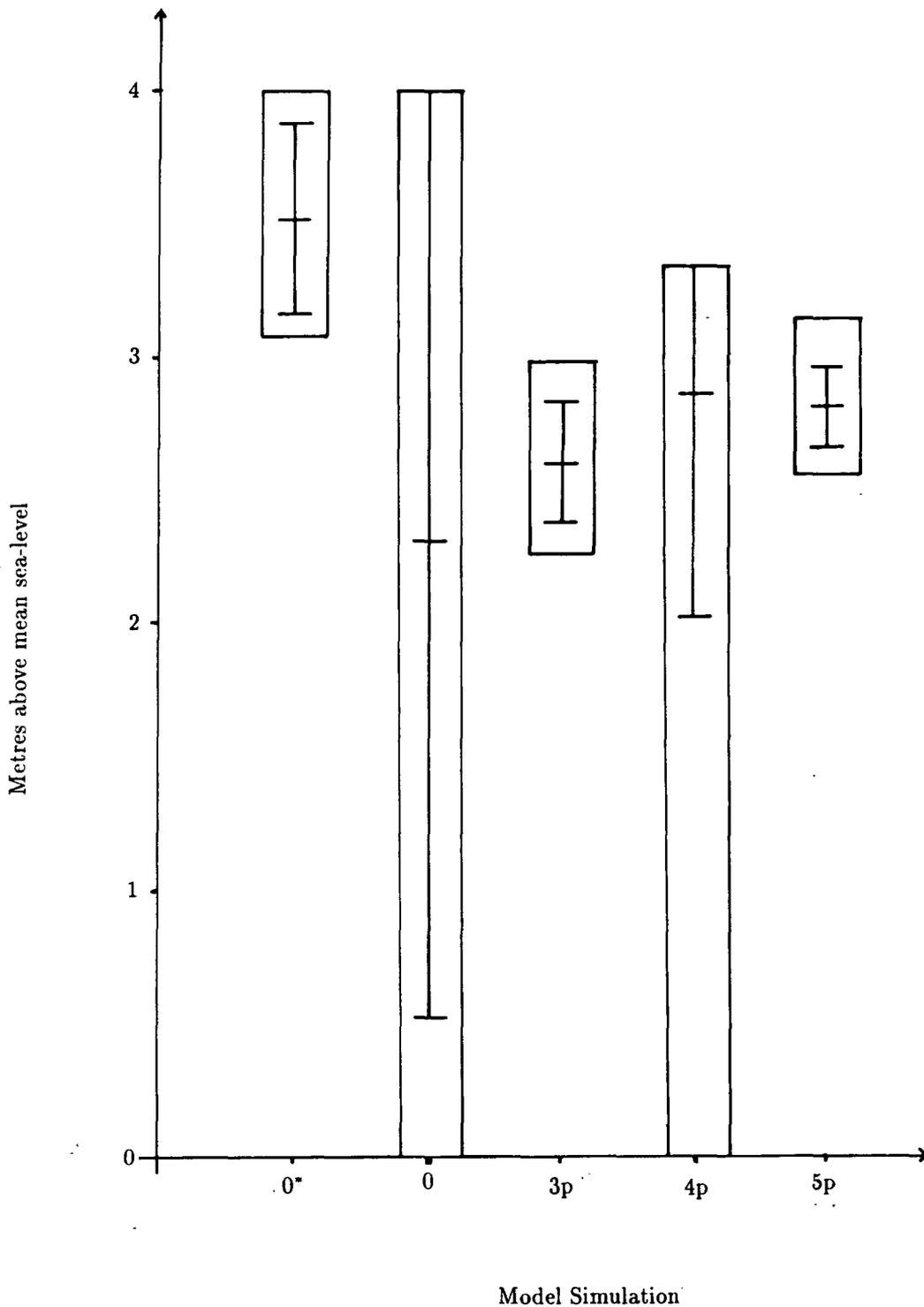


Key

ID	Inner Dowsing	RM	Roaring Middle
S	Skegness	WSt	West Stones
GP	Gibraltar Point	1	Point 1
B	Burnham	2	Point 2
W	Wells	3	Point 3
TH	Tabs Head	4	Point 4
H	Hunstanton	5	Point 5

Figure 6.6. WASH Model Grid Showing the Locations from which the Data in Table 6.7 are taken.

Figure 6.7. WASH Model Data from Table 6.8. The bars represent the maximum and minimum extents of the data, whilst the line within each bar gives the standard deviation of the data about the mean value. The standard deviation is not shown to exceed the minimum or maximum value of the data, although this does occur in some cases.



Key

- 0* Present Sea-Level Simulation excluding Points 1 to 5 from Table 6.7
- 0 Present Sea-Level Simulation
- 3p 3,000 Years B.P. Palaeogeography
- 4p 4,000 Years B.P. Palaeogeography
- 5p 5,000 Years B.P. Palaeogeography

Figure 6.8. WASH Model Histogram: Present Sea-Level with data from Table 6.7.

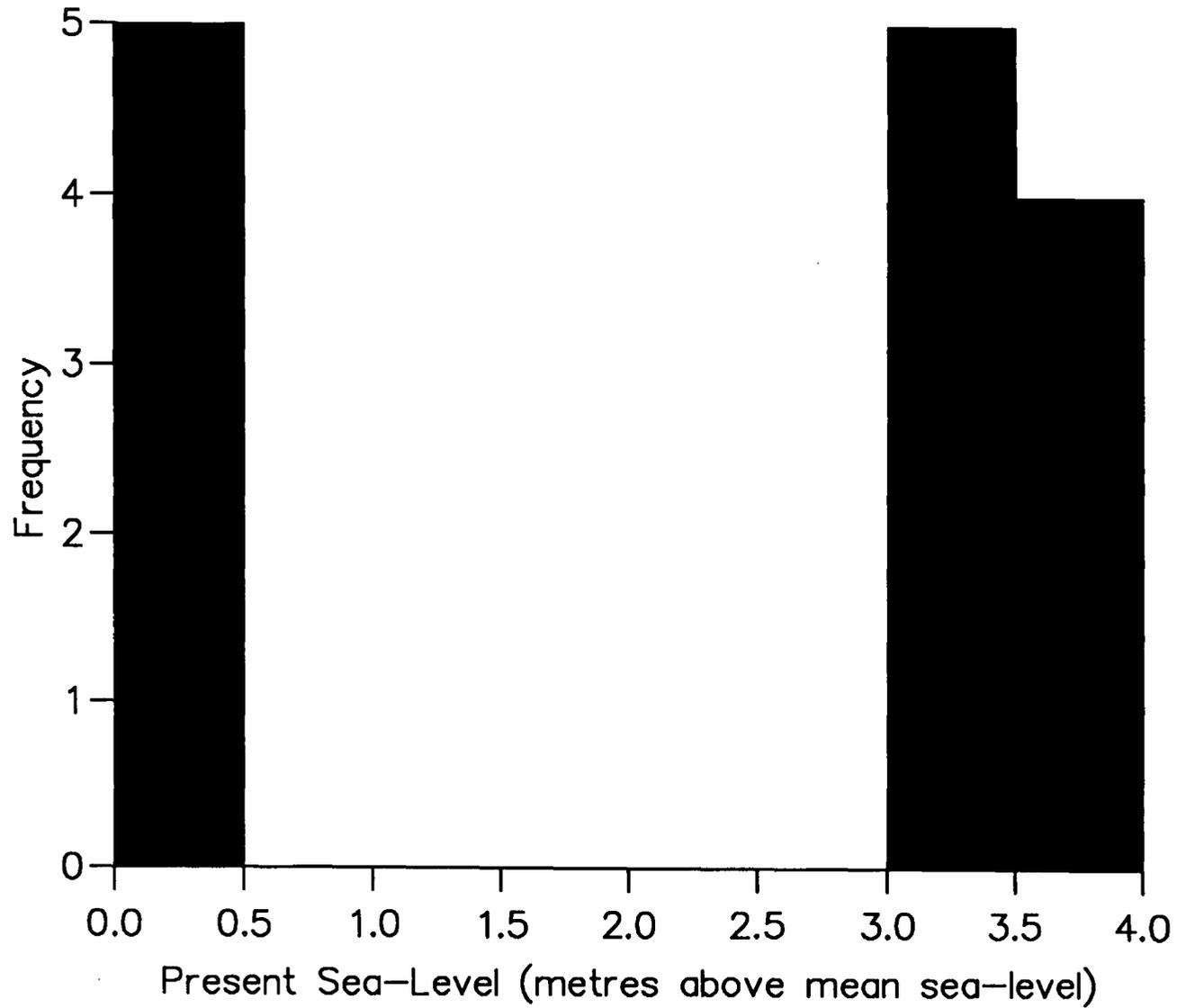
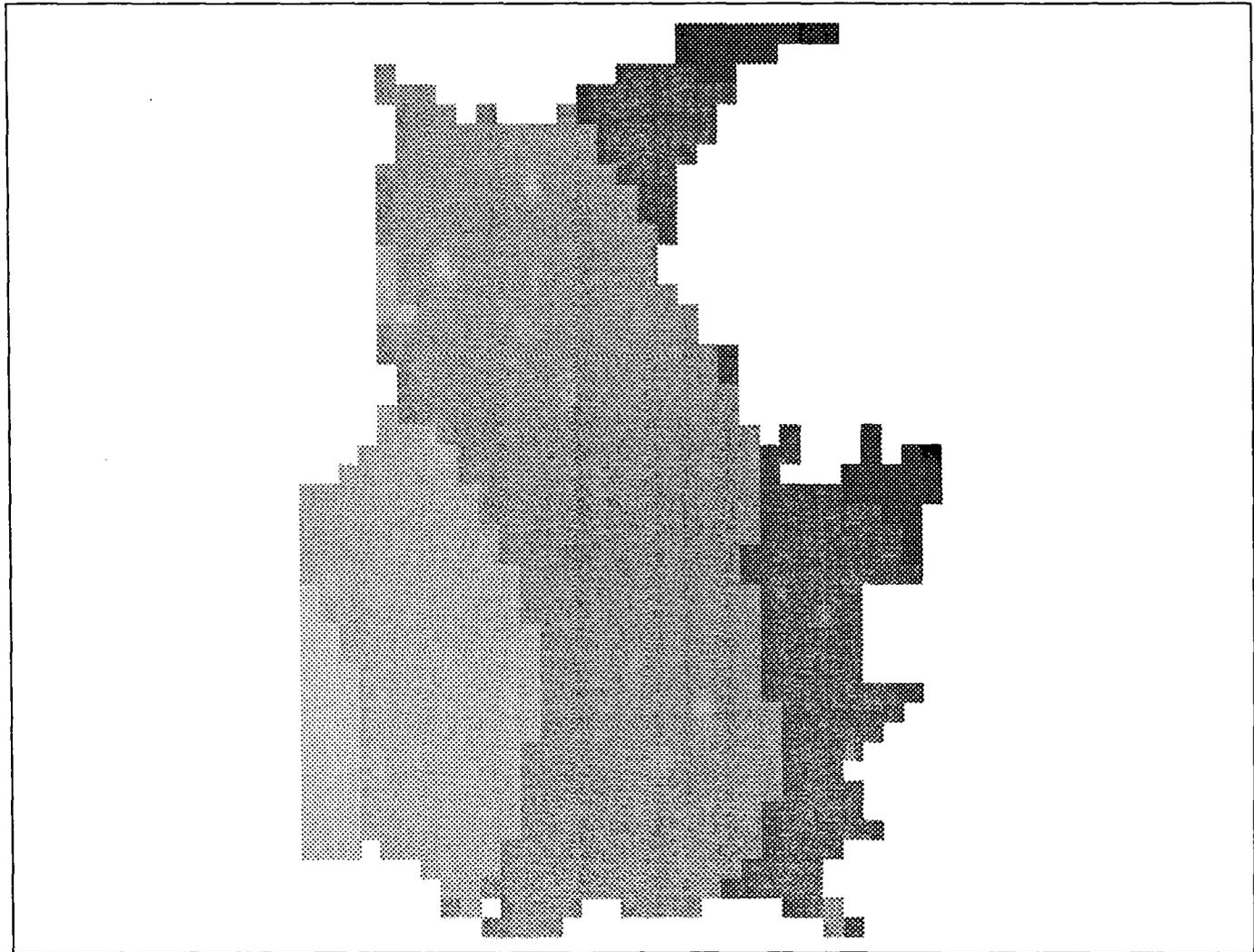
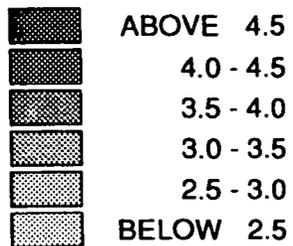
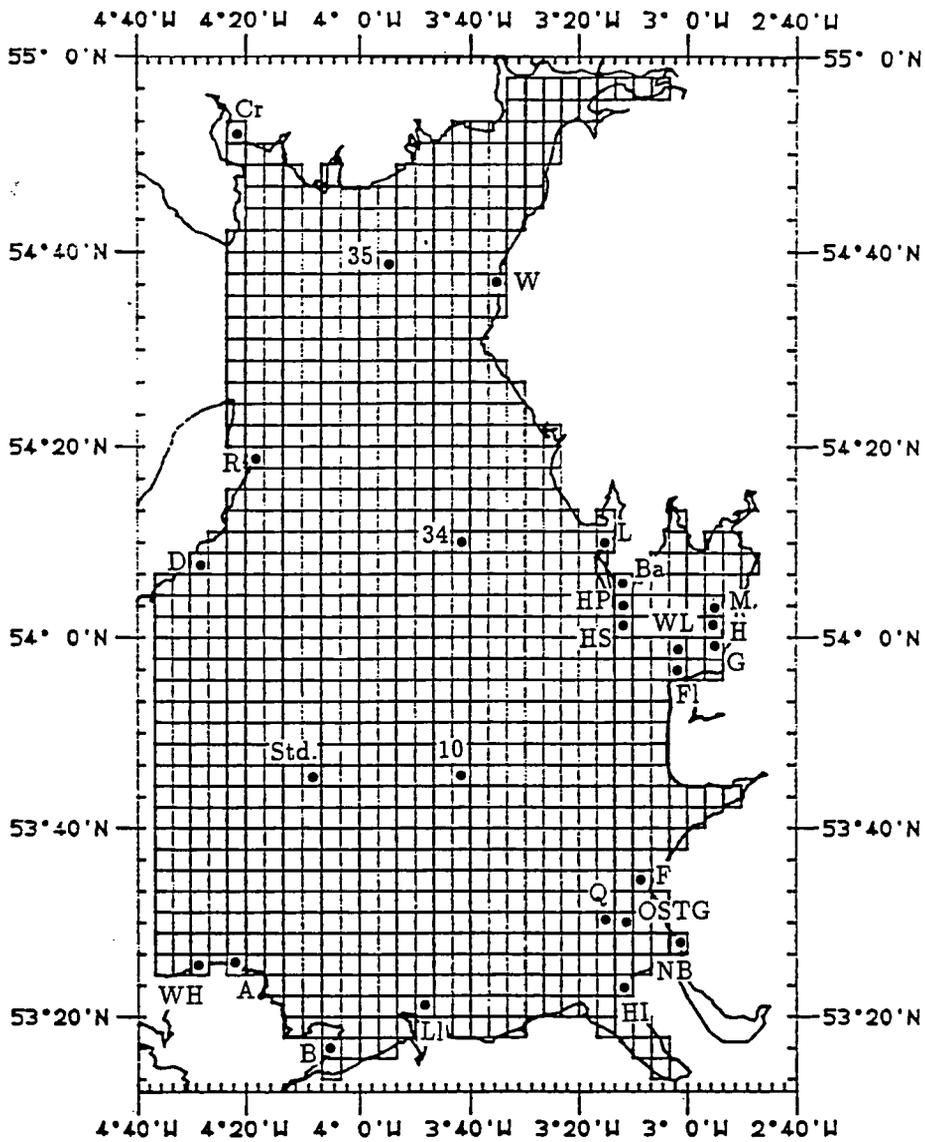


Figure 6.9. LIVERPOOL BAY MODEL Present Sea-Level

Maximum Tidal Heights (m.)

10



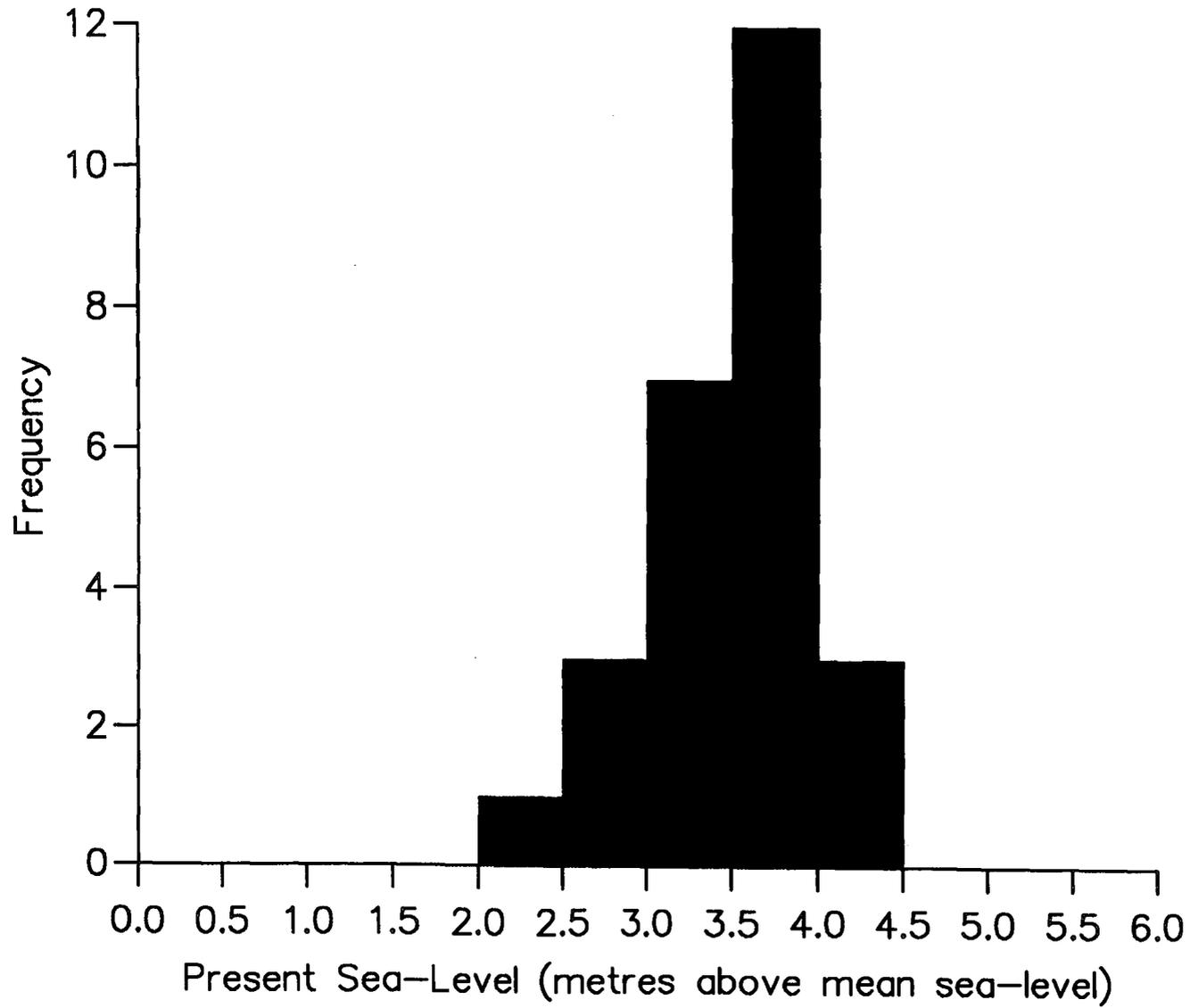


Key

Cr	Creetown	G	Glasson Docks
35	35 Irish Sea	Fl	Fleetwood
W	Workington	Std.	Std. Irish Sea
R	Ramsay	10	10 Irish Sea
34	34 Irish Sea	F	Formby
L	Lowsy Point	Q	Queens Channel
D	Douglas	OSTG	OSTG
Ba	Barrow	NB	New Brighton
HP	Hawes Point	WH	Wylfa Head
M	Morecambe	A	Amlwch
HS	Halfway Shoals	HI	Hilbre Island
H	Heysham	LI	Llandudno
WL	Wyre Light	B	Beaumaris

Figure 6.10. LBM Model Grid Showing the Locations from which the Data in Table 6.9 are taken.

Figure 6.11. LBM Model Histogram: Present Sea-Level with data from Table 6.9.



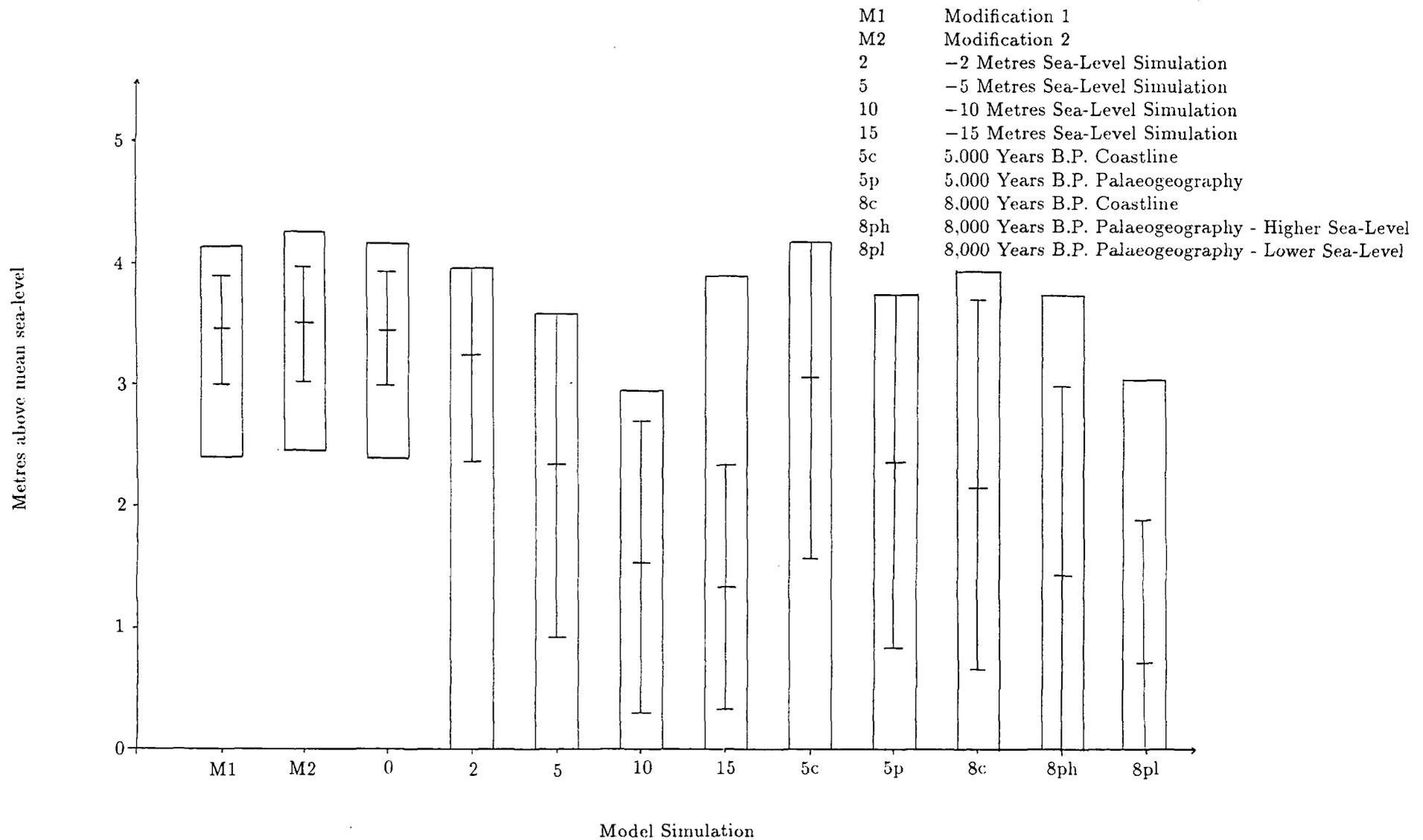
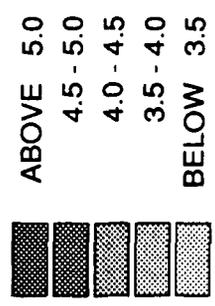
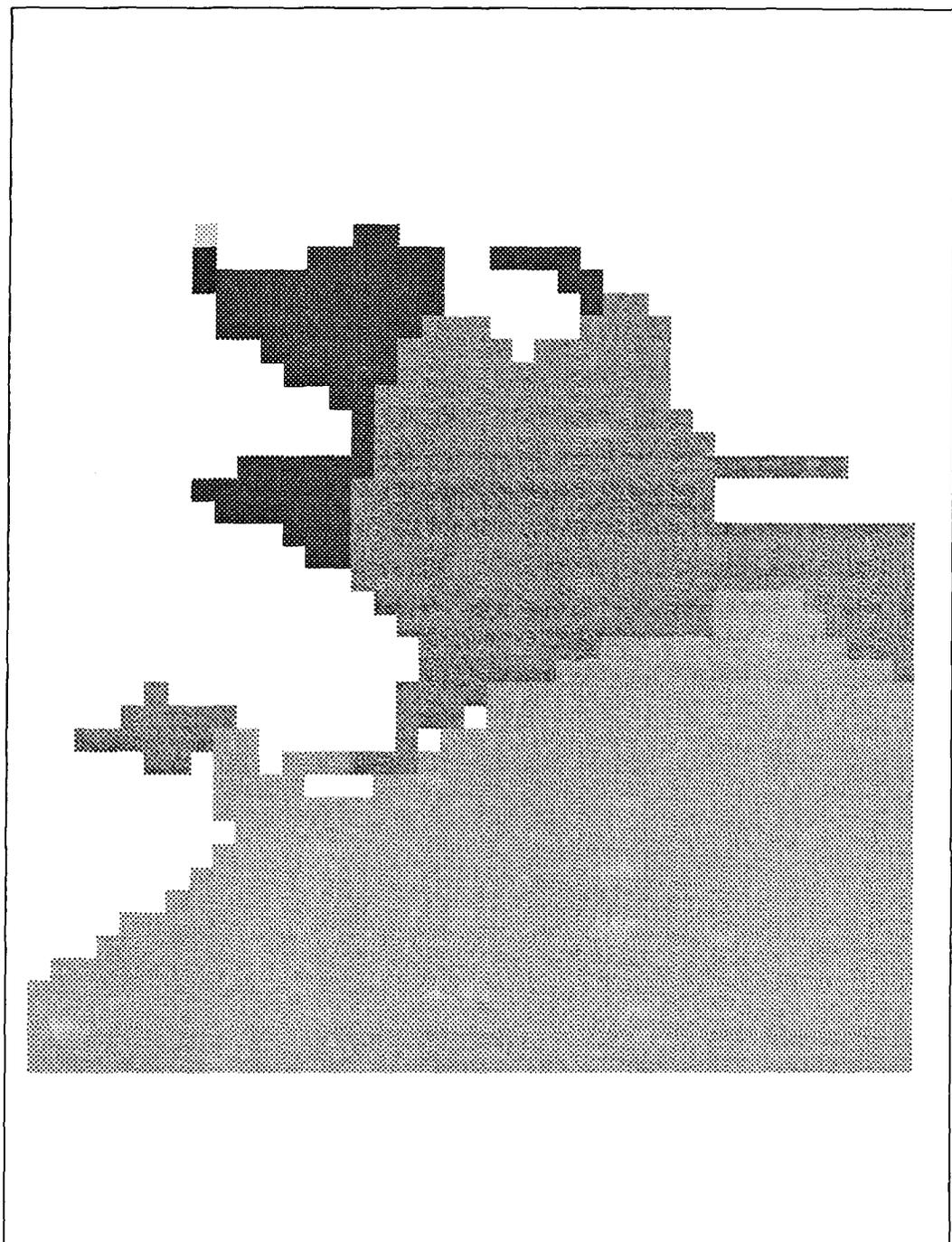
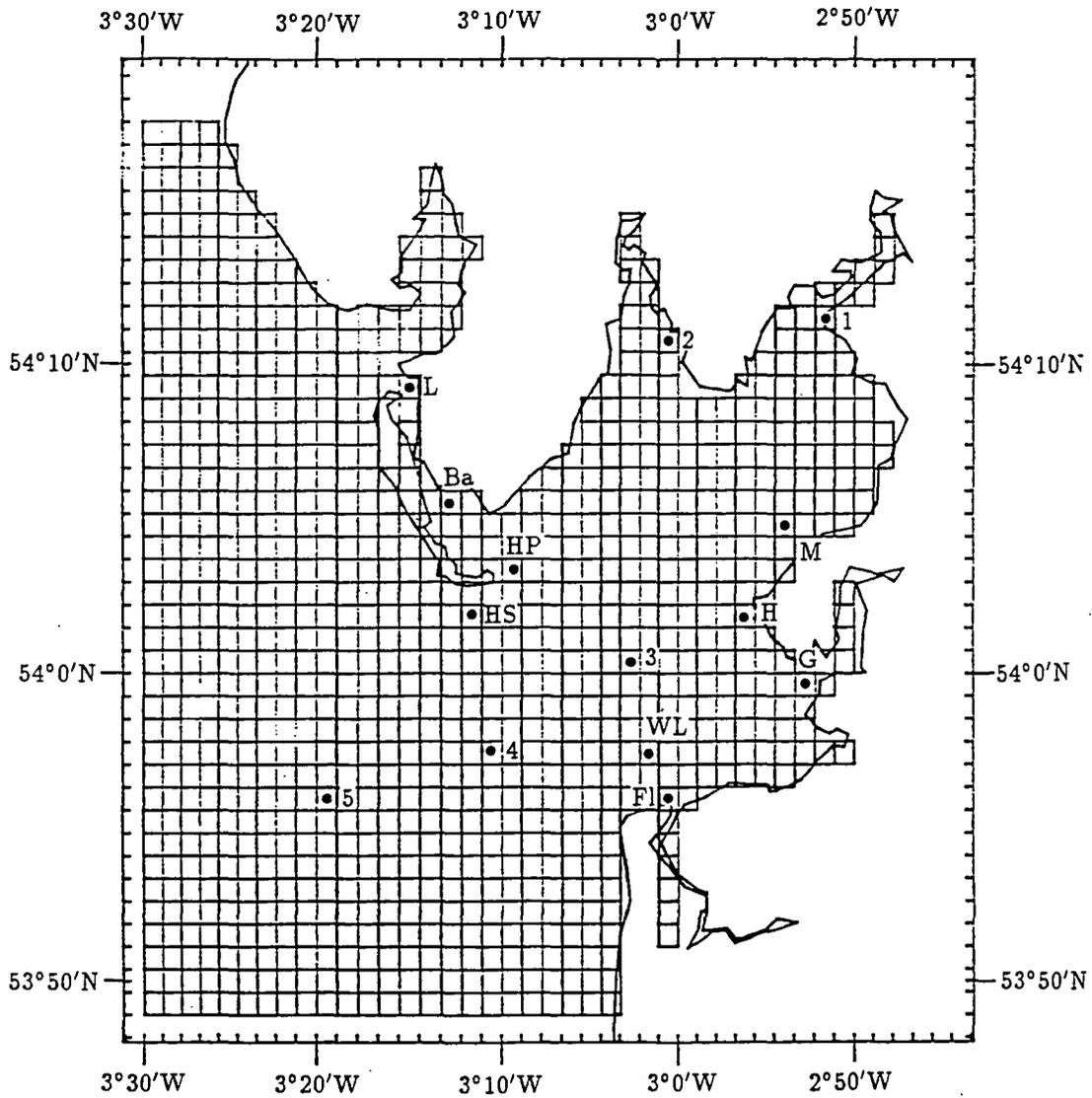


Figure 6.12. LBM Model Data from Table 6.10. The bars represent the maximum and minimum extents of the data, whilst the line within each bar gives the standard deviation of the data about the mean value. The standard deviation is not shown to exceed the minimum or maximum value of the data, although this does occur in some cases.

MORECAMBE BAY MODEL Present Sea-Level

Maximum Tidal Heights (m.)





Key

Ba	Barrow	L	Lowsy Point
HP	Hawes Point	Fl	Fleetwood
M	Morecambe	1	Point 1
HS	Halfway Shoals	2	Point 2
H	Heysham	3	Point 3
WL	Wyre Light	4	Point 4
G	Glasson Docks	5	Point 5

Figure 6.14. MBM Model Grid Showing the Locations from which the Data in Table 6.11 are taken.

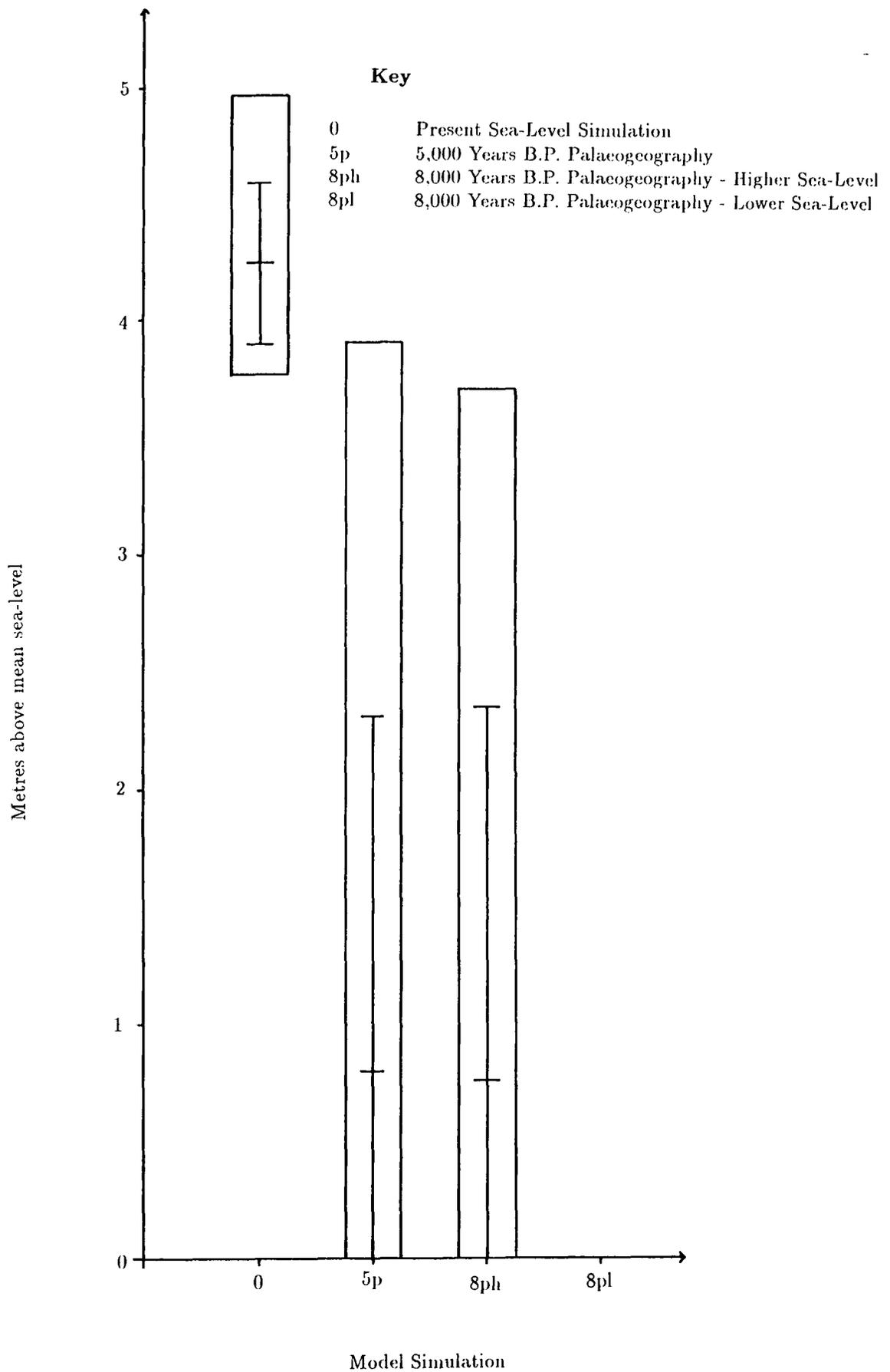


Figure 6.15. MBM Model Data from Table 6.12. The bars represent the maximum and minimum extents of the data, whilst the line within each bar gives the standard deviation of the data about the mean value. The standard deviation is not shown to exceed the minimum or maximum value of the data, although this does occur in some cases.

Figure 6.16. MBM Model Histogram: Present Sea-Level with data from Table 6.11.

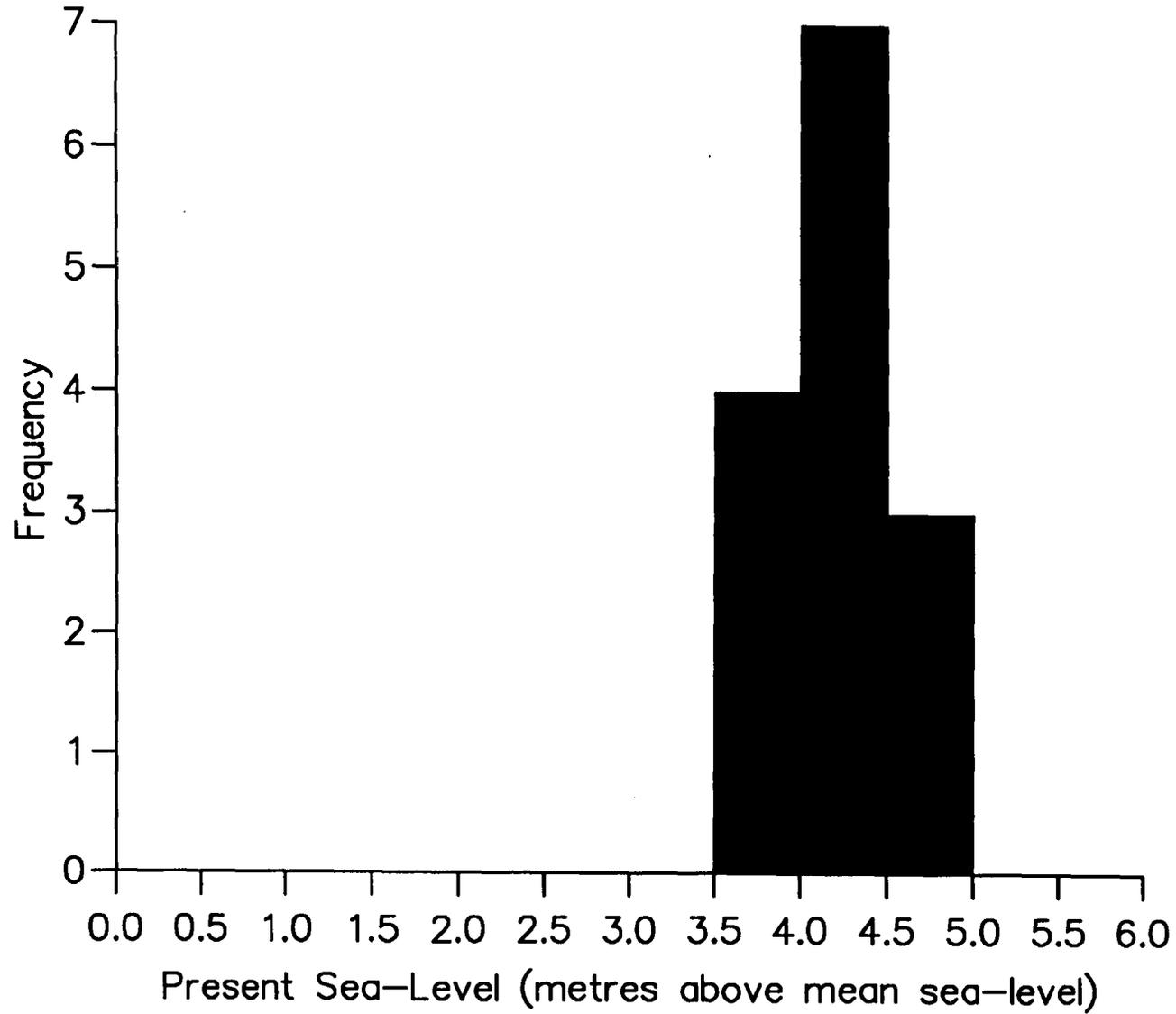


Figure 6.17. EAST COAST 3 MODEL

Maximum Tidal Altitudes (m.)

Modification 1

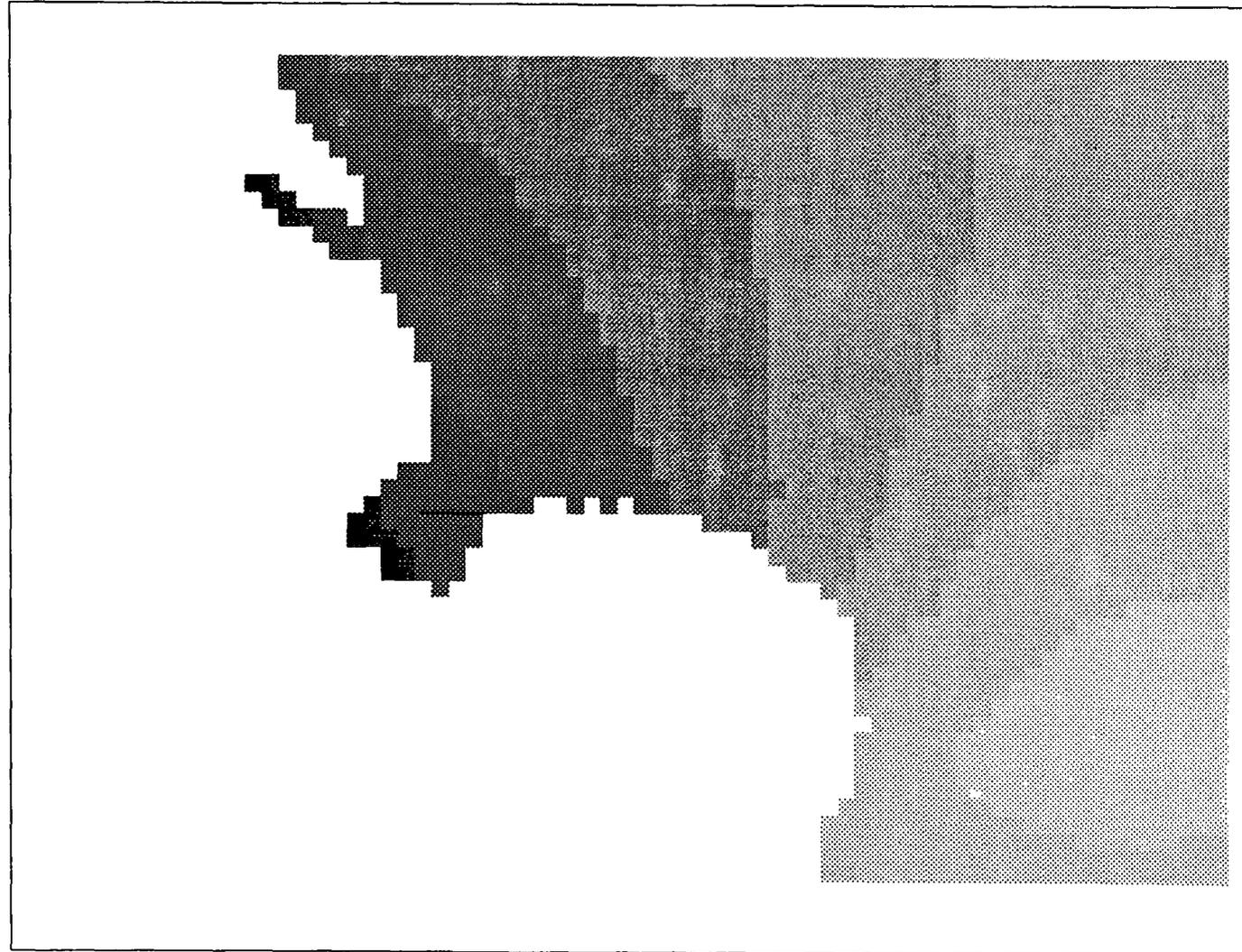


Figure 6.18.

EAST COAST 3 MODEL

Maximum Tidal Altitudes (m.) Present Sea-Level Minus Modification 1

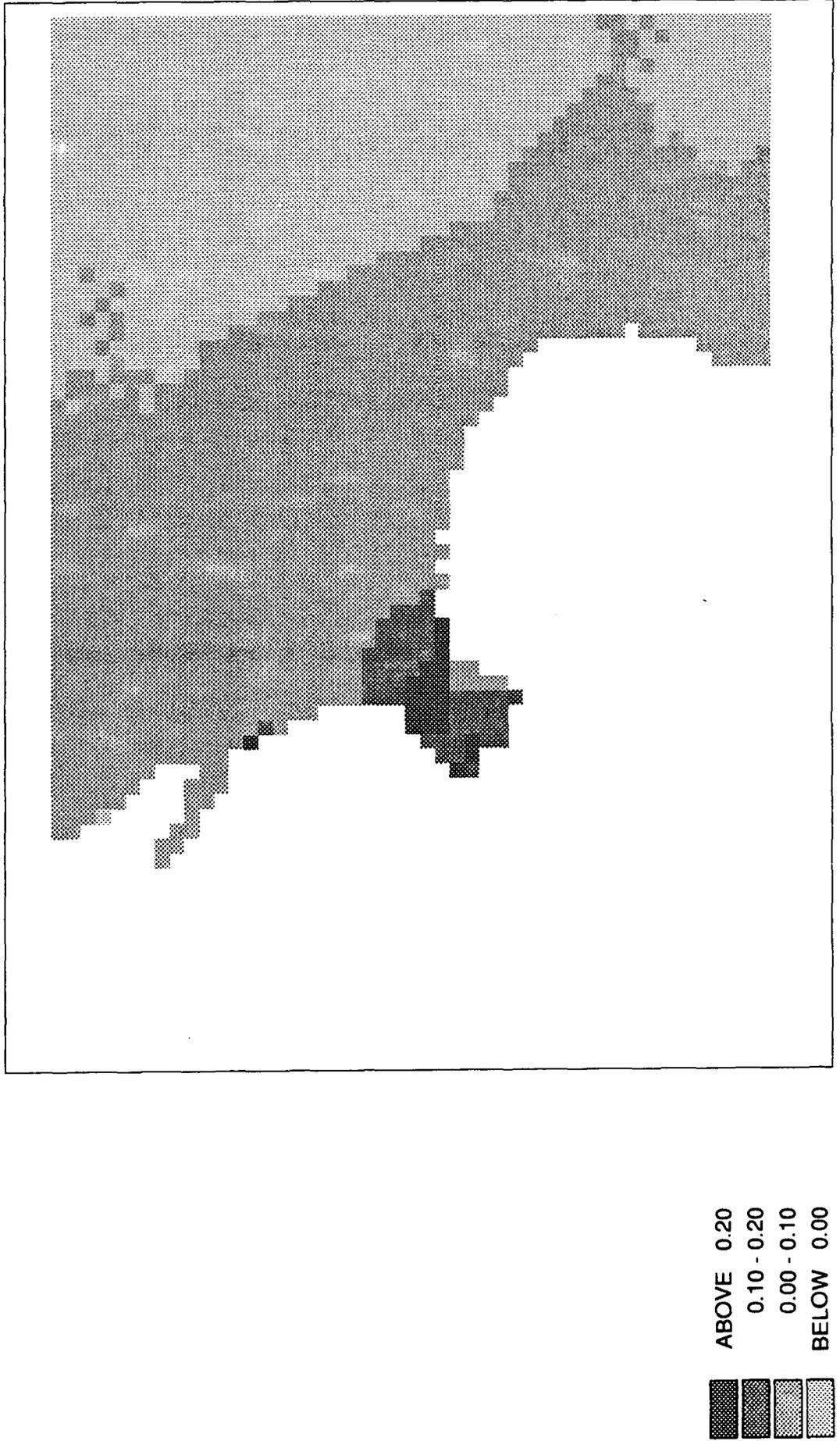


Figure 6.19. EC3 Model Histogram: Modification 1 with data from Table 6.5.

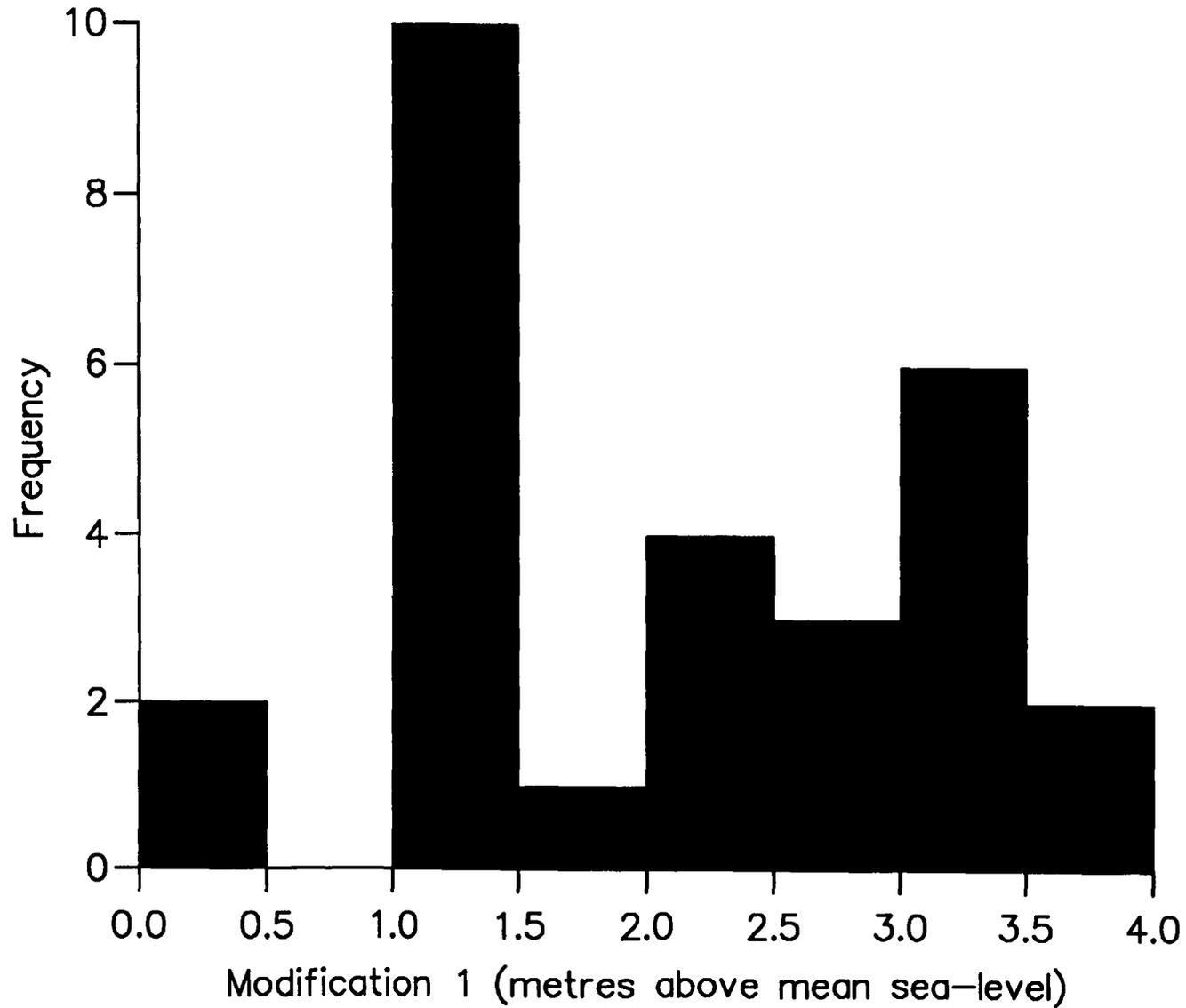
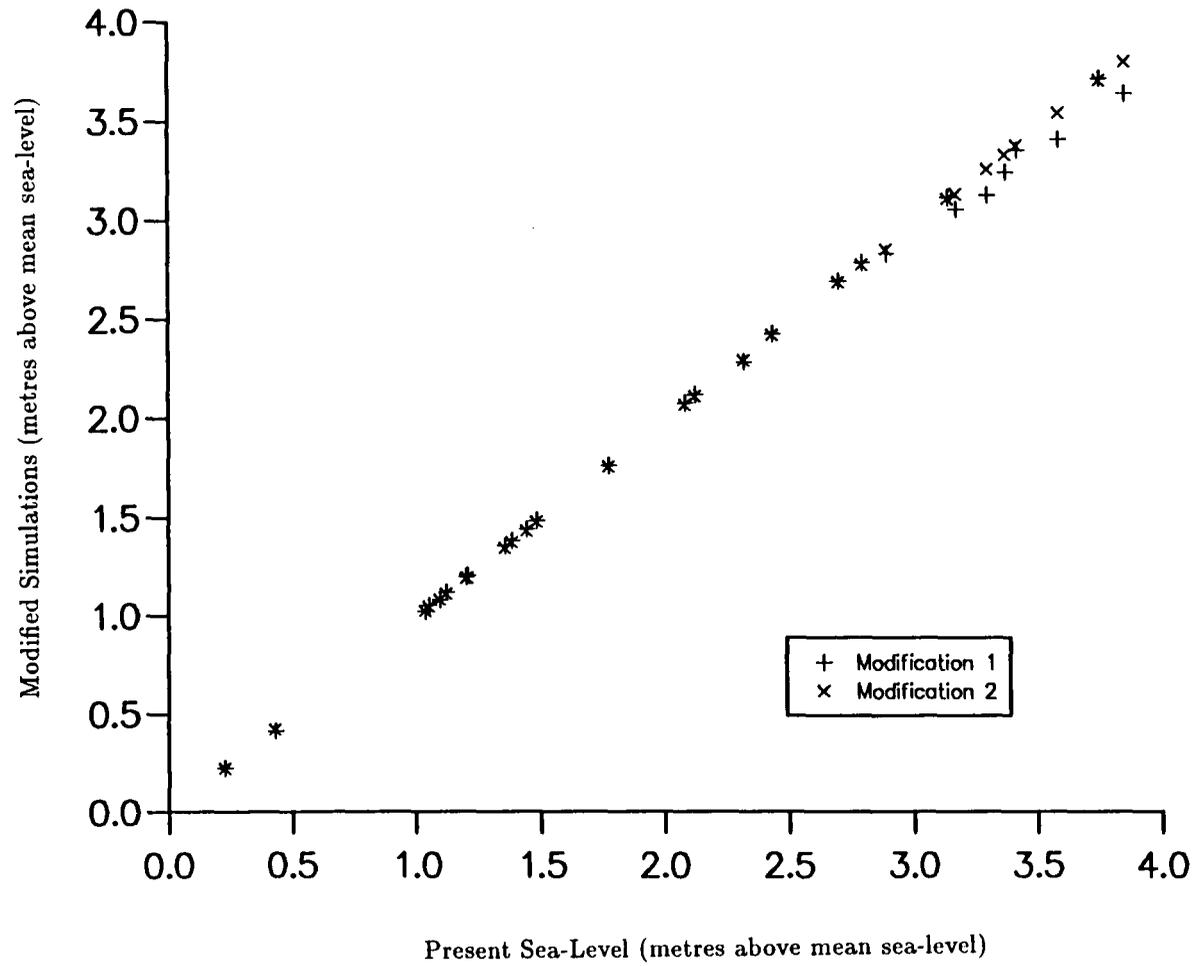


Figure 6.20. EC3 Model Scatter Plot: Present Sea-Level against Modified Simulations with data from Table 6.5.



LIVERPOOL BAY MODEL Modification 1

Maximum Tidal Heights (m.)

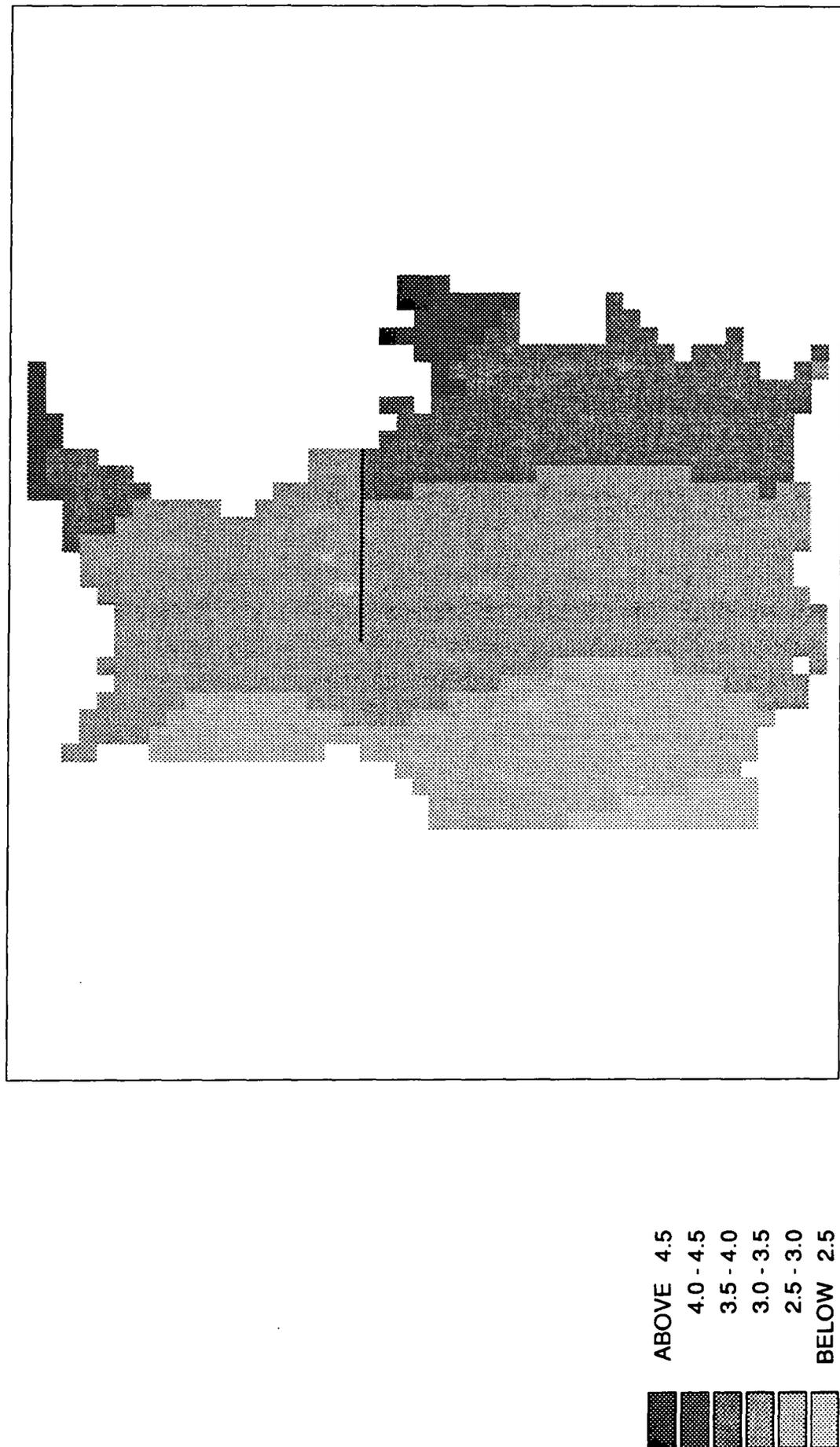


Figure 6.21.

LIVERPOOL BAY MODEL Present Sea-Level Minus

Figure 6.22.

Modification 1

Maximum Tidal Heights (m.)

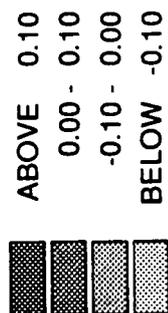
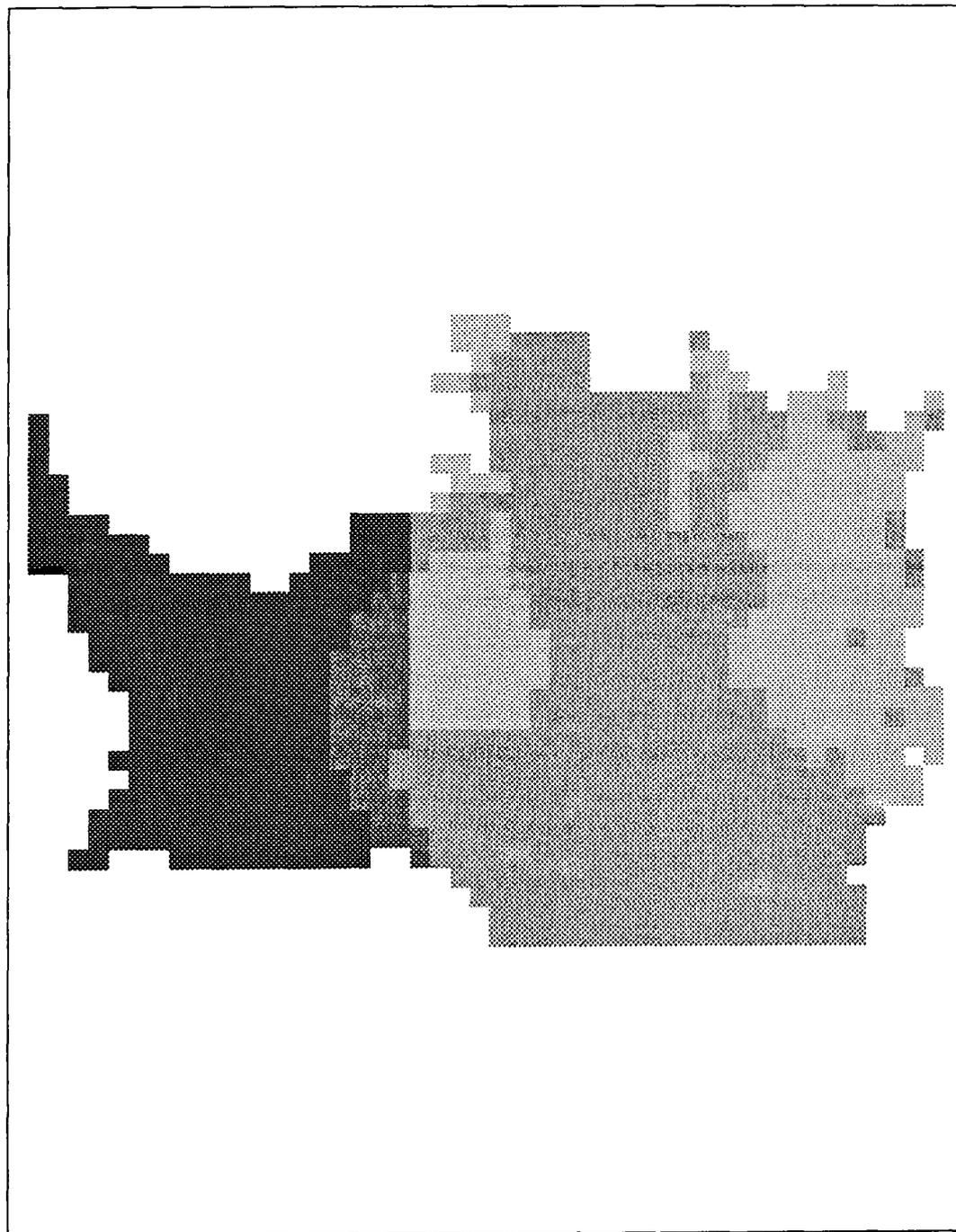


Figure 6.23. LBM Model Histogram: Modification 1 with data from Table 6.9.

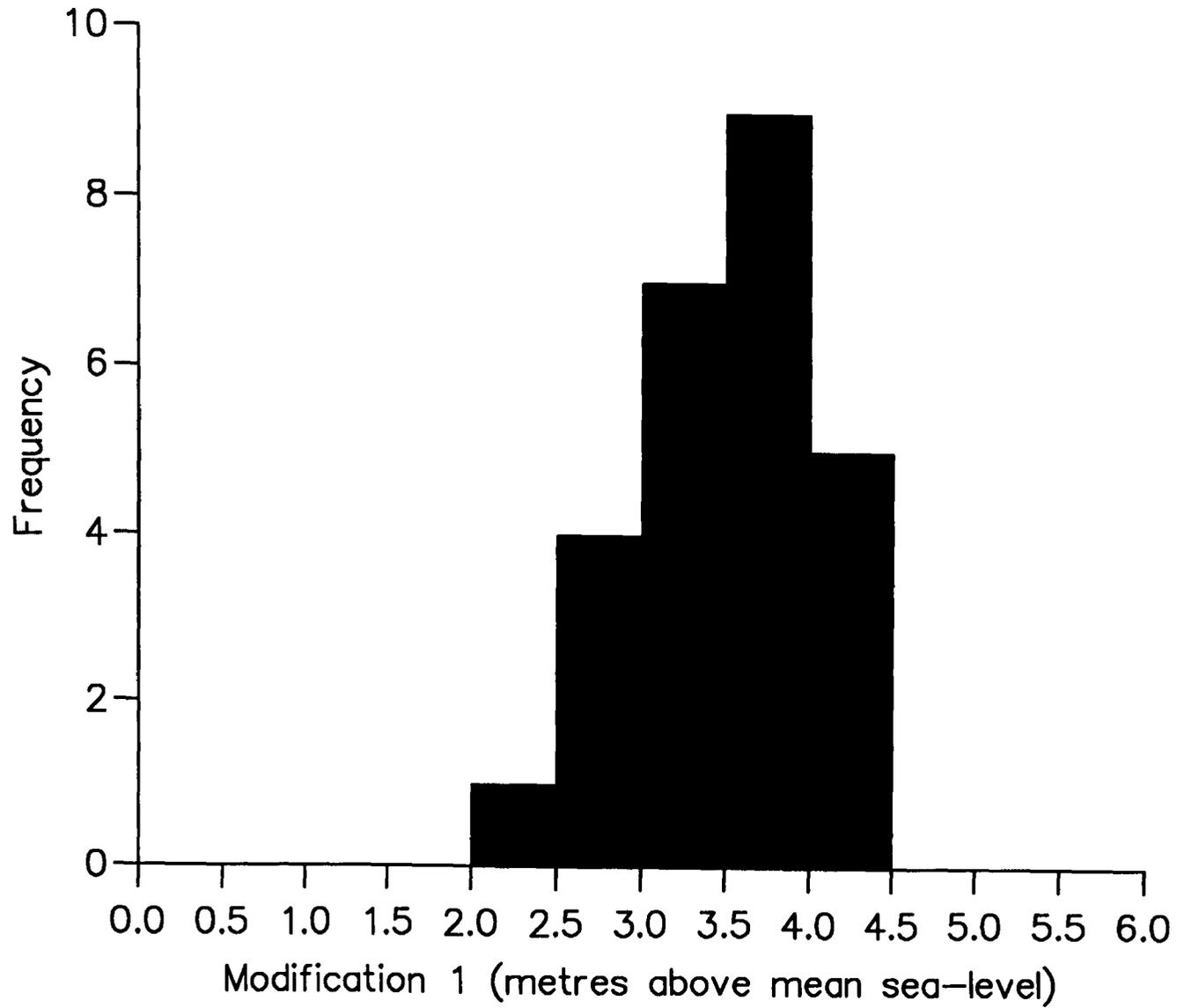


Figure 6.24. LBM Model Scatter Plot: Present Sea-Level against Modified Simulations with data from Table 6.9.

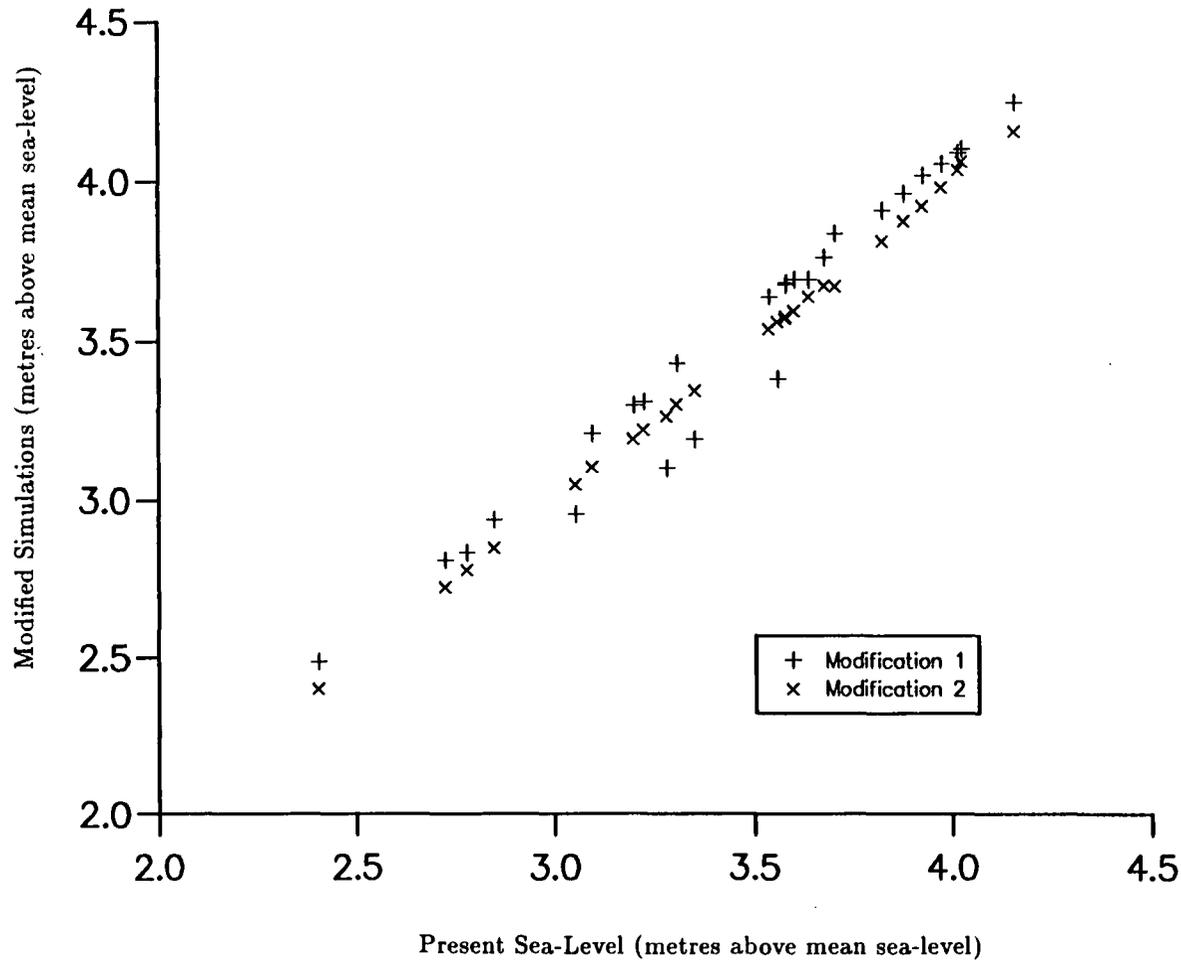


Figure 6.25. EAST COAST 3 MODEL

Maximum Tidal Altitudes (m.)

Modification 2

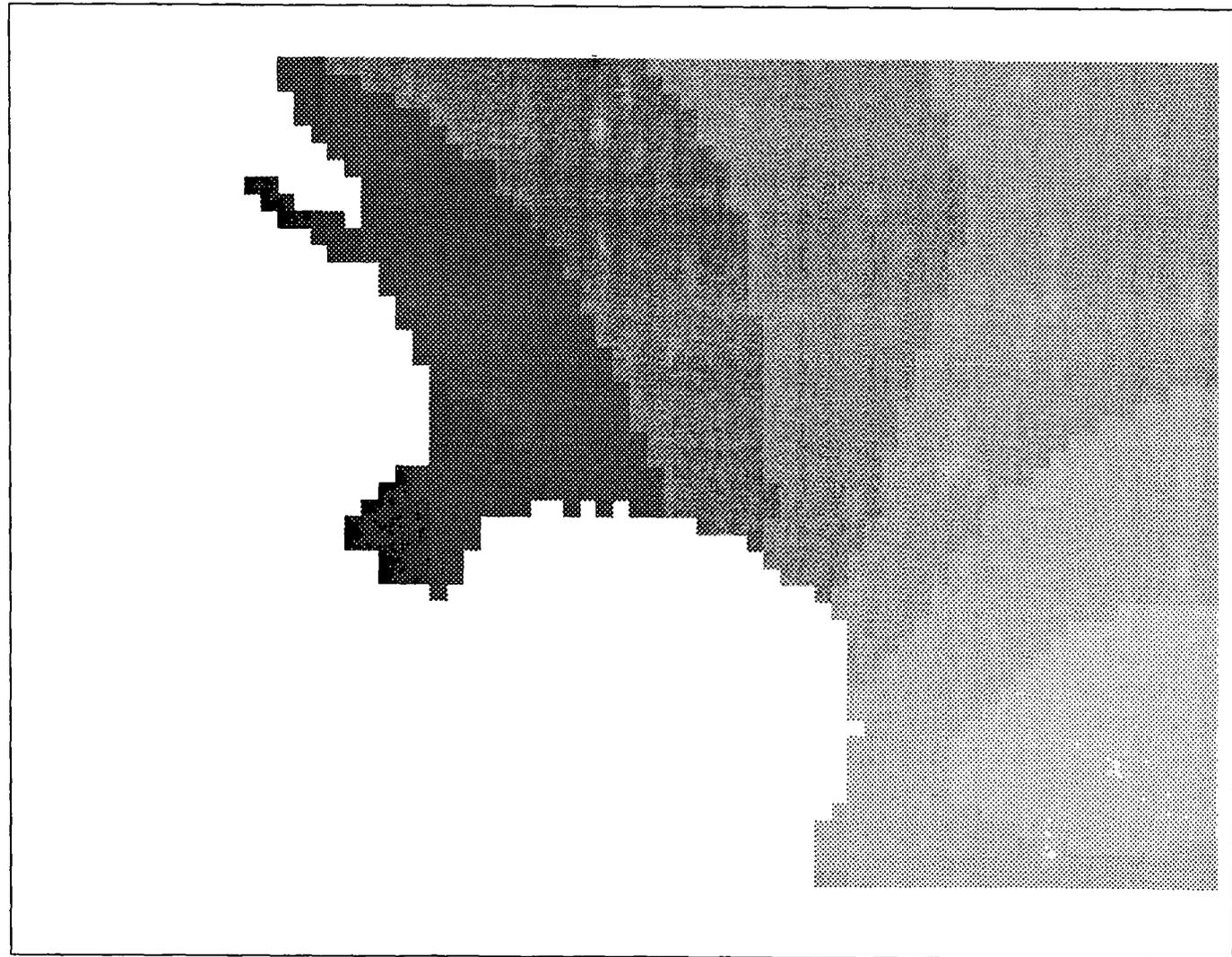


Figure 6.26. EAST COAST 3 MODEL

Maximum Tidal Altitudes (m.)

Present Sea-Level Minus Modification 2

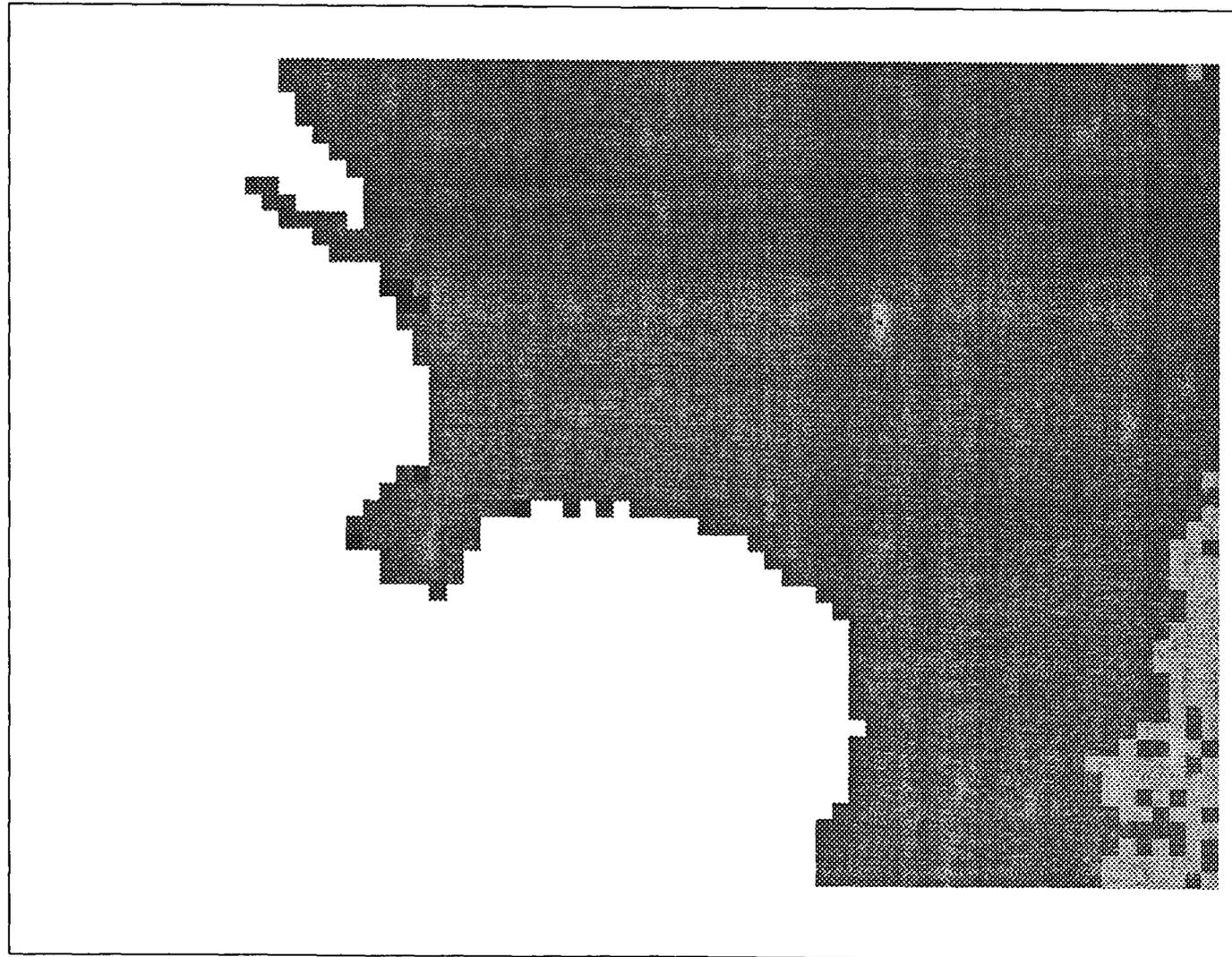


Figure 6.27. EC3 Model Histogram: Modification 2 with data from Table 6.5.

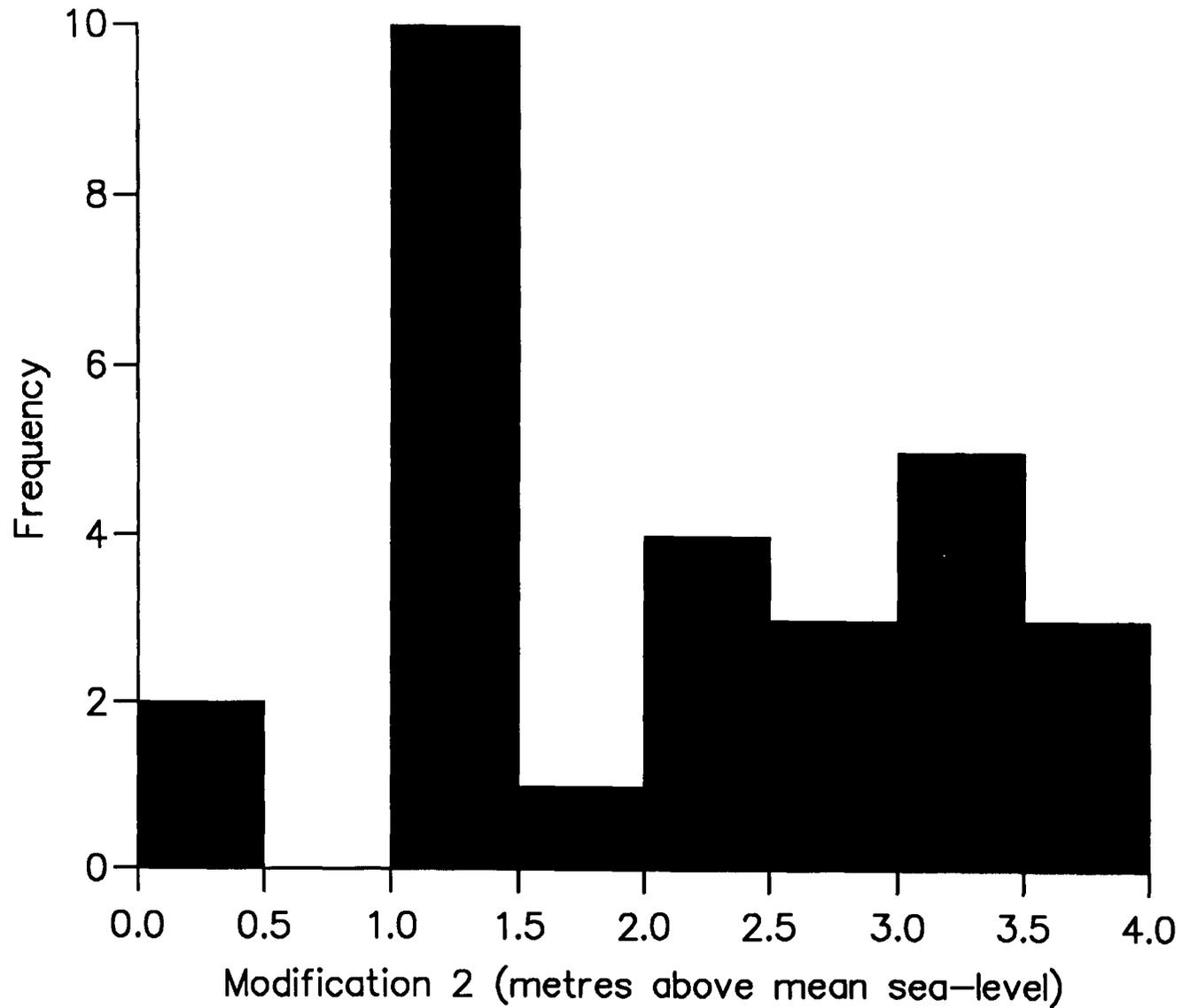


Figure 6.28. LIVERPOOL BAY MODEL Modification 2

Maximum Tidal Heights (m.)

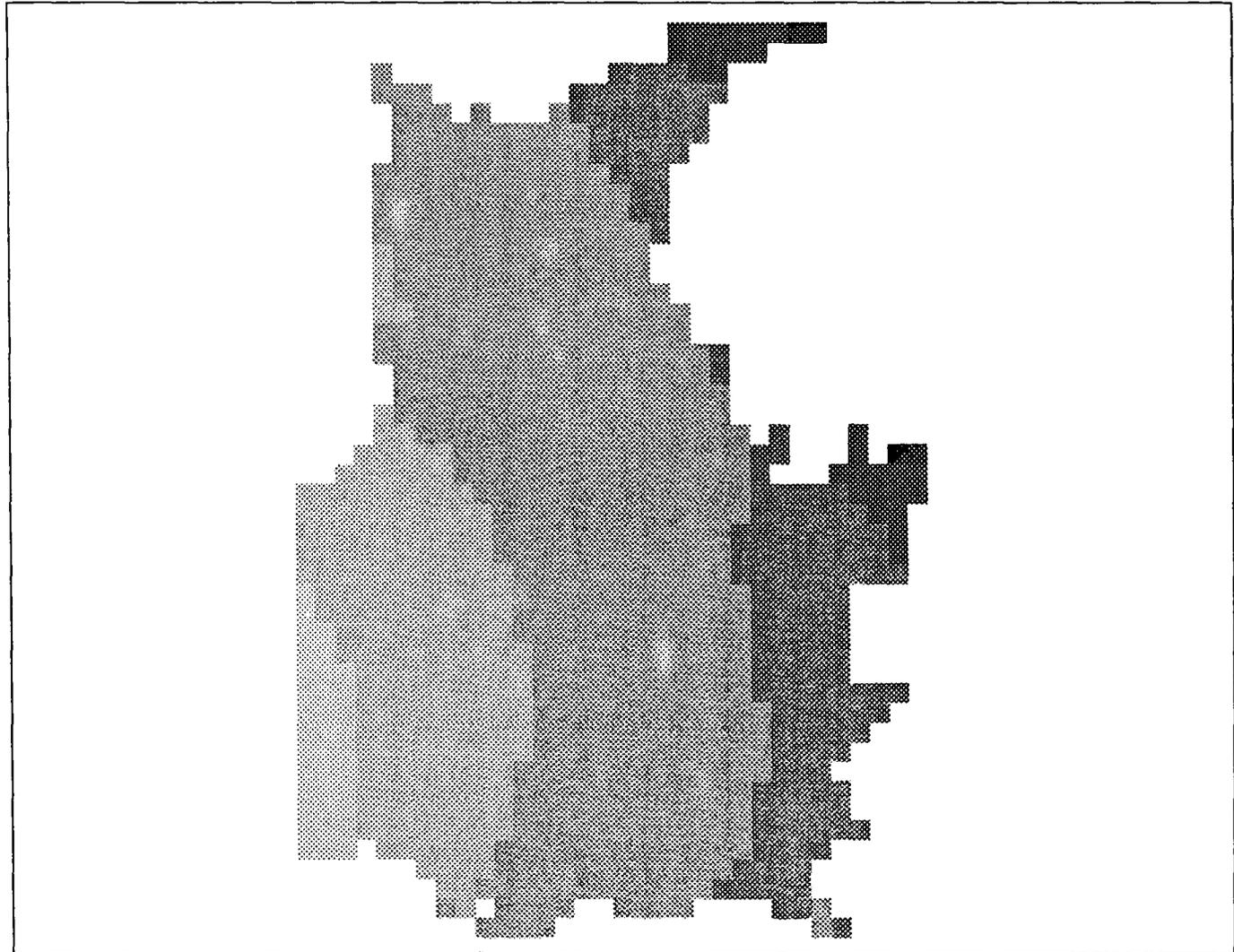
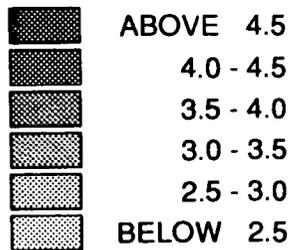


Figure 6.29. LIVERPOOL BAY MODEL Present Sea-Level Minus

Modification 2

Maximum Tidal Heights (m.)



Figure 6.30. LBM Model Histogram: Modification 2 with data from Table 6.9.

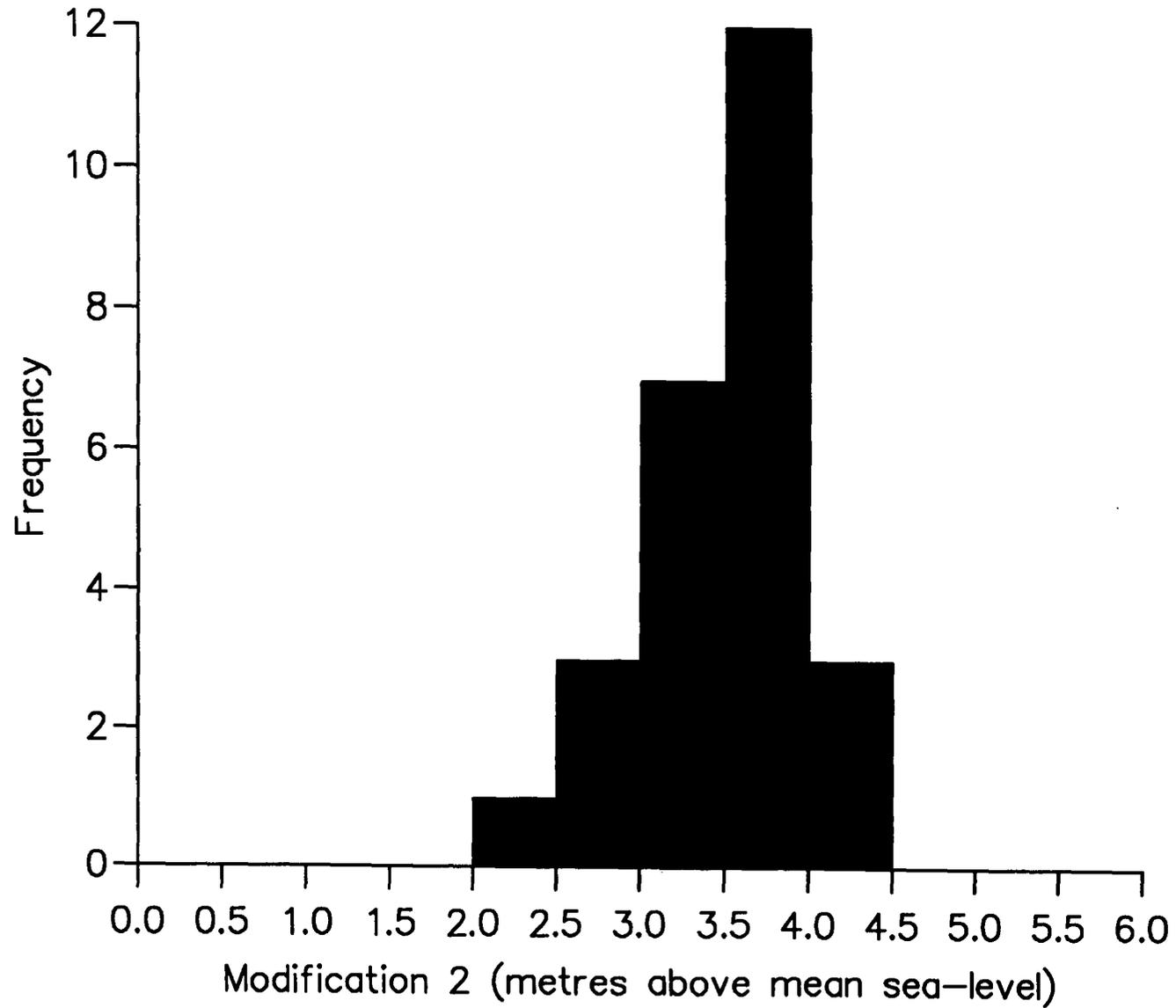


Figure 6.31. EAST COAST 3 MODEL

Maximum Tidal Altitudes (m.)

2 Metres Bathymetric Reduction

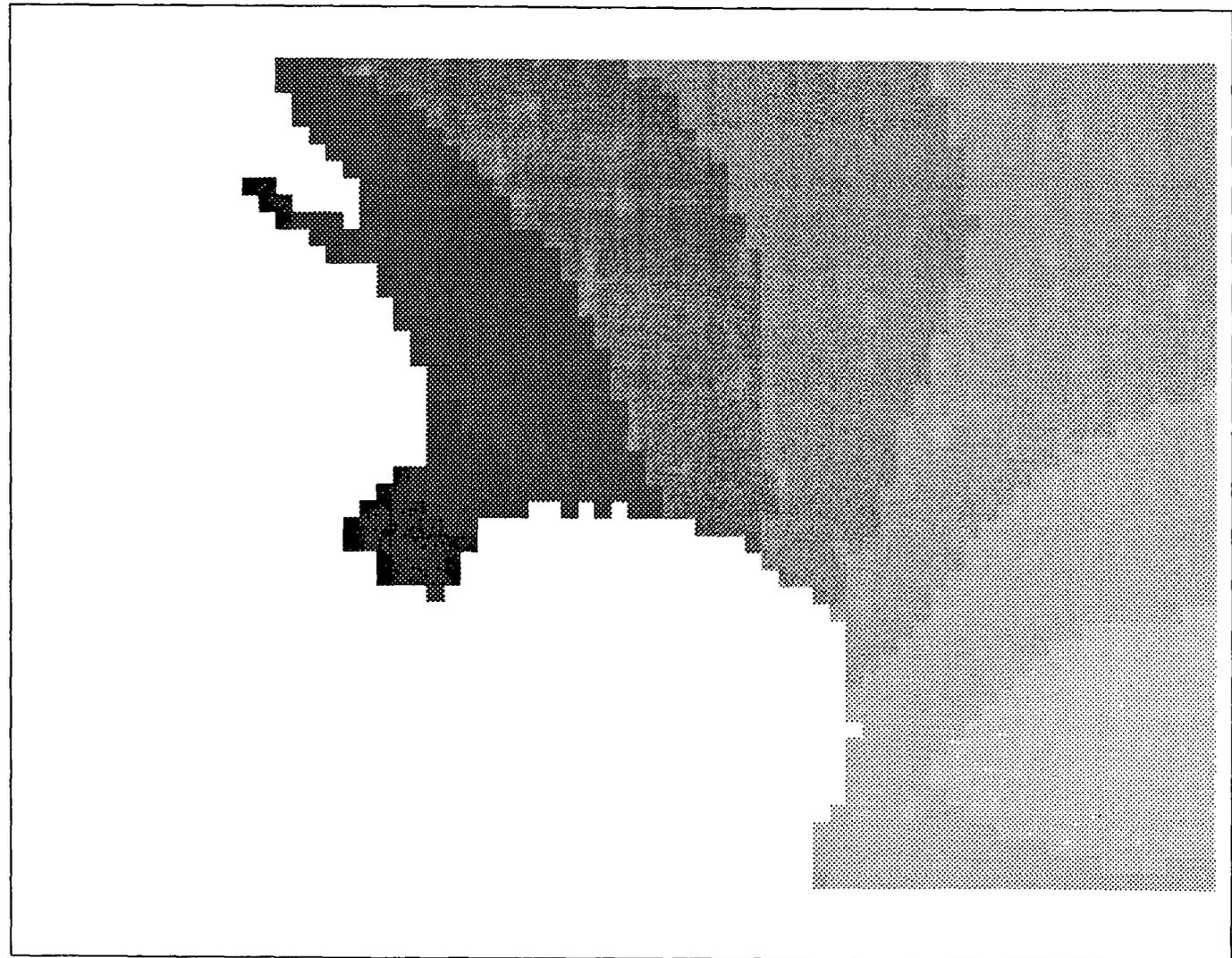


Figure 6.32. EAST COAST 3 MODEL

Maximum Tidal Altitudes Difference (m.)

Present Sea-Level Minus 2 Metres Bathymetric Reduction

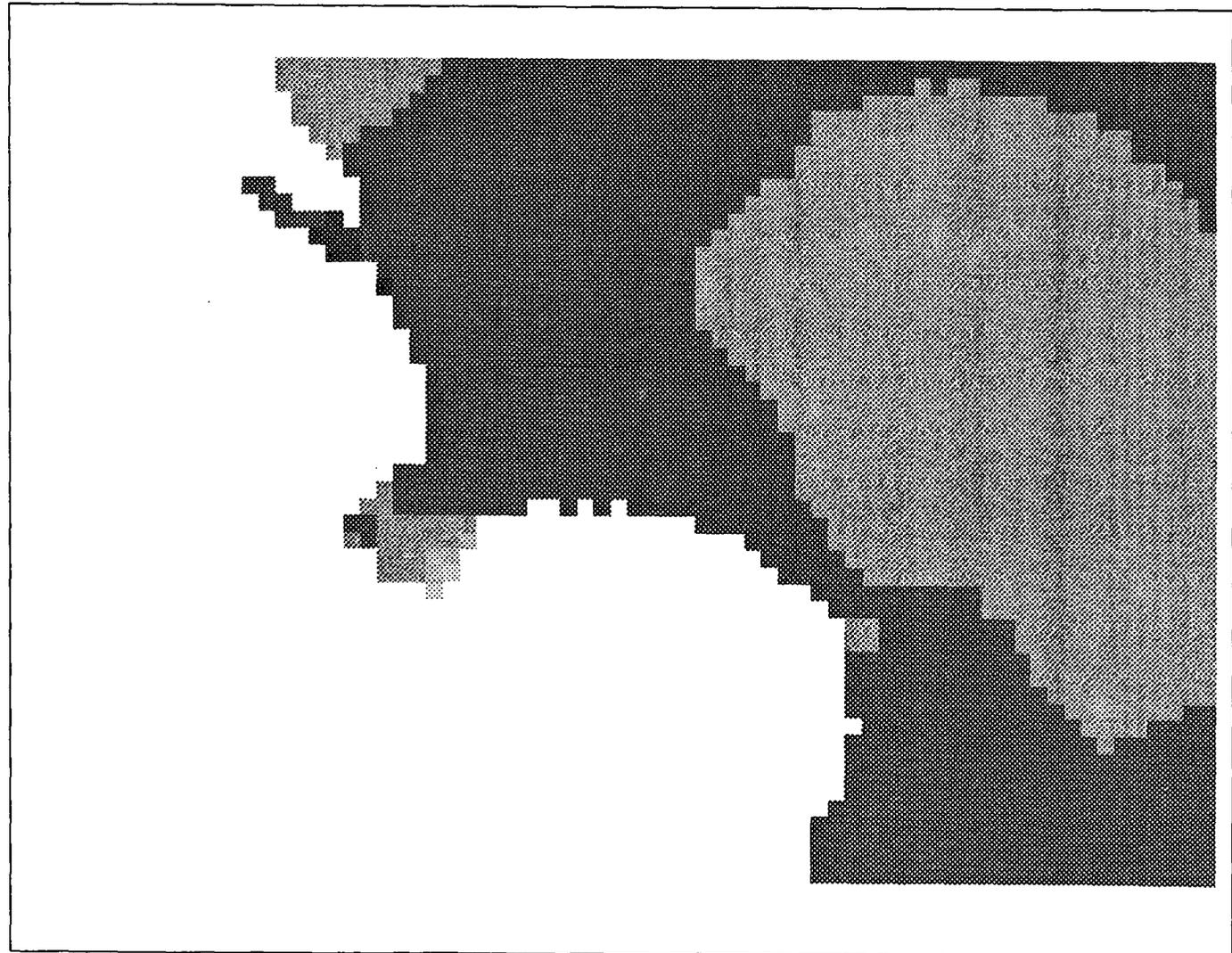


Figure 6.33. EC3 Model Histogram: 2 Metres Bathymetric Reduction Simulation with data from Table 6.5.

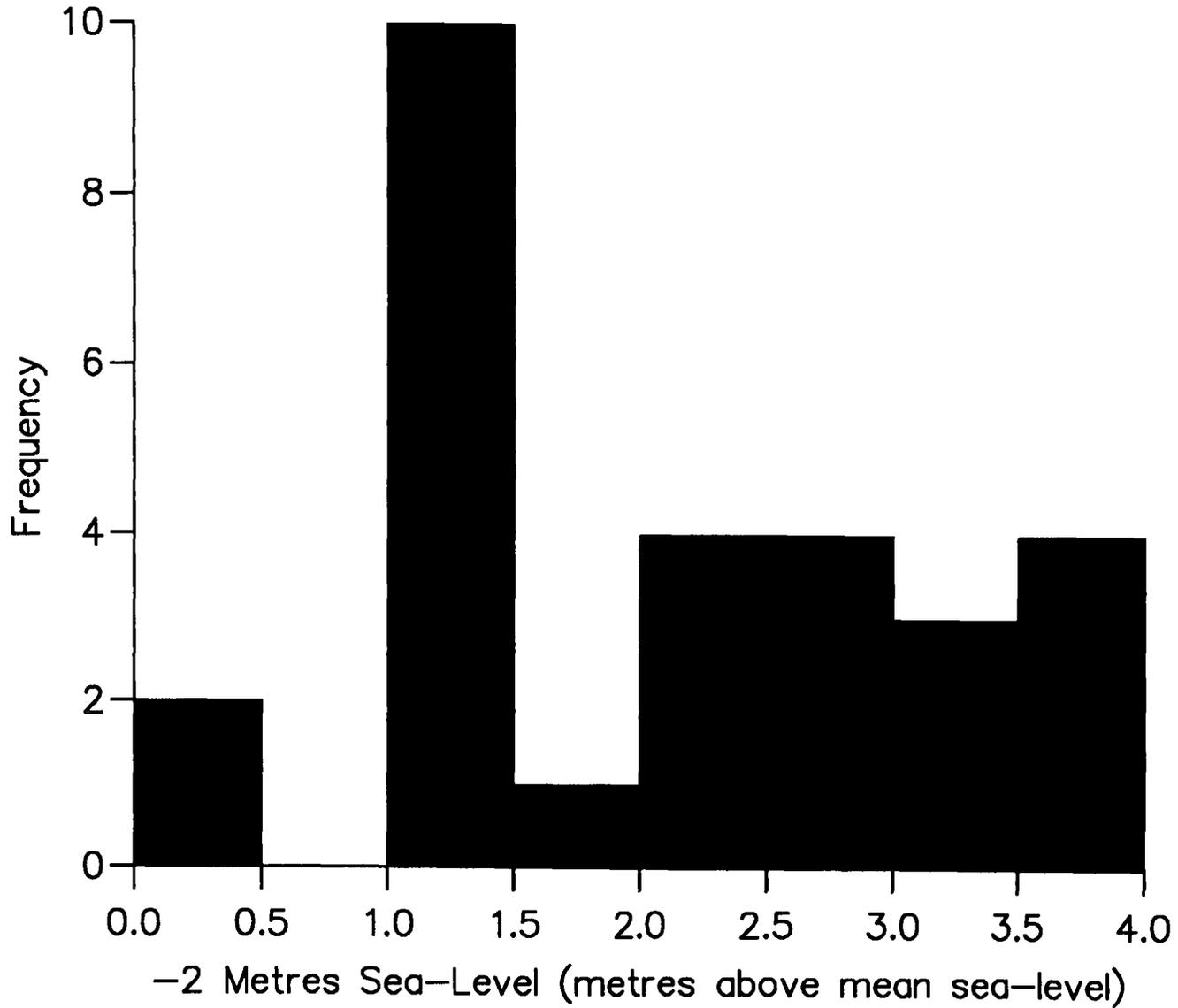


Figure 6.35. EAST COAST 3 MODEL

Maximum Tidal Altitudes (m.)

5 Metres Bathymetric Reduction

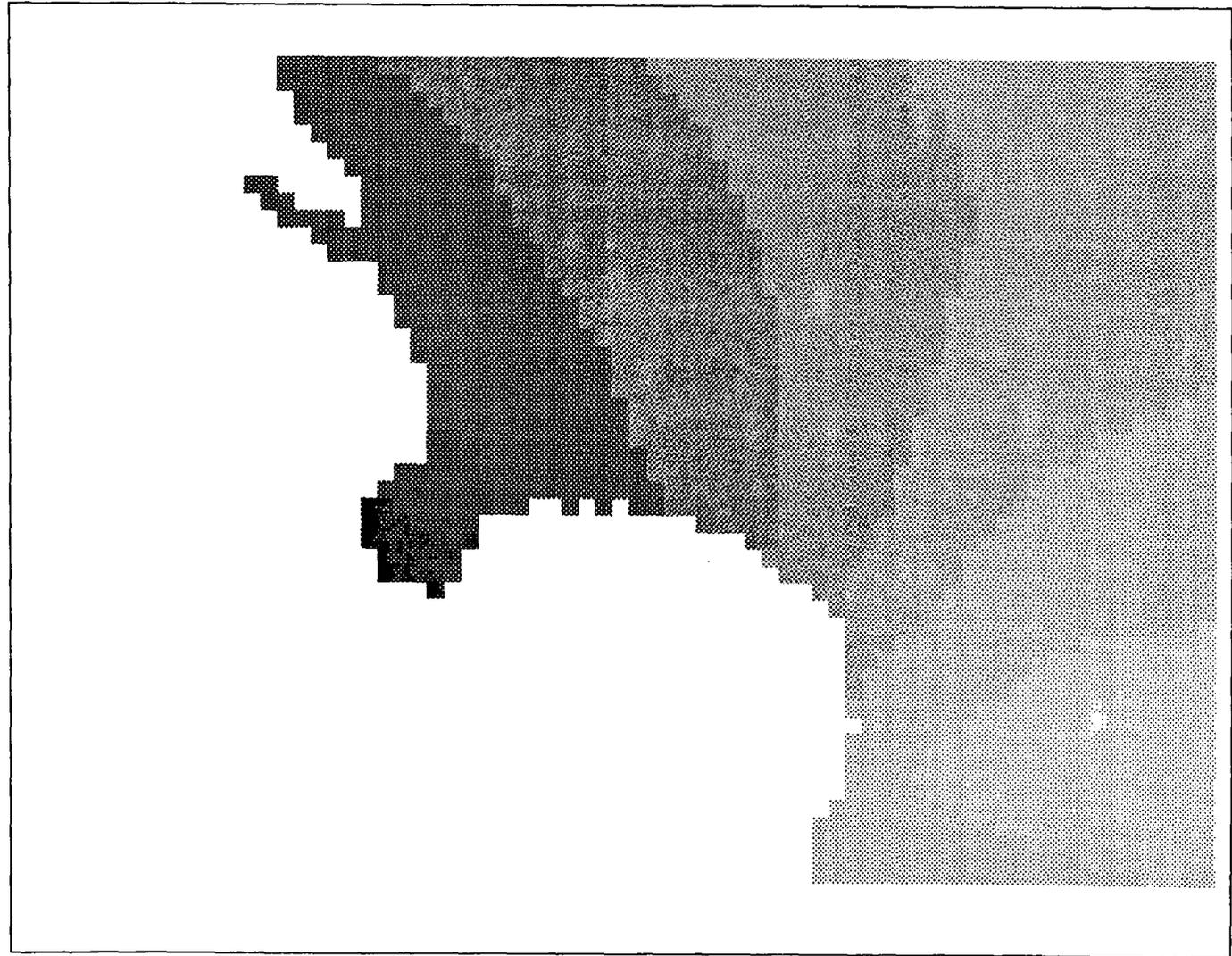


Figure 6.36. EAST COAST 3 MODEL

Maximum Tidal Altitudes Difference (m.)

Present Sea-Level Minus 5 Metres Bathymetric Reduction

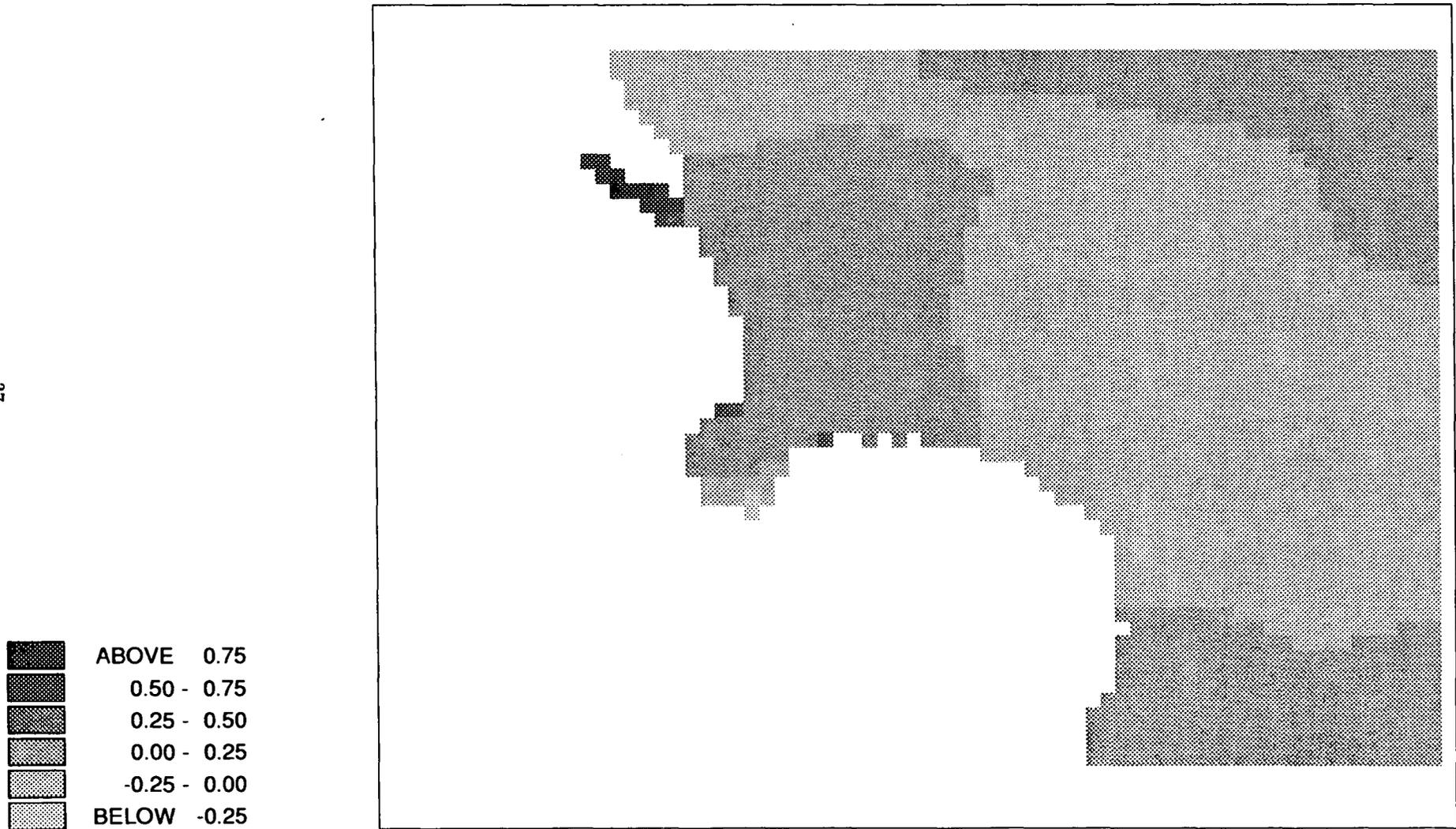


Figure 6.37. EAST COAST 3 MODEL

Maximum Tidal Altitudes Difference (m.)

2 Metres Minus 5 Metres Bathymetric Reduction

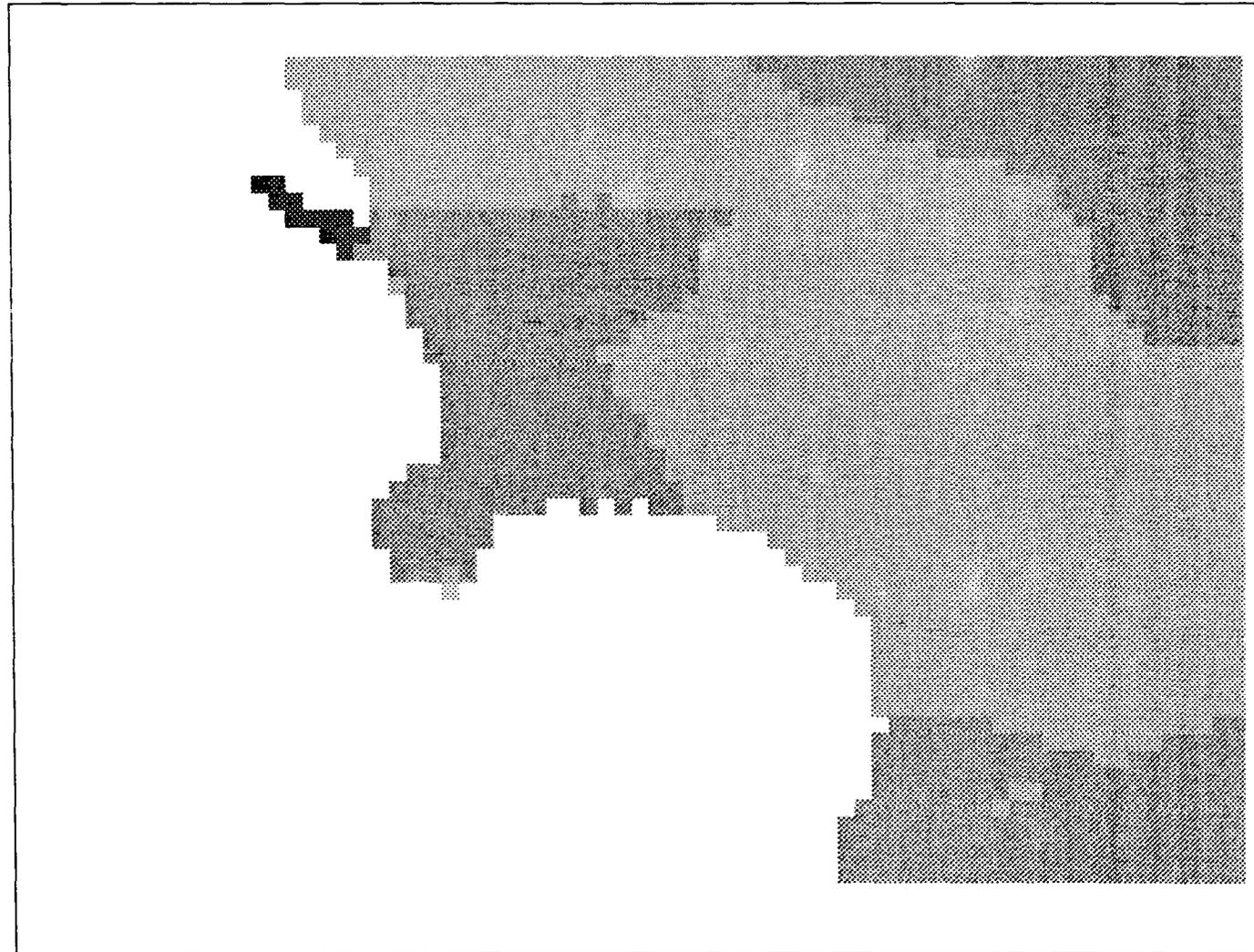


Figure 6.38. EC3 Model Histogram: 5 Metres Bathymetric Reduction Simulation with data from Table 6.5.

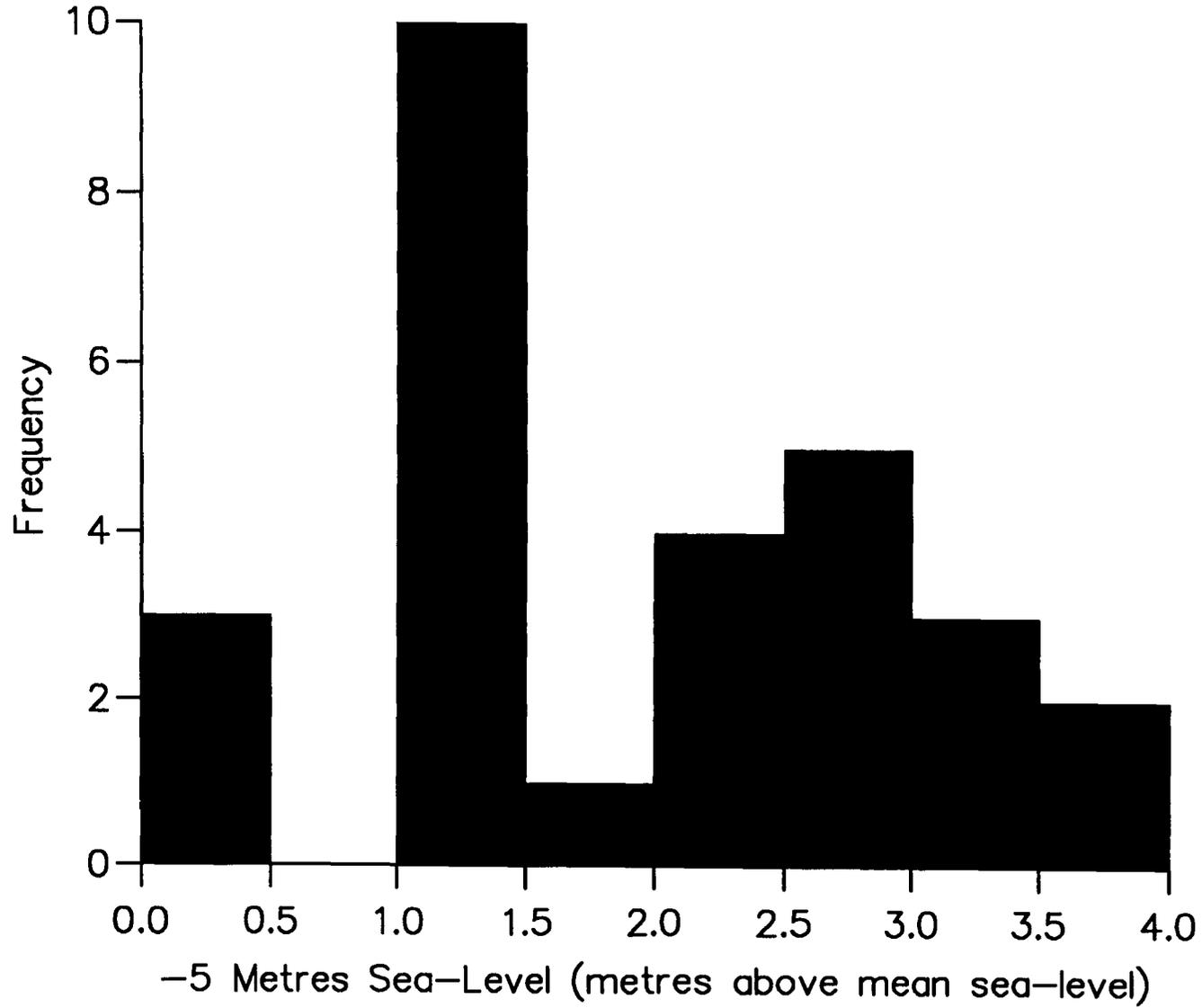


Figure 6.39. EAST COAST 3 MODEL

Maximum Tidal Altitudes (m.)

10 Metres Bathymetric Reduction

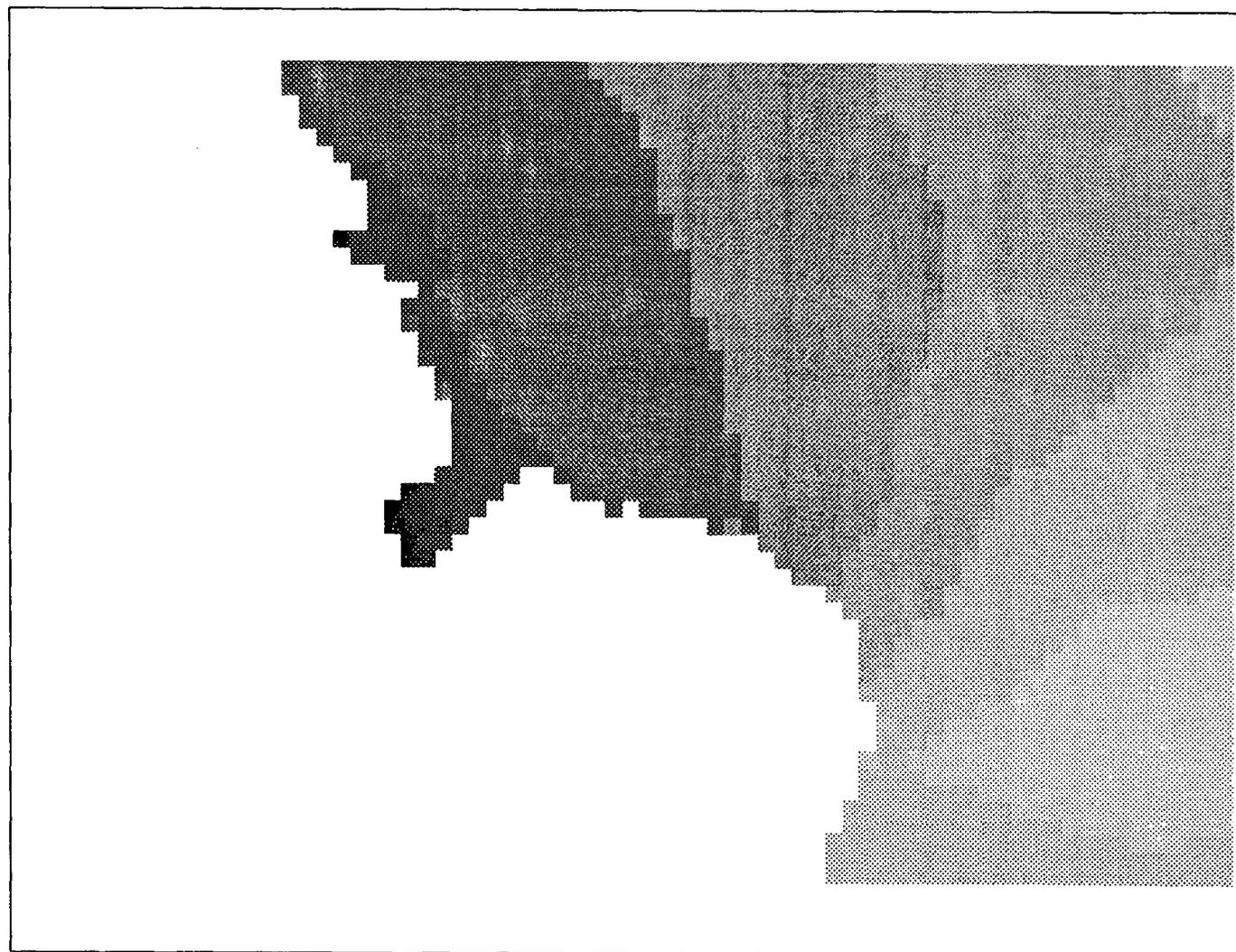
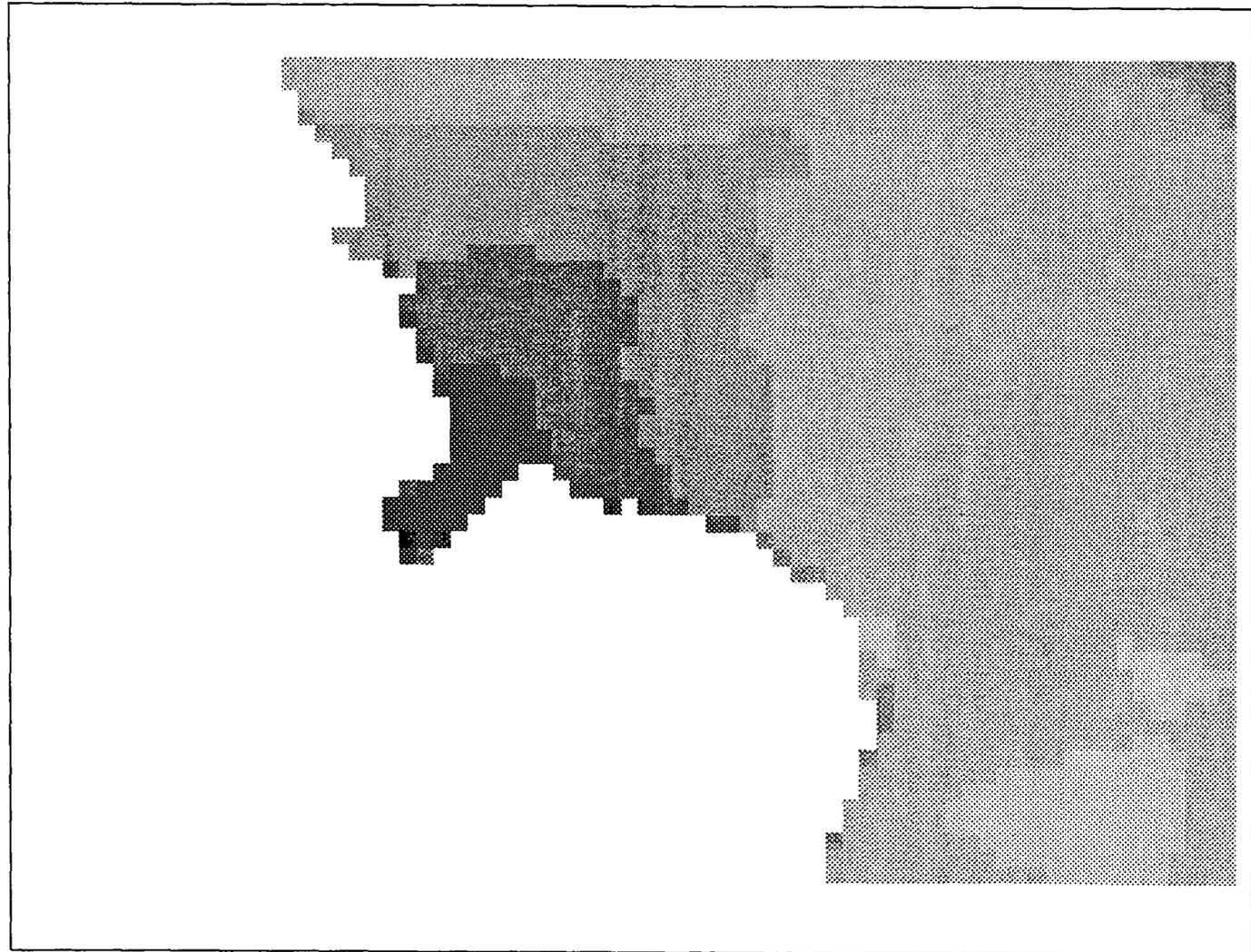
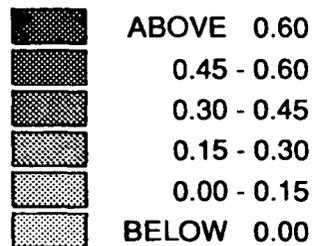


Figure 6.40. EAST COAST 3 MODEL

Maximum Tidal Altitudes Difference (m.)

Present Sea-Level Minus 10 Metres Bathymetric Reductin

41



EAST COAST 3 MODEL

Maximum Tidal Altitudes Difference (m.) 5 Metres Minus 10 Metres Bathymetric Reduction

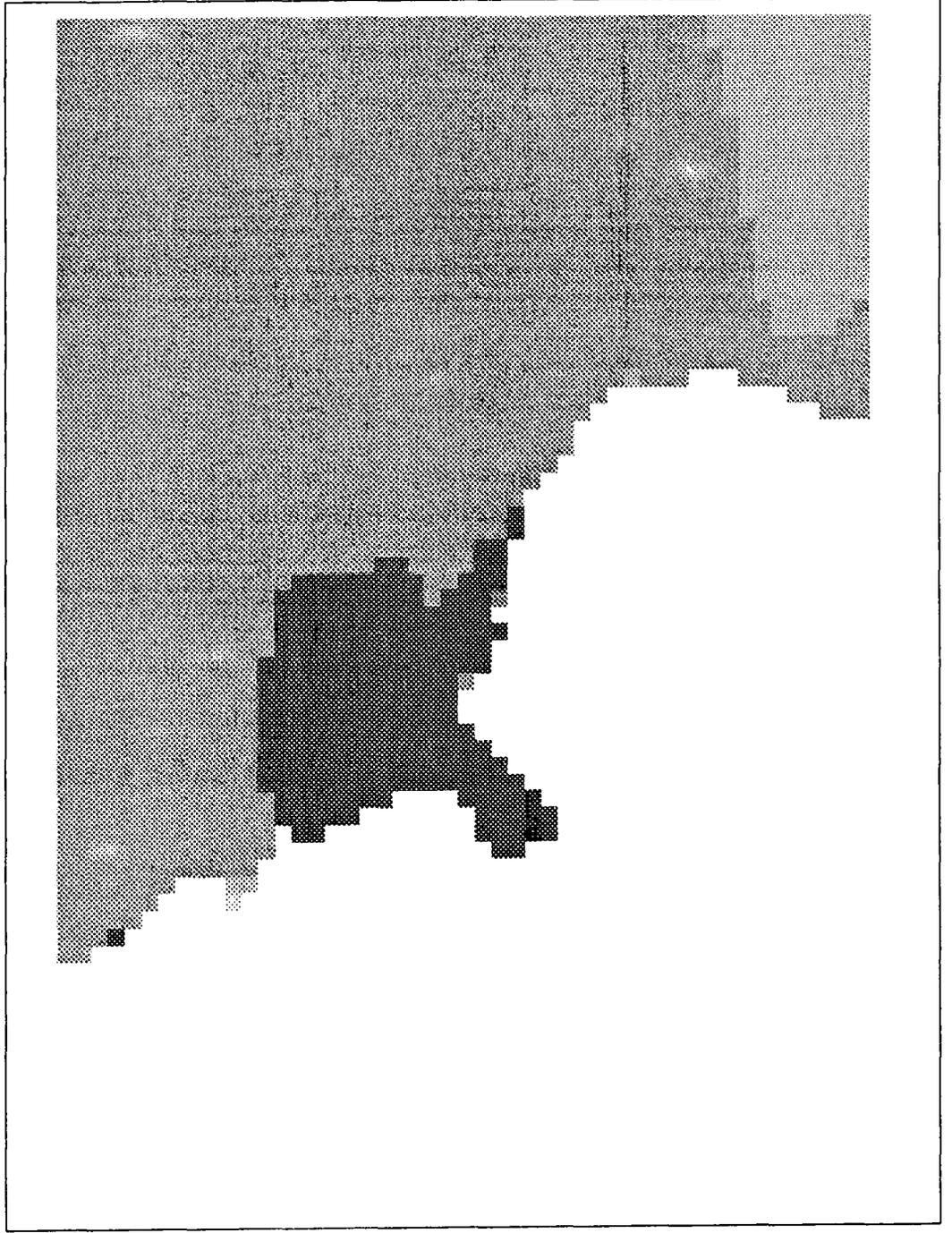


Figure 6.41.

Figure 6.42. EC3 Model Histogram: 10 Metres Bathymetric Reduction Simulation with data from Table 6.5.

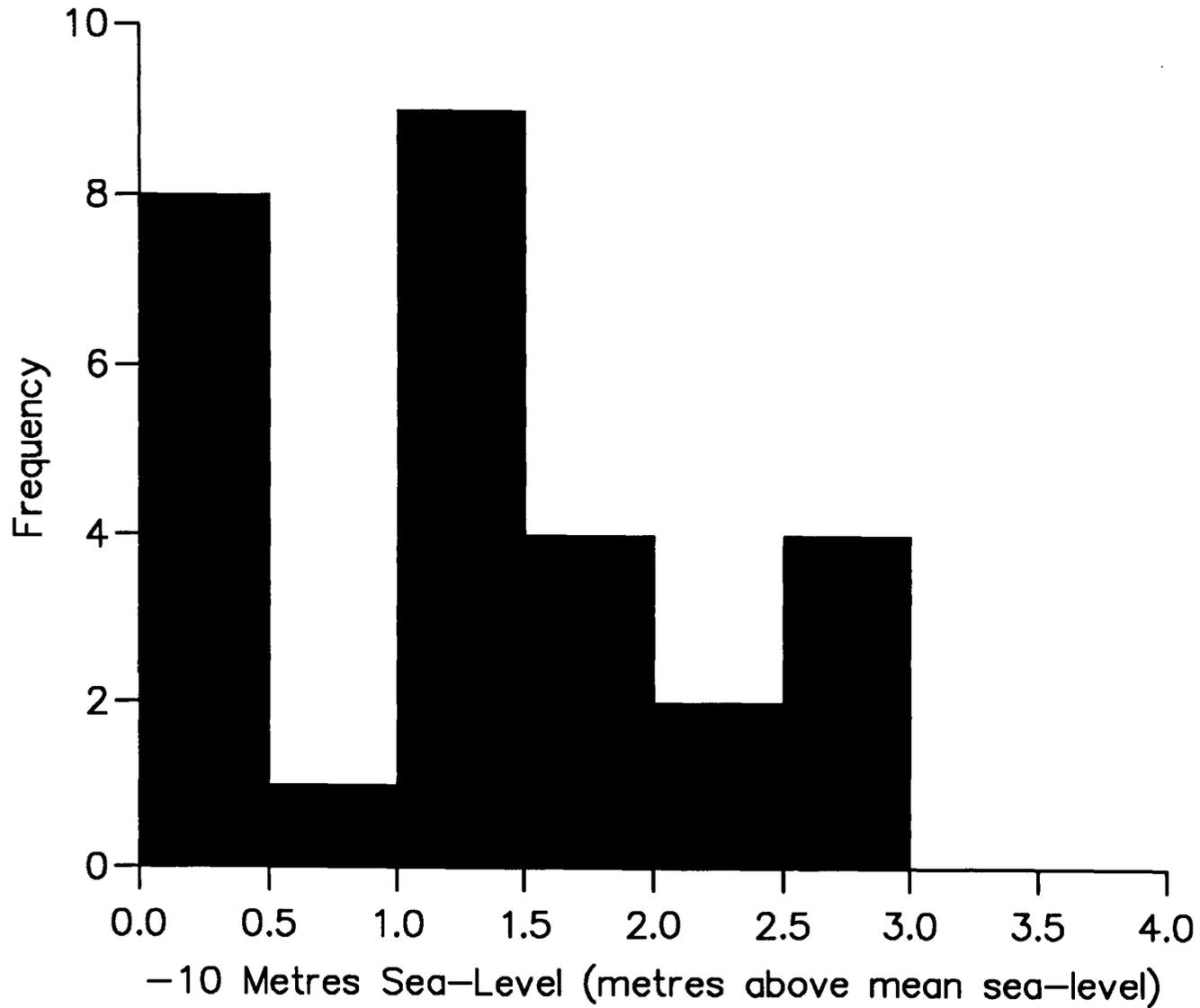


Figure 6.43. EAST COAST 3 MODEL

Maximum Tidal Altitudes (m.)

15 Metres Bathymetric Reduction

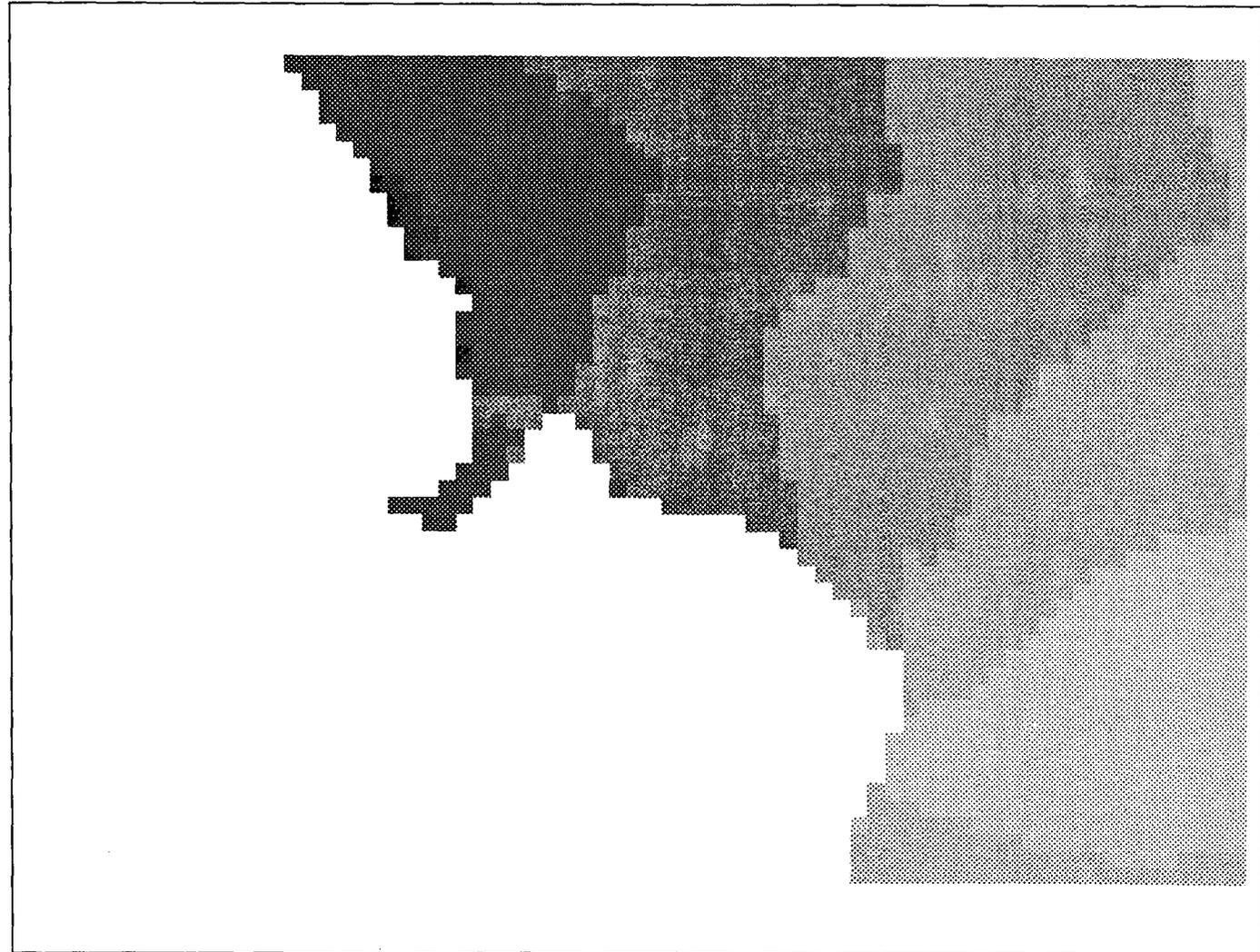


Figure 6.44. EAST COAST 3 MODEL

Maximum Tidal Altitudes Difference (m.)

Present Sea-Level Minus 15 Metres Bathymetric Reductin

45

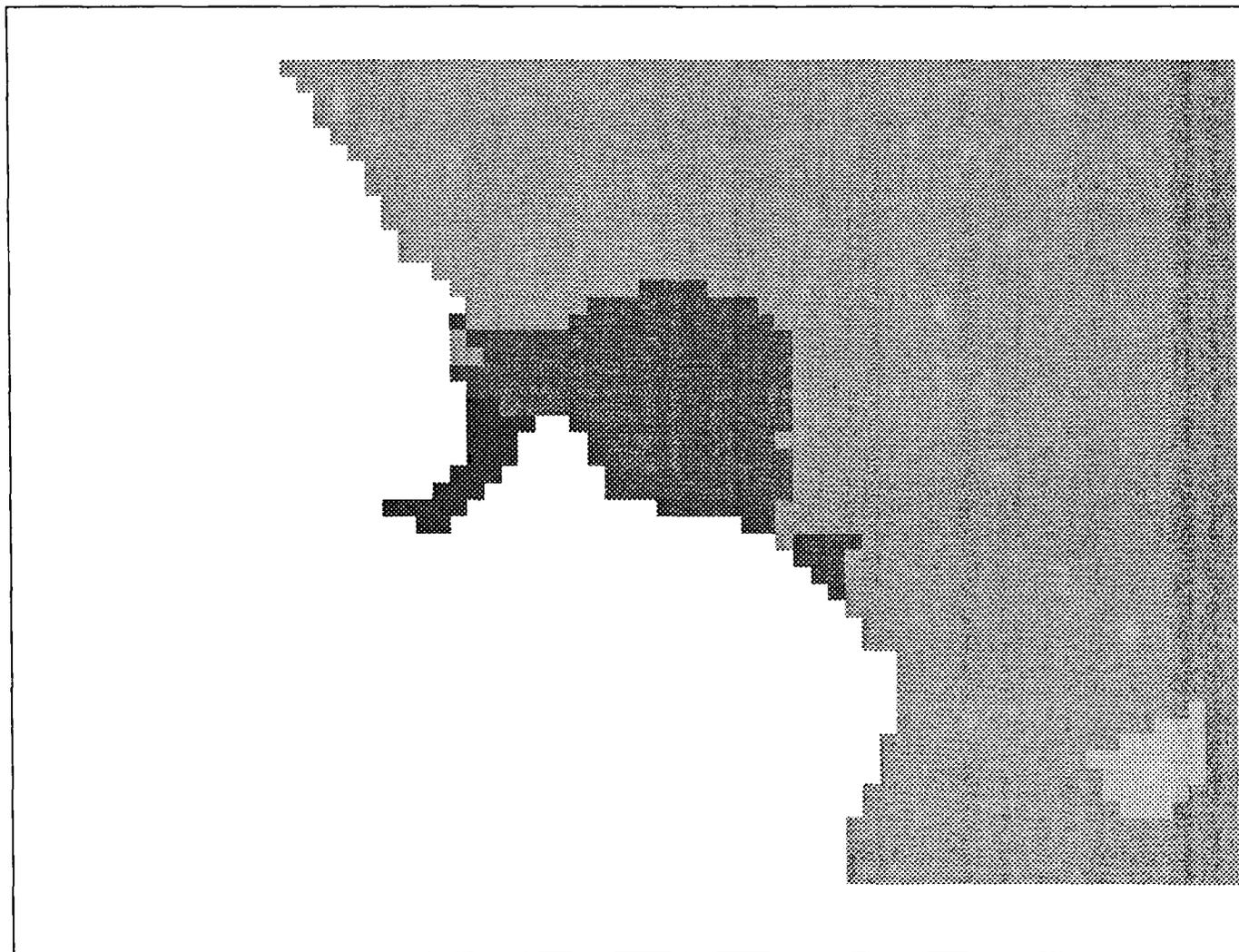
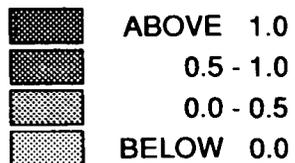


Figure 6.45. EAST COAST 3 MODEL

Maximum Tidal Altitudes Difference (m.)

10 Metres Minus 15 Metres Bathymetric Reduction

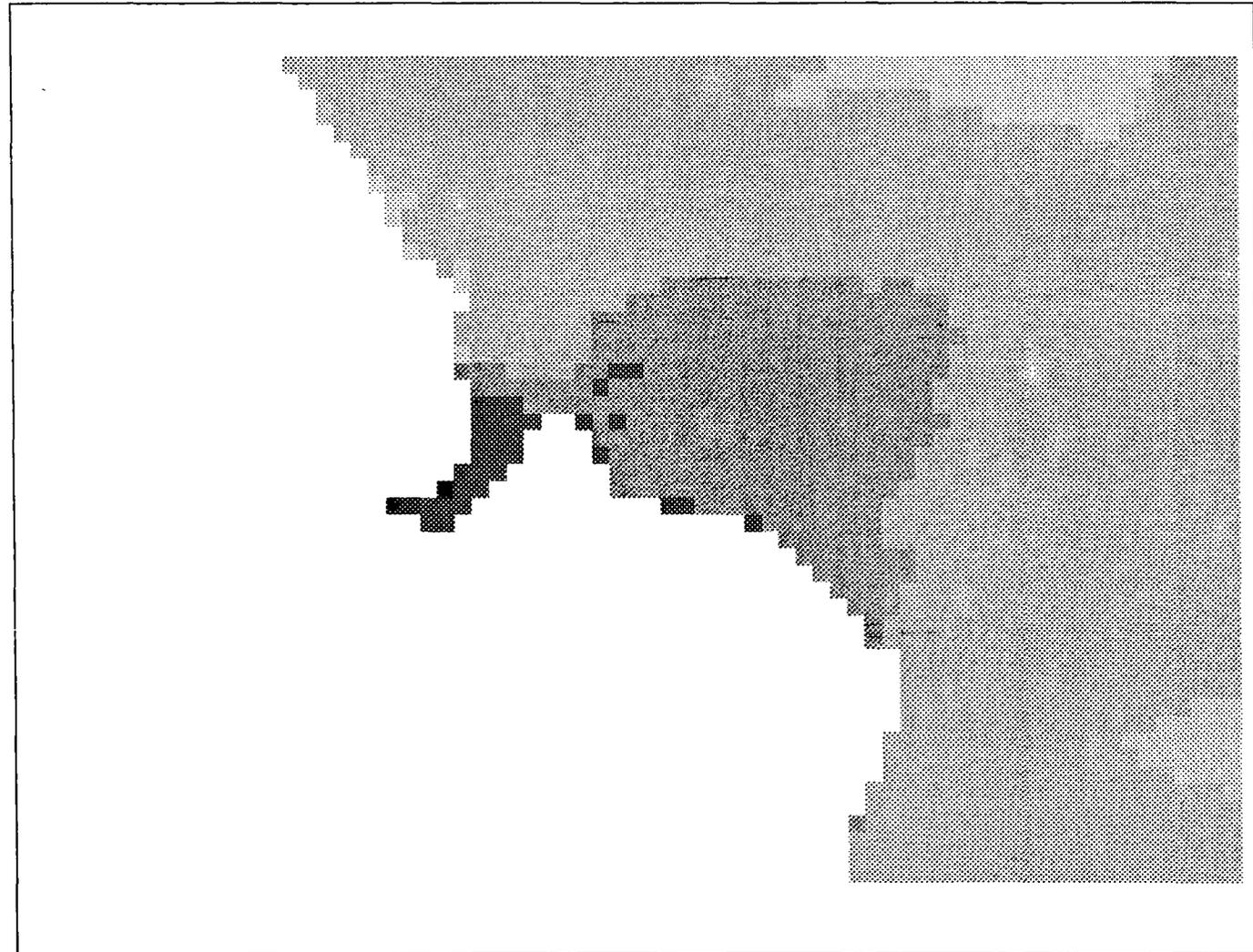
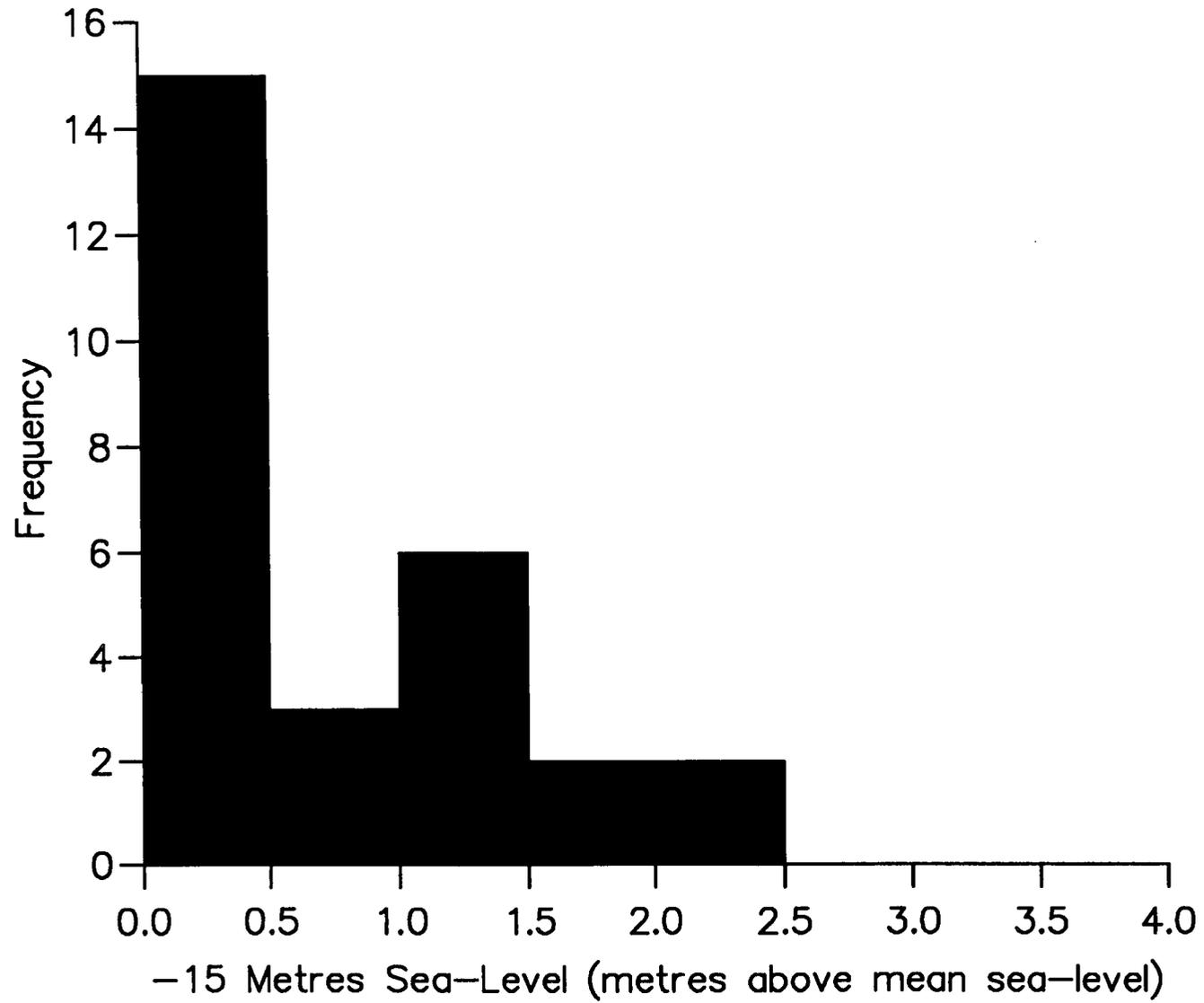


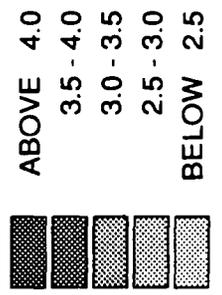
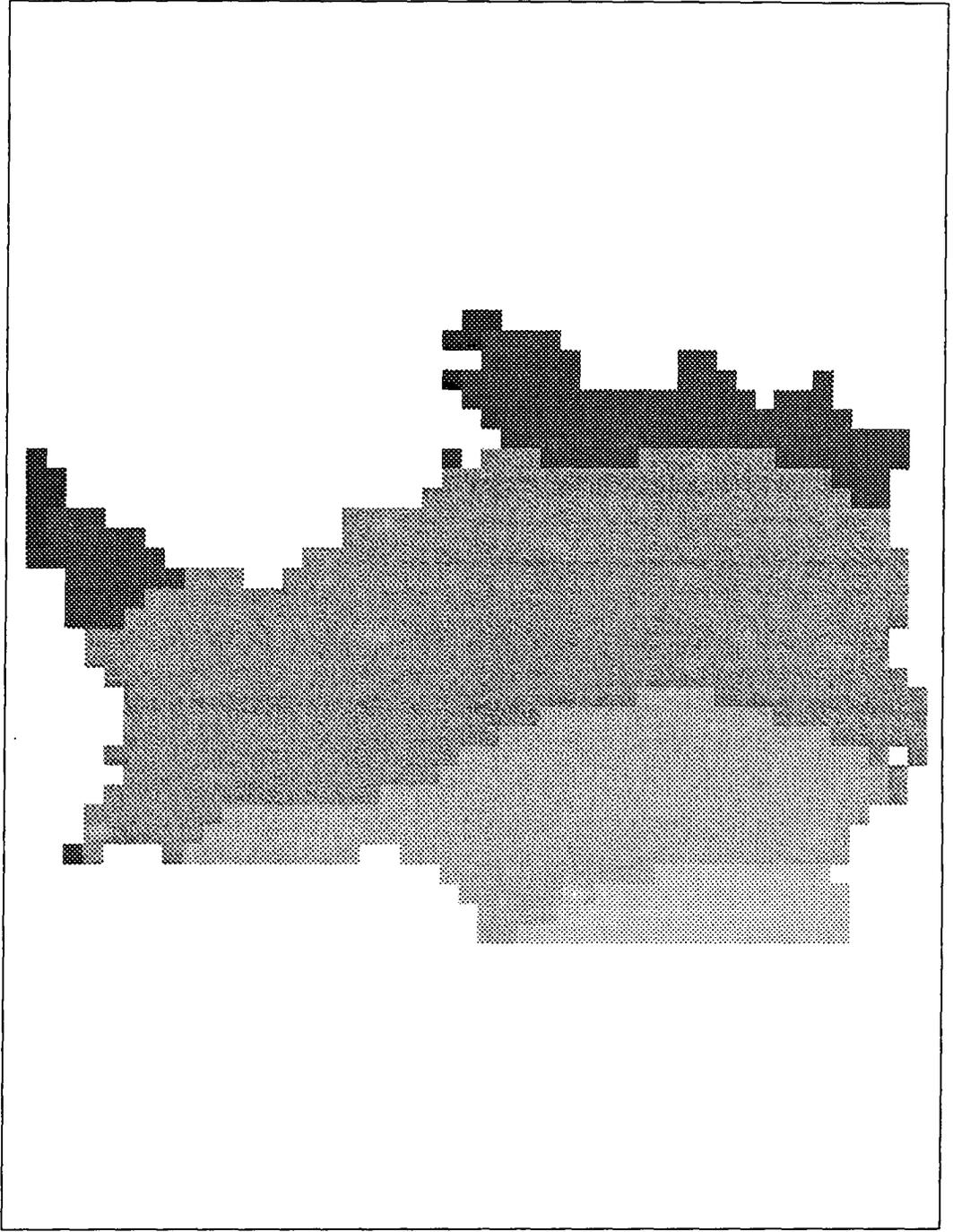
Figure 6.46. EC3 Model Histogram: 15 Metres Bathymetric Reduction Simulation with data from Table 6.5.



LIVERPOOL BAY MODEL -2 Metres Sea-Level

Figure 6.47.

Maximum Tidal Heights (m.)



LIVERPOOL BAY MODEL Present Sea-Level Minus

-2 Metres Sea-Level

Maximum Tidal Heights (m.)

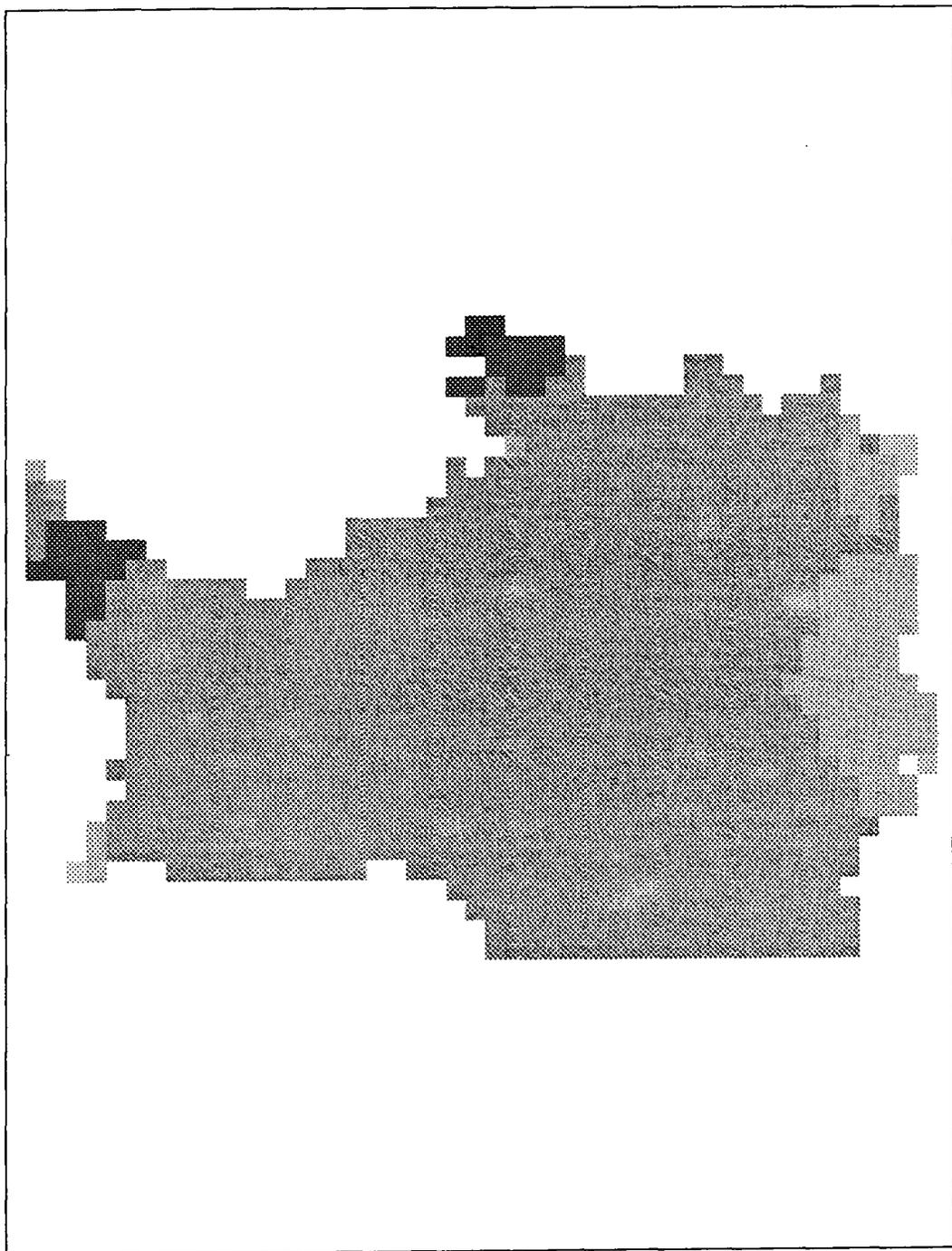


Figure 6.48.

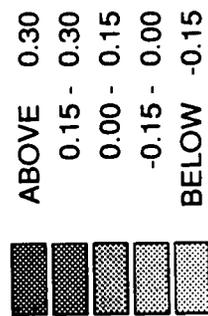


Figure 6.49. LBM Model Histogram: 2 Metres Bathymetric Reduction Simulation with data from Table 6.9.

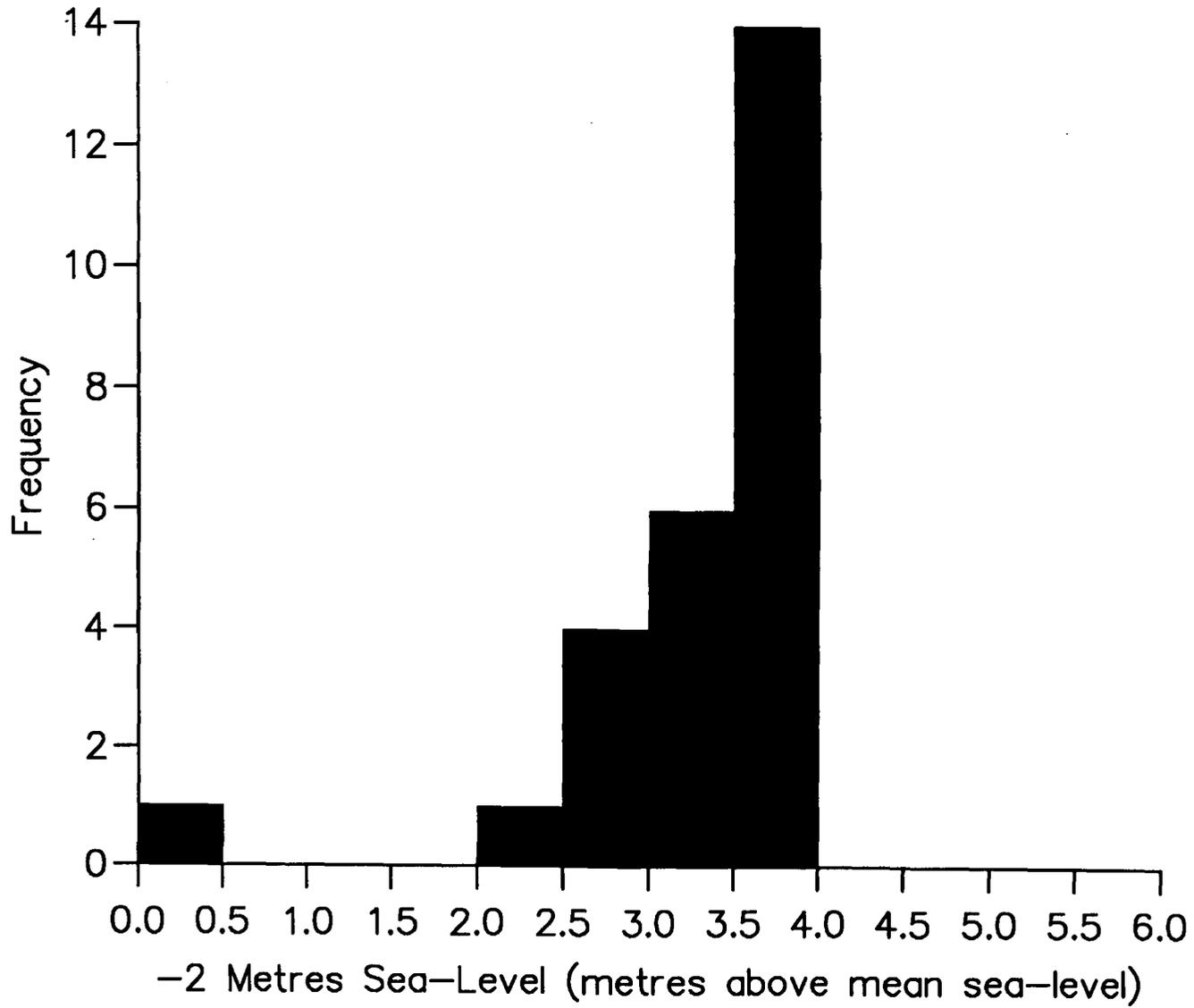
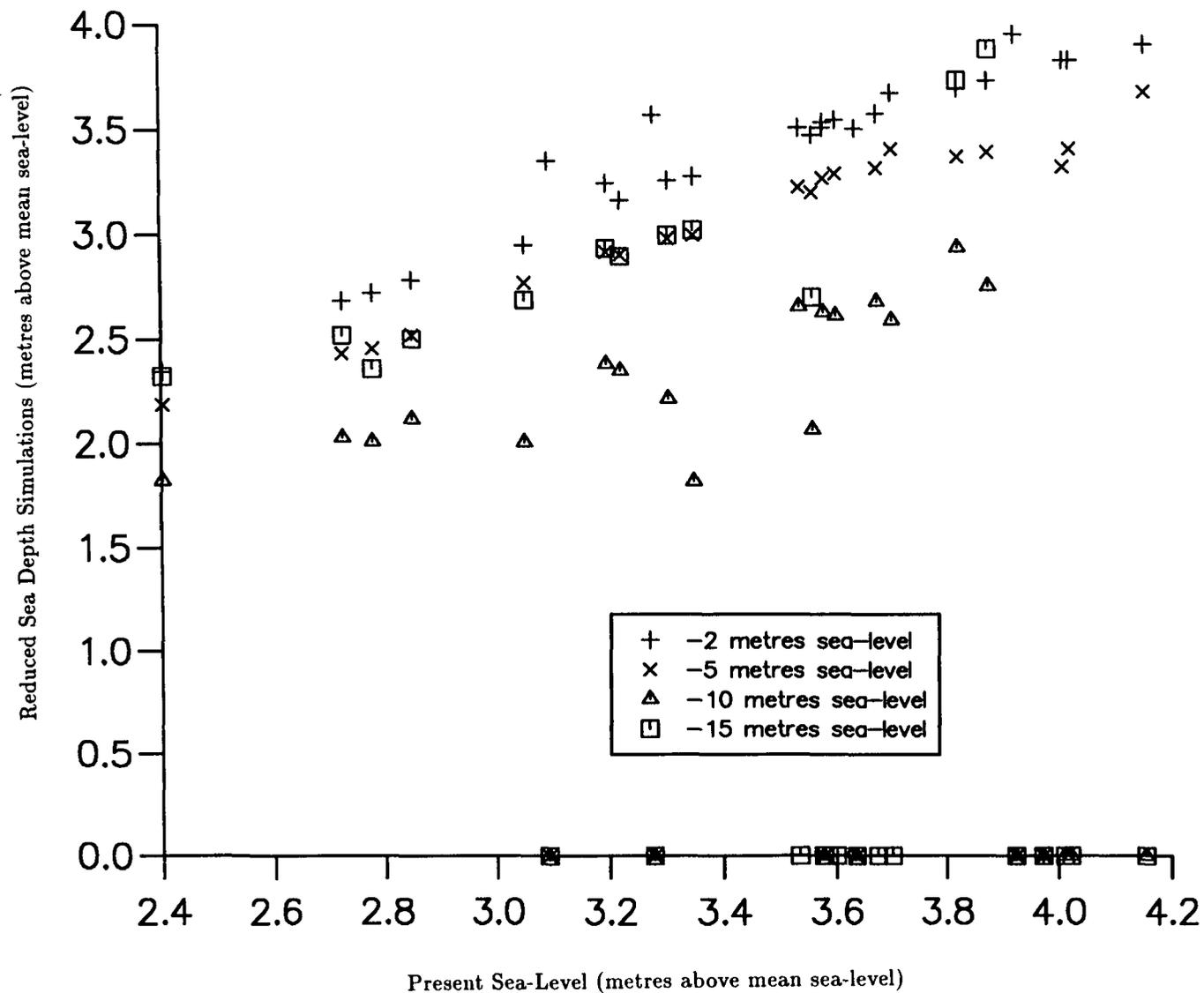


Figure 6.50. LBM Model Scatter Plot: Present Sea-Level against Reduced Sea Depth Simulations with data from Table 6.9.



LIVERPOOL BAY MODEL -5 Metres Sea-Level

Figure 6.51.

Maximum Tidal Heights (m.)

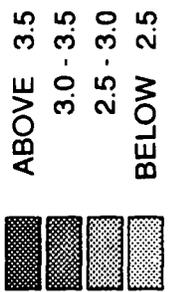
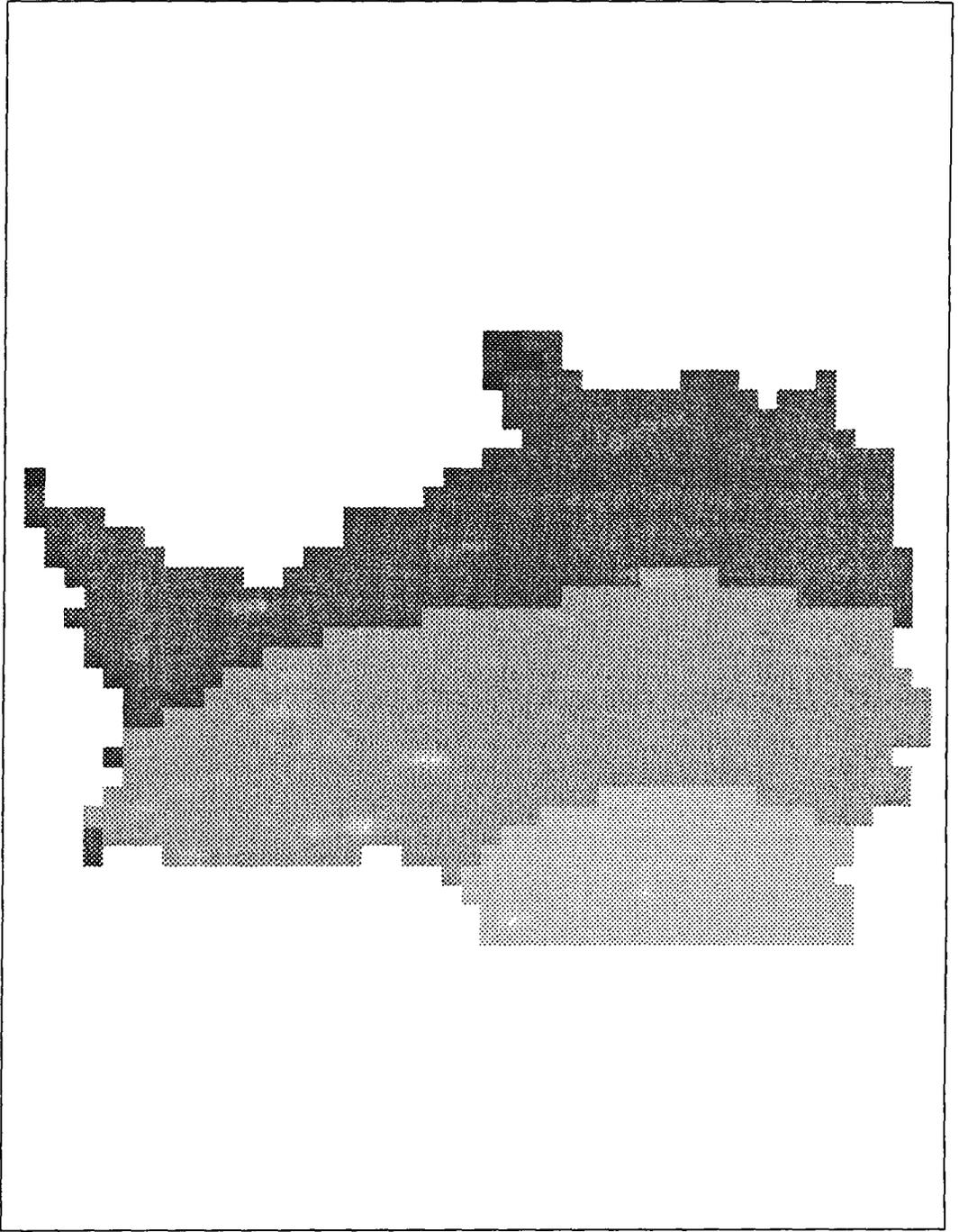


Figure 6.52. LIVERPOOL BAY MODEL Present Sea-Level Minus

-5 Metres Sea-Level

Maximum Tidal Heights (m.)

53

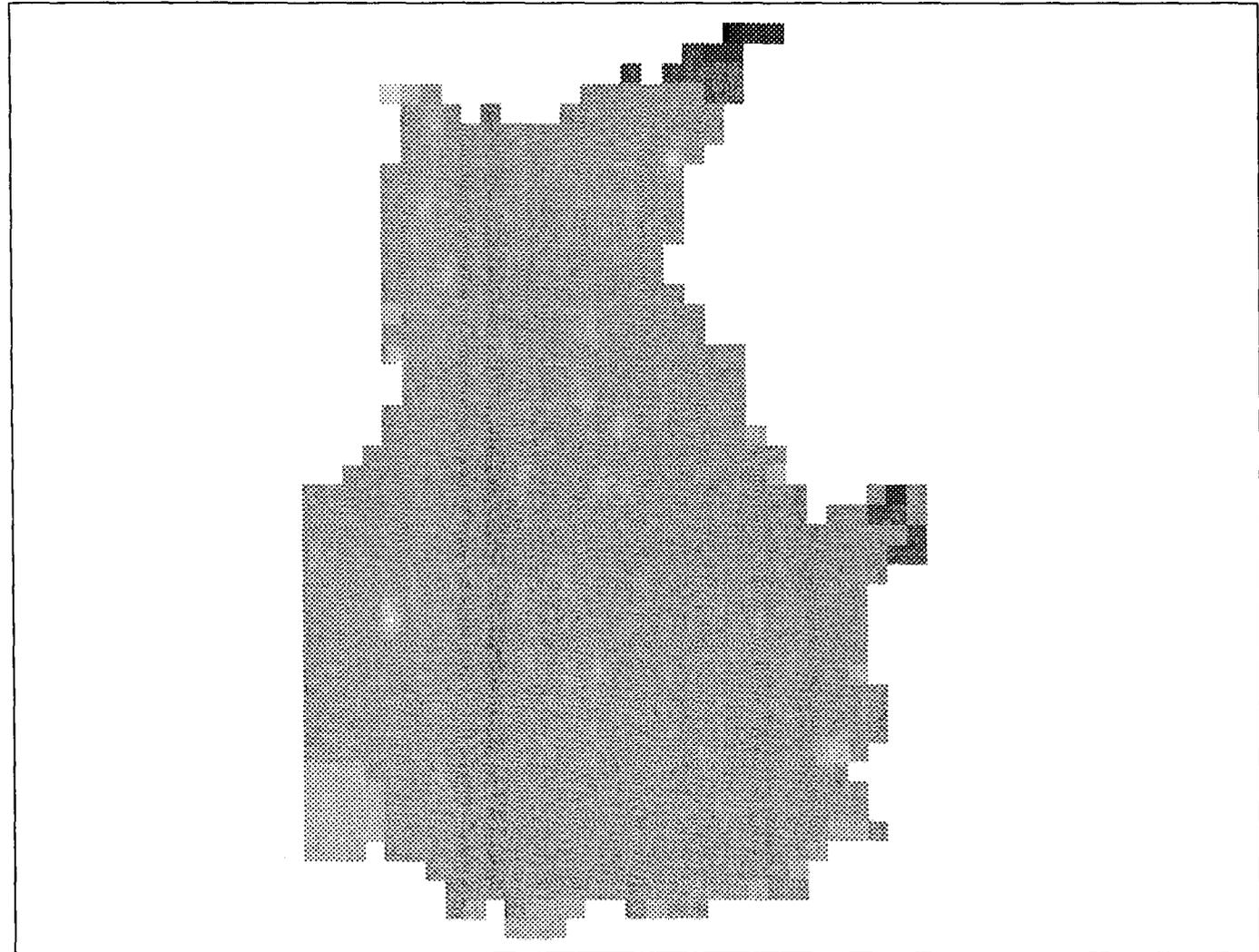
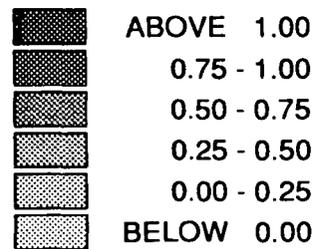
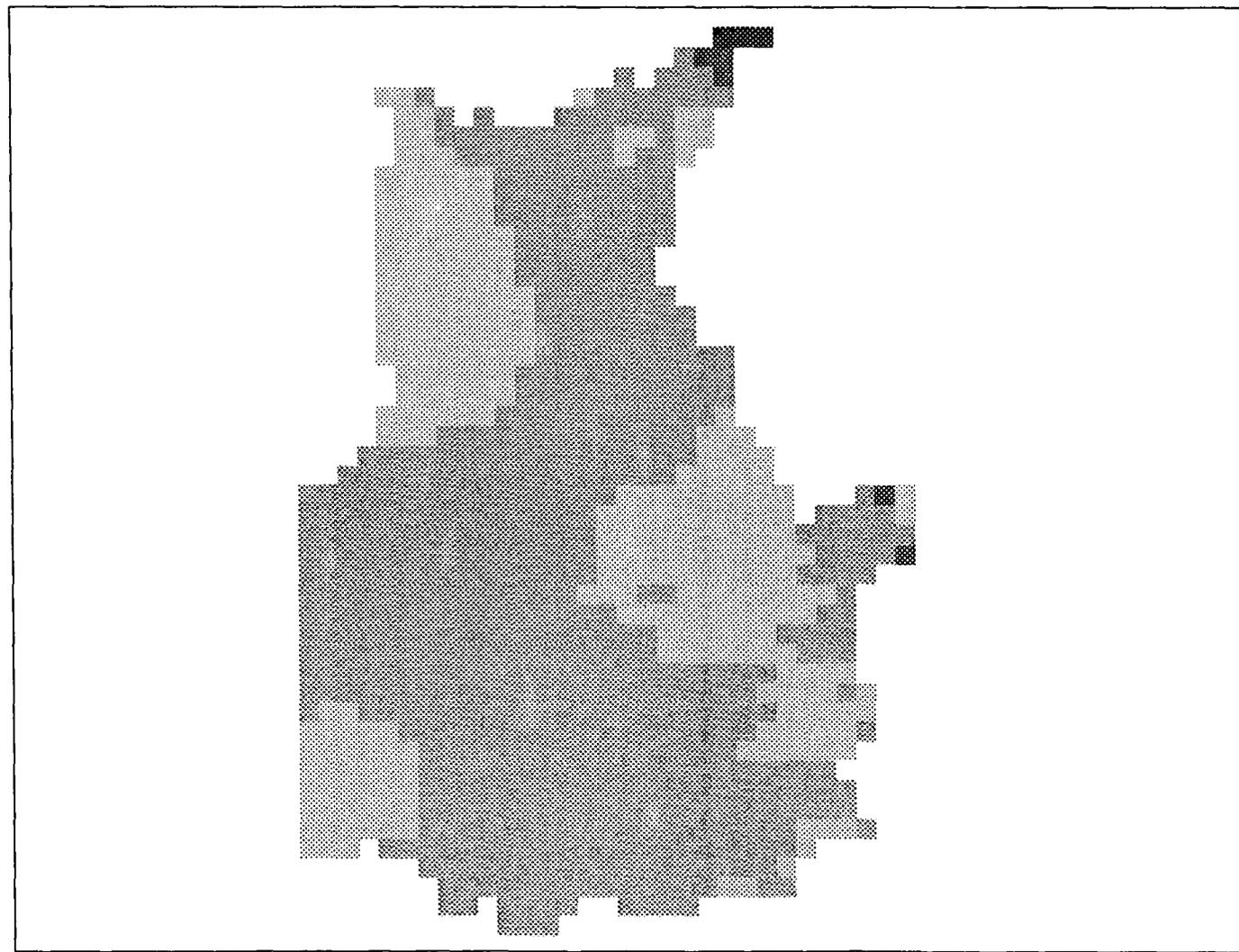


Figure 6.53. LIVERPOOL BAY MODEL -2 Metres Sea-Level Minus

-5 Metres Sea-Level
Maximum Tidal Heights (m.)



	ABOVE 0.75
	0.50 - 0.75
	0.25 - 0.50
	BELOW 0.25

Figure 6.54. LBM Model Histogram: 5 Metres Bathymetric Reduction Simulation with data from Table 6.9.

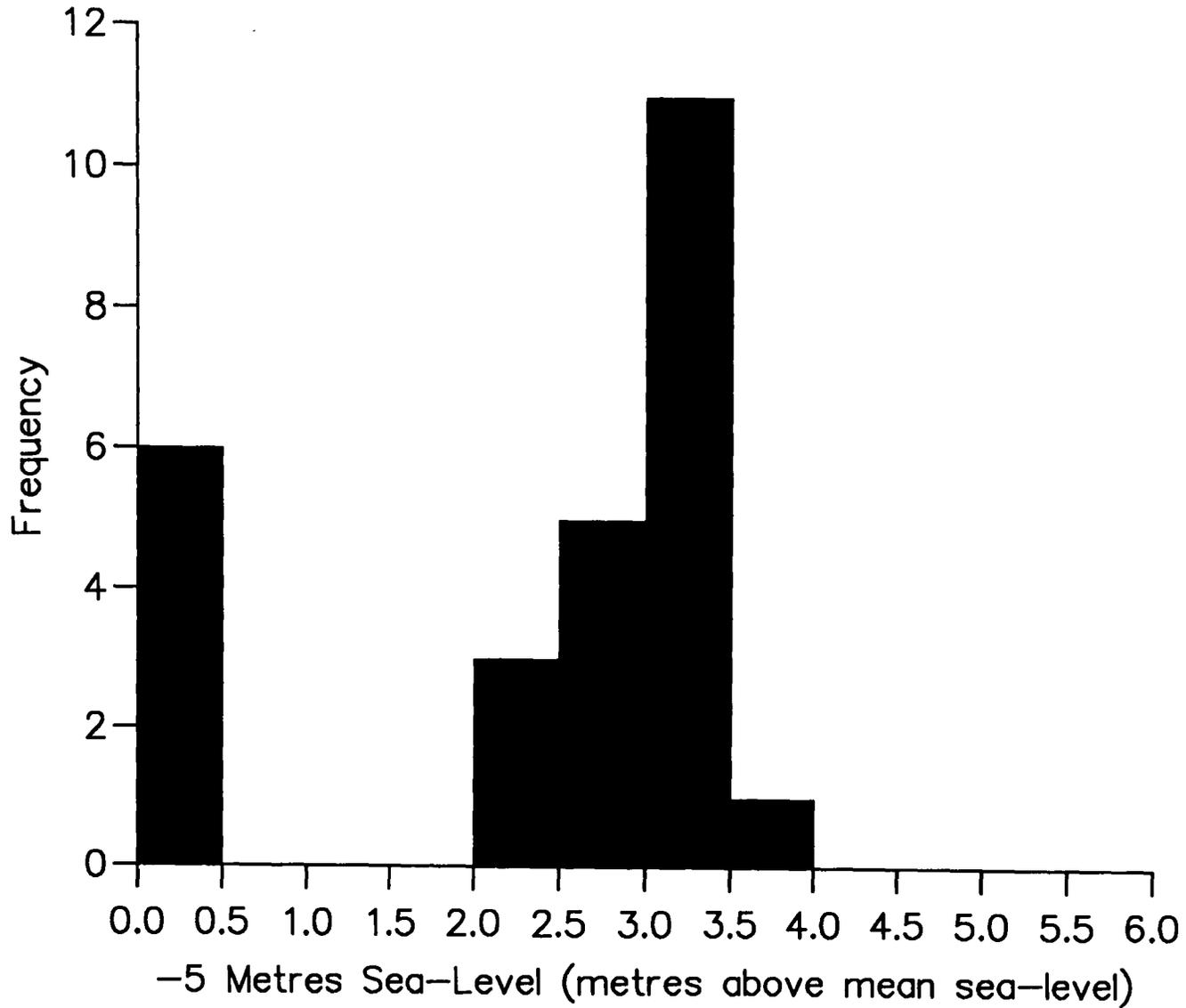
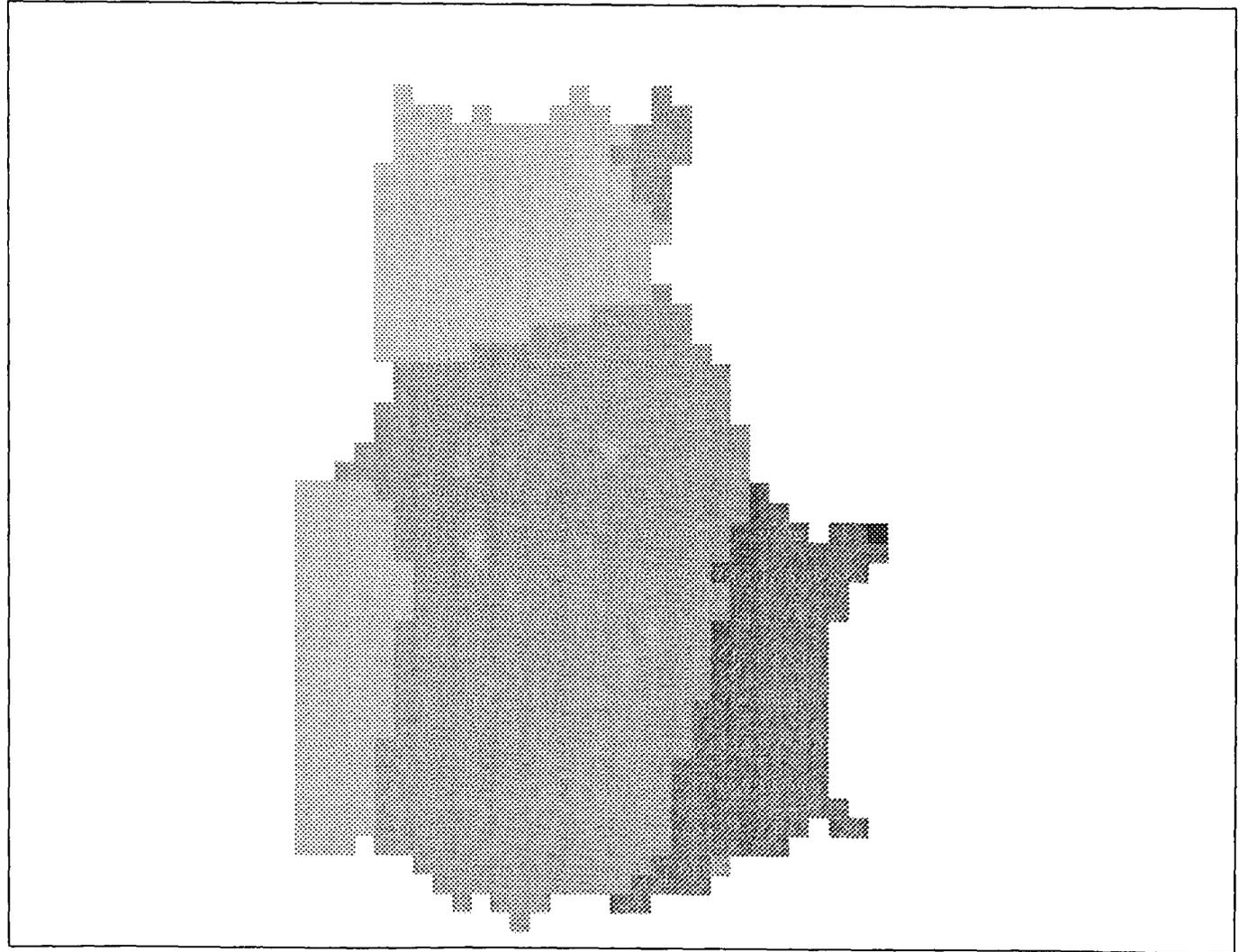
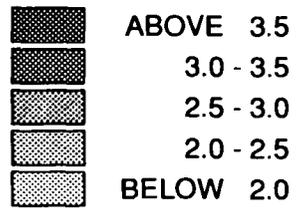


Figure 6.55. LIVERPOOL BAY MODEL -10 Metres Sea-Level

Maximum Tidal Heights (m.)

56



LIVERPOOL BAY MODEL Present Sea-Level Minus

-10 Metres Sea-Level

Maximum Tidal Heights (m.)

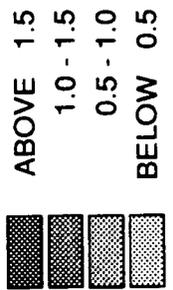
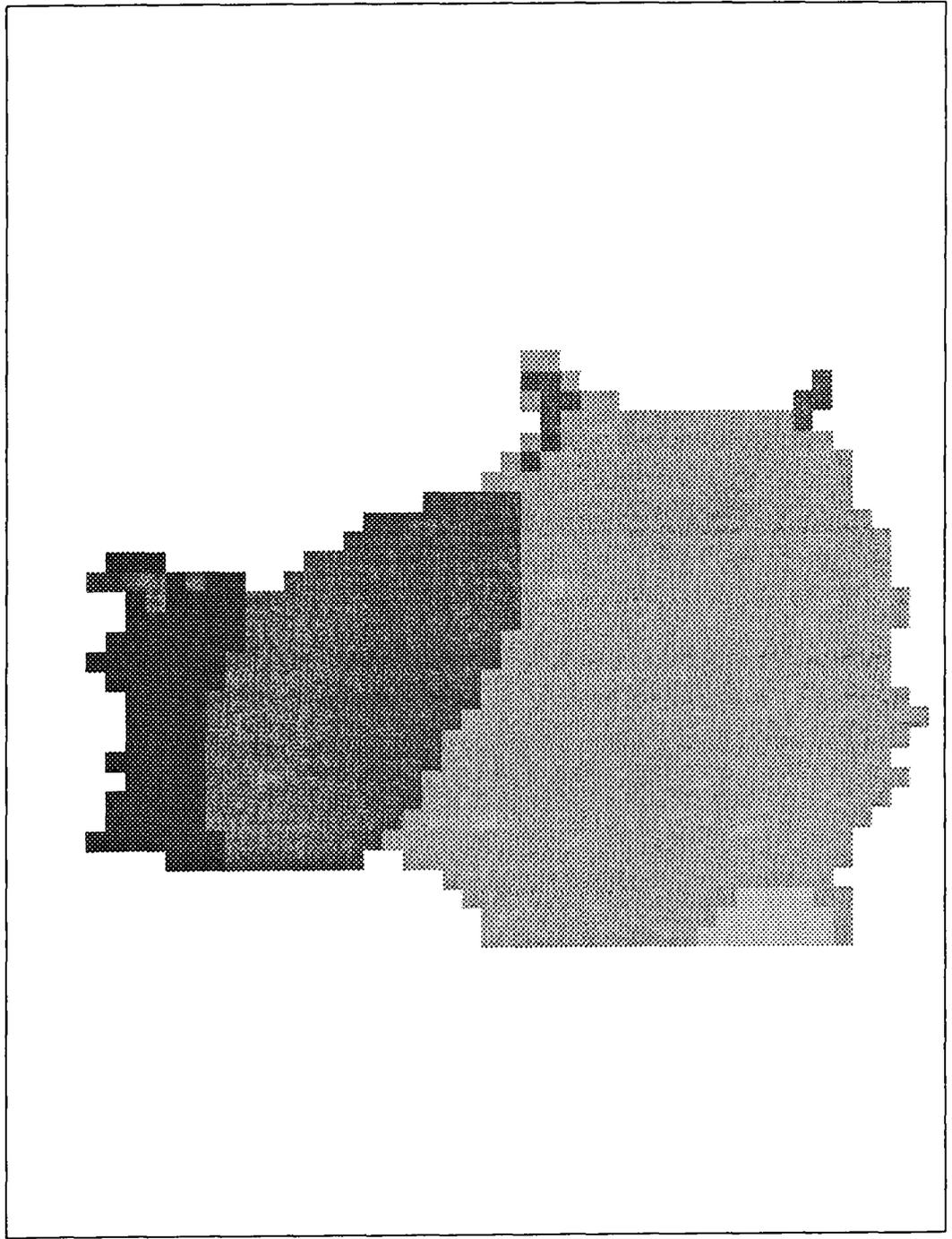


Figure 6.57. LIVERPOOL BAY MODEL -5 Metres Sea-Level Minus

-10 Metres Sea-Level

Maximum Tidal Heights (m.)

58

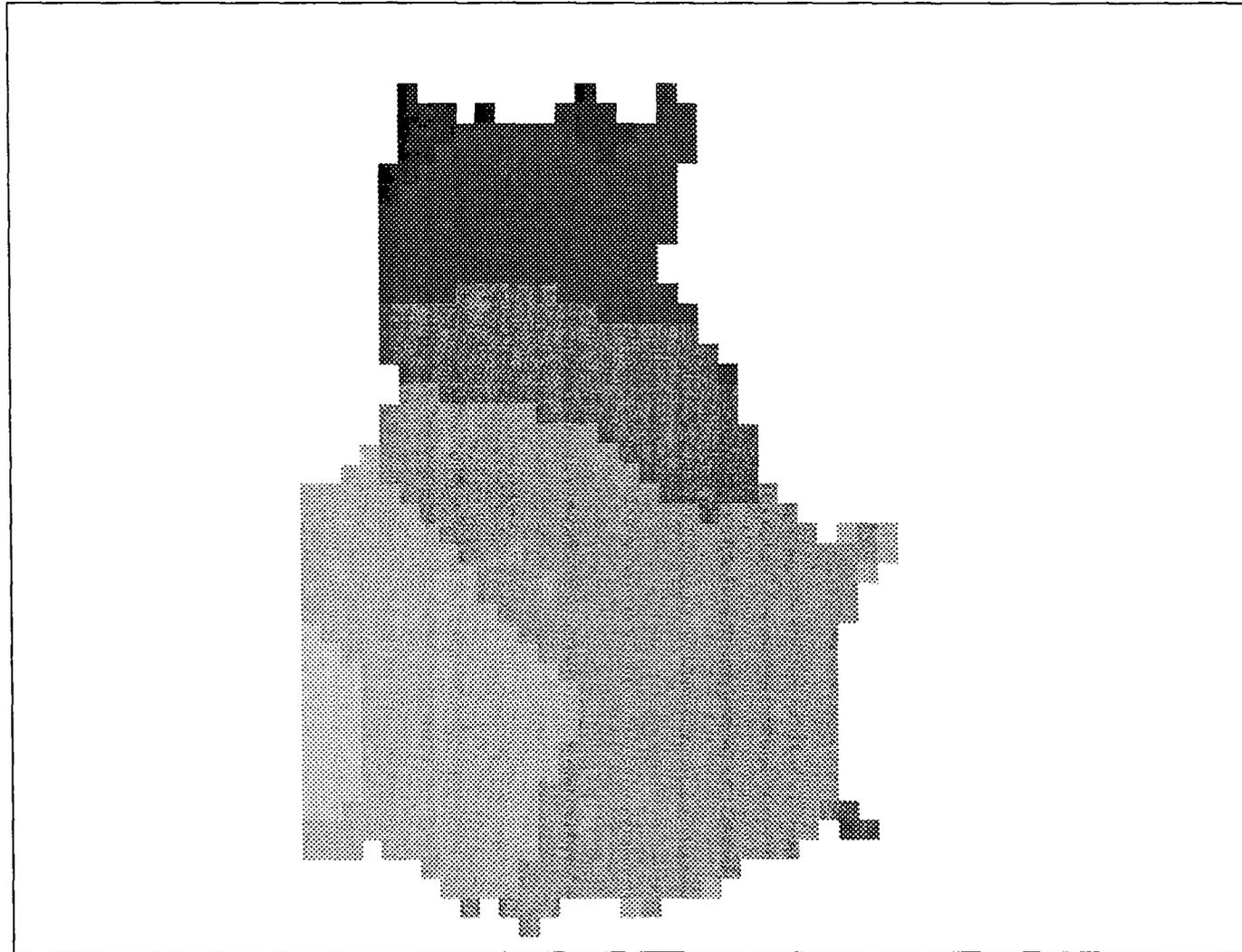
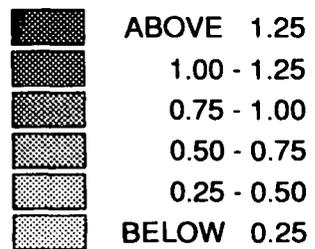


Figure 6.58. LBM Model Histogram: 10 Metres Bathymetric Reduction Simulation with data from Table 6.9.

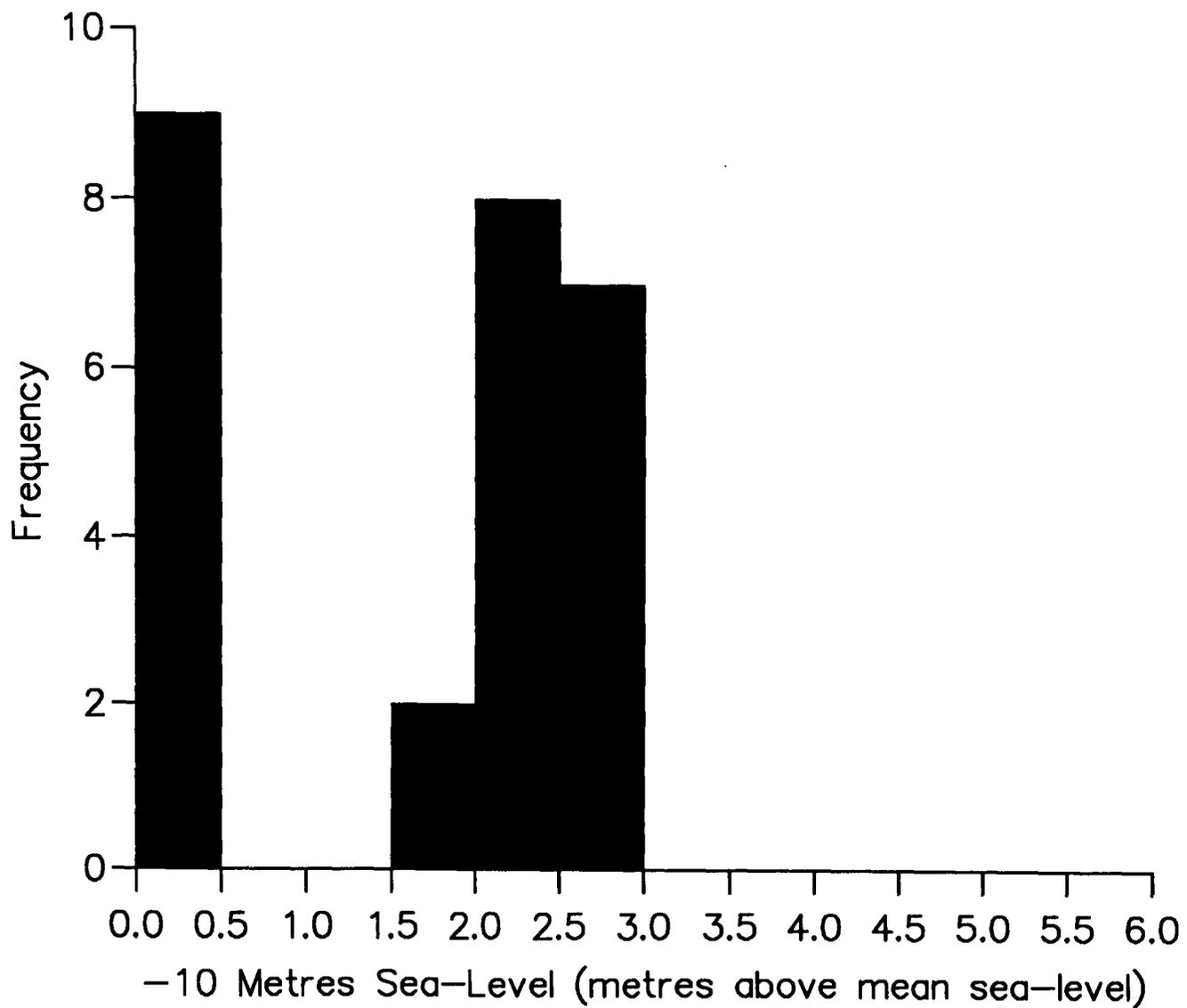


Figure 6.59. LIVERPOOL BAY MODEL -15 Metres Sea-Level

Maximum Tidal Heights (m.)

09

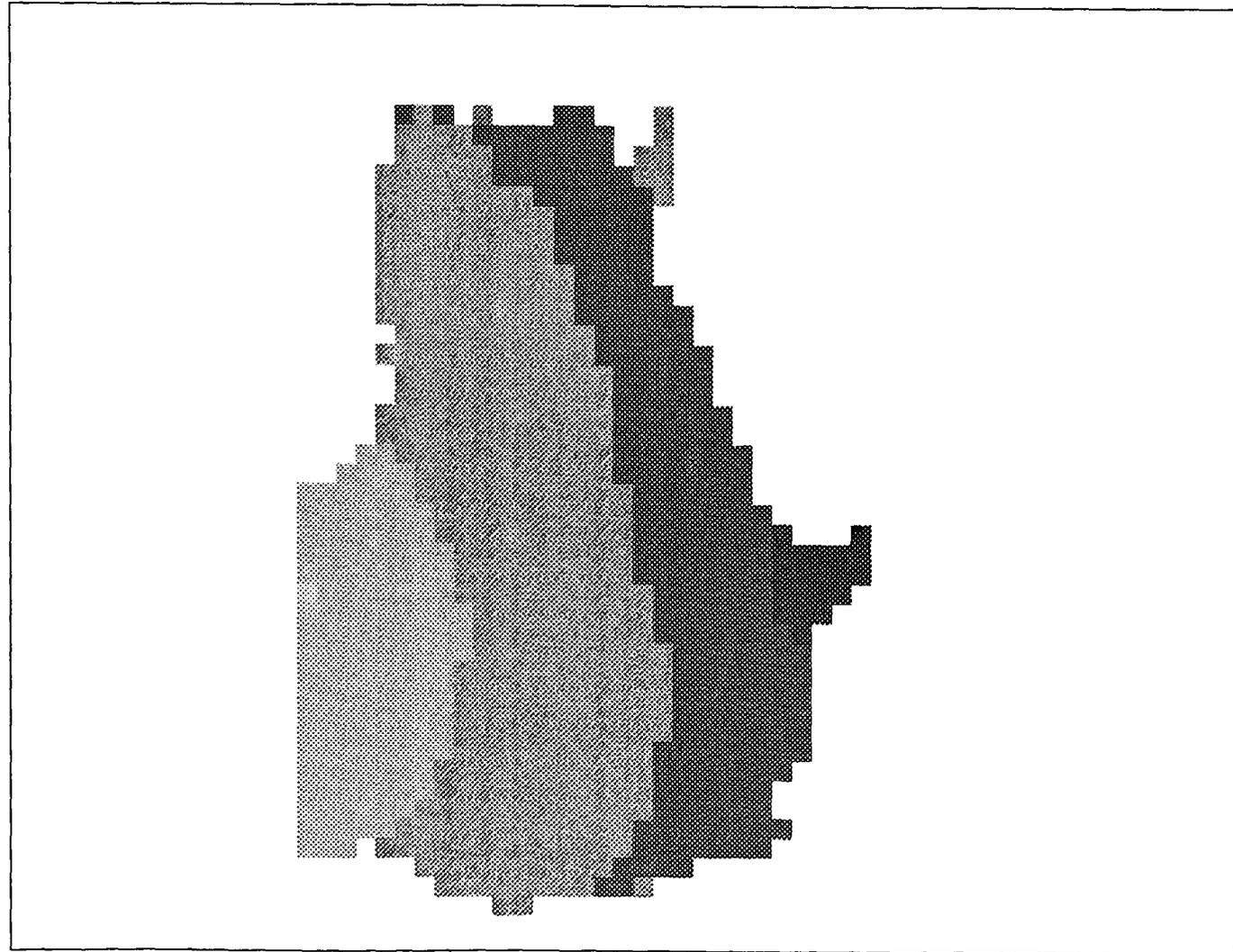
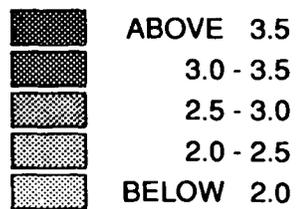


Figure 6.60. LIVERPOOL BAY MODEL Present Sea-Level Minus

-15 Metres Sea-Level
Maximum Tidal Heights (m.)

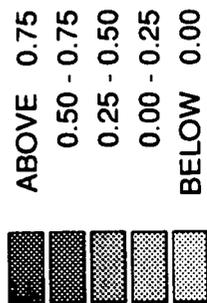
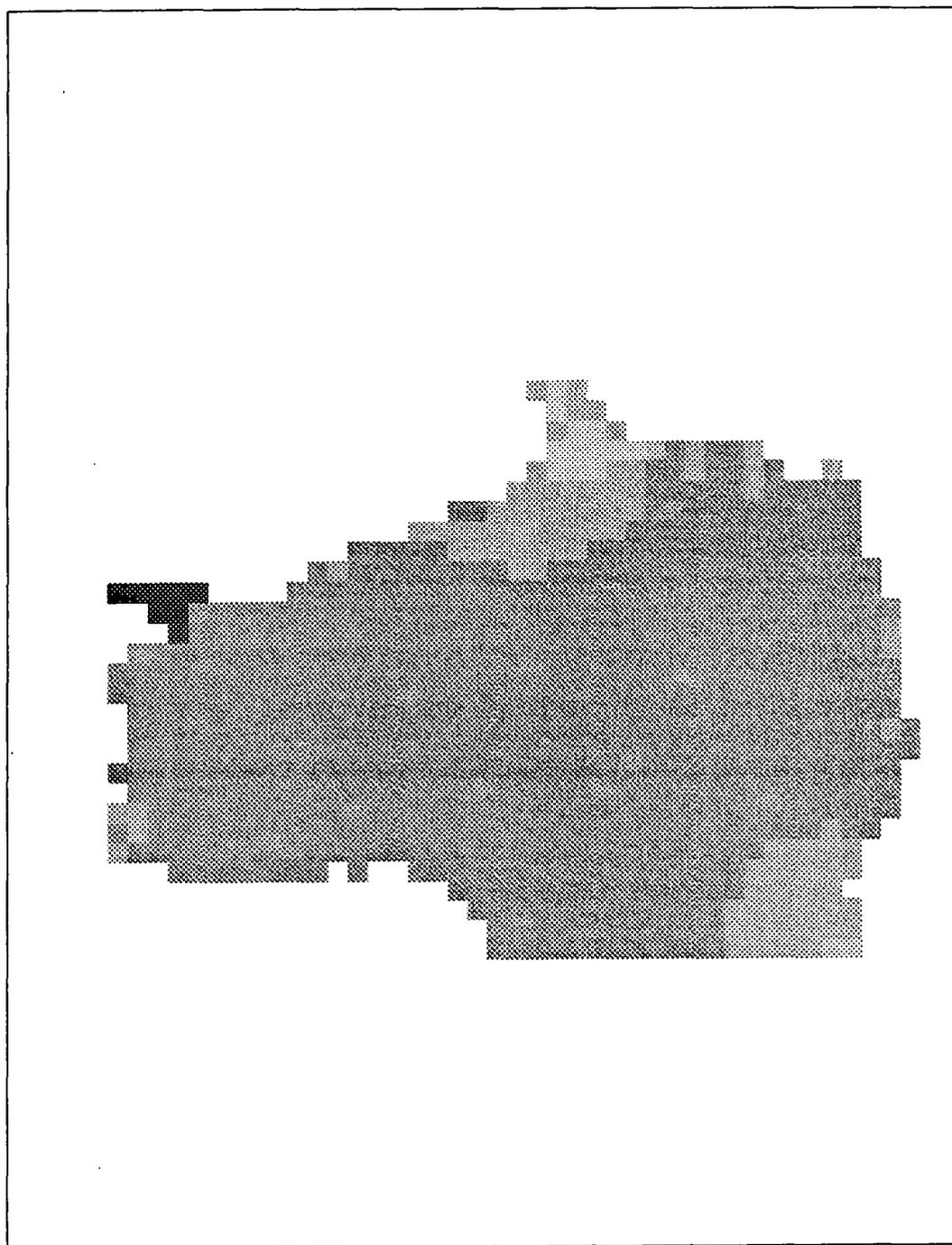


Figure 6.61. LIVERPOOL BAY MODEL -10 Metres Sea-Level Minus

-15 Metres Sea-Level

Maximum Tidal Heights (m.)

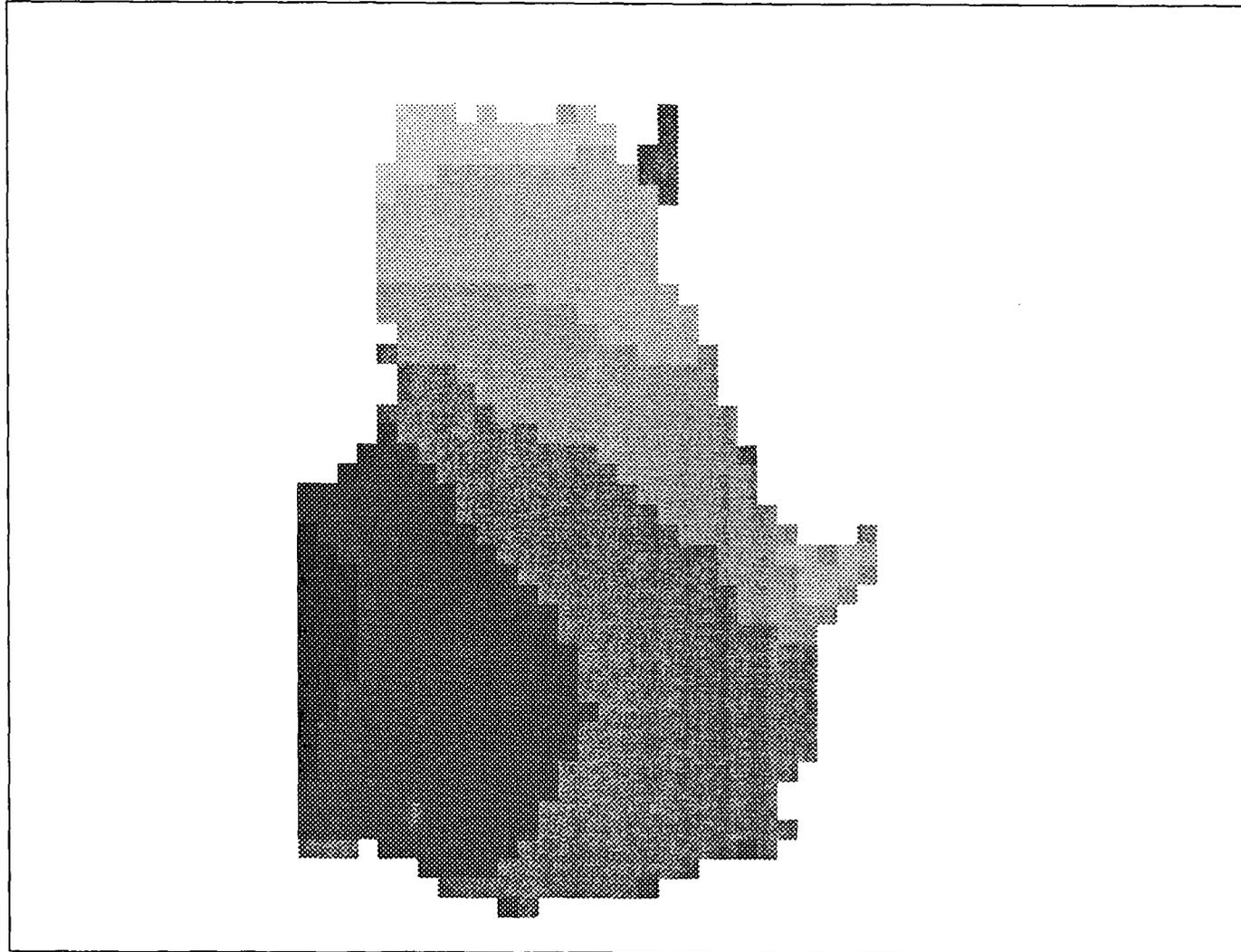
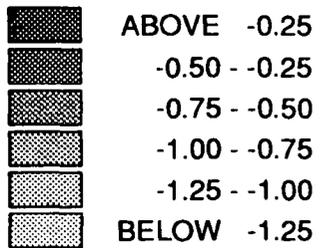


Figure 6.62. LBM Model Histogram: 15 Metres Bathymetric Reduction Simulation with data from Table 6.9.

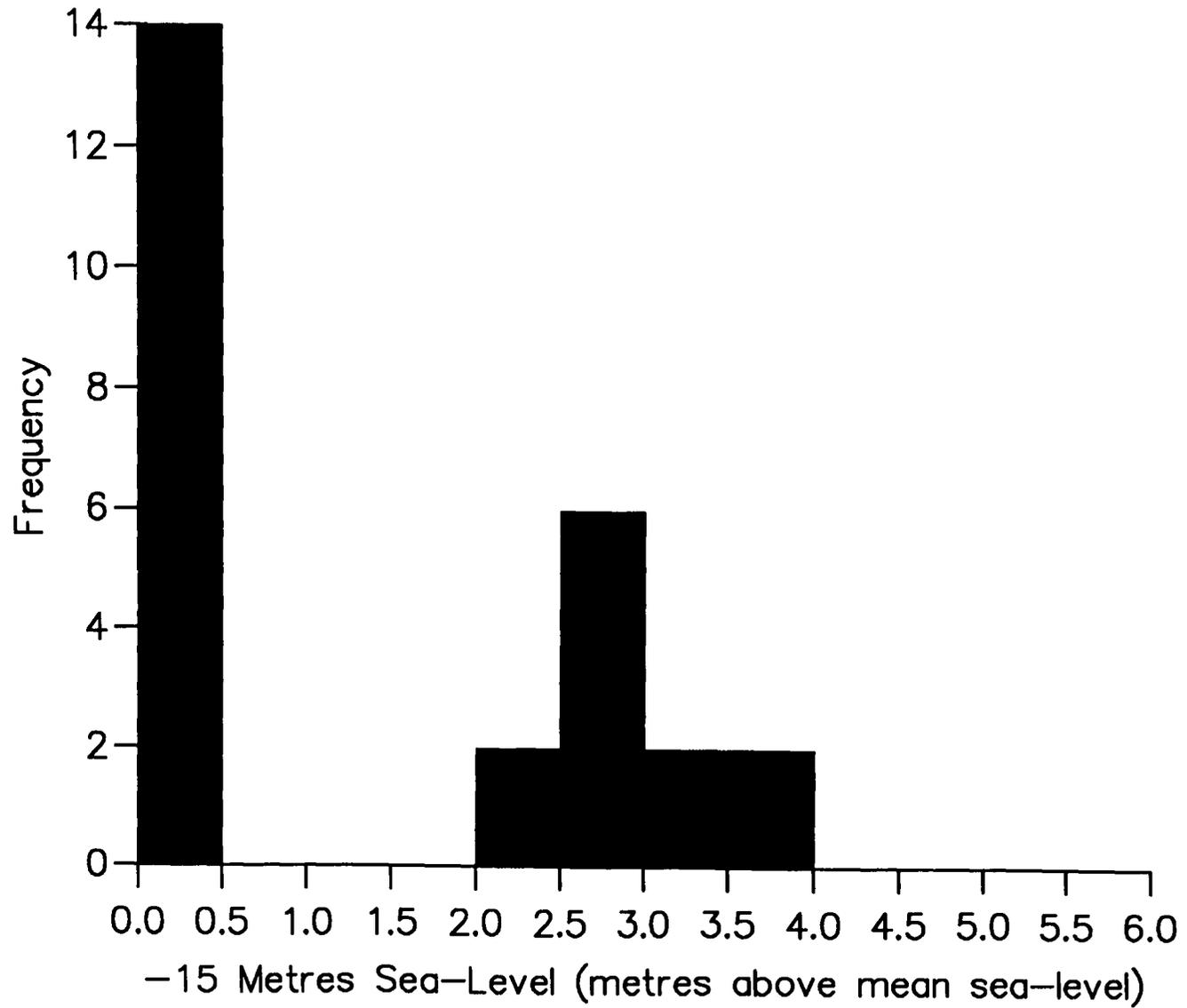


Figure 6.63. EAST COAST 3 MODEL 3,000 Years B.P. Coastline

Maximum Tidal Altitudes Difference (m.)

64

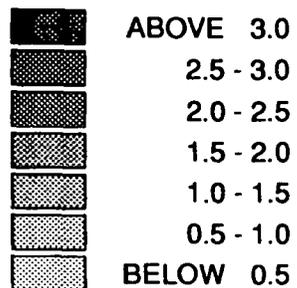


Figure 6.64. EC3 Model Histogram: 3,000 Years B.P. Coastline Simulation with data from Table 6.5.

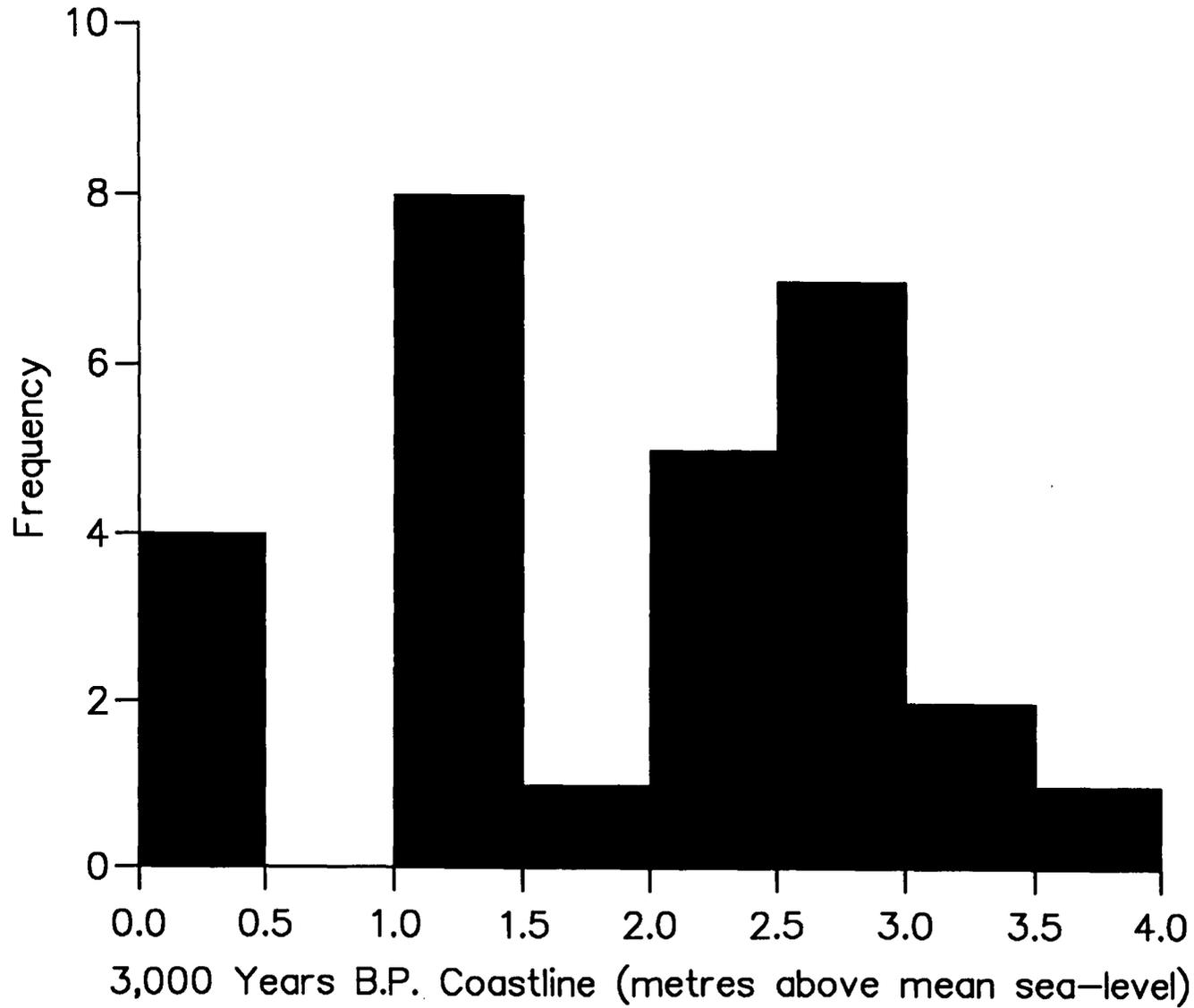


Figure 6.65. EAST COAST 3 MODEL 4,000 Years B.P. Coastline

Maximum Tidal Altitudes Difference (m.)

99

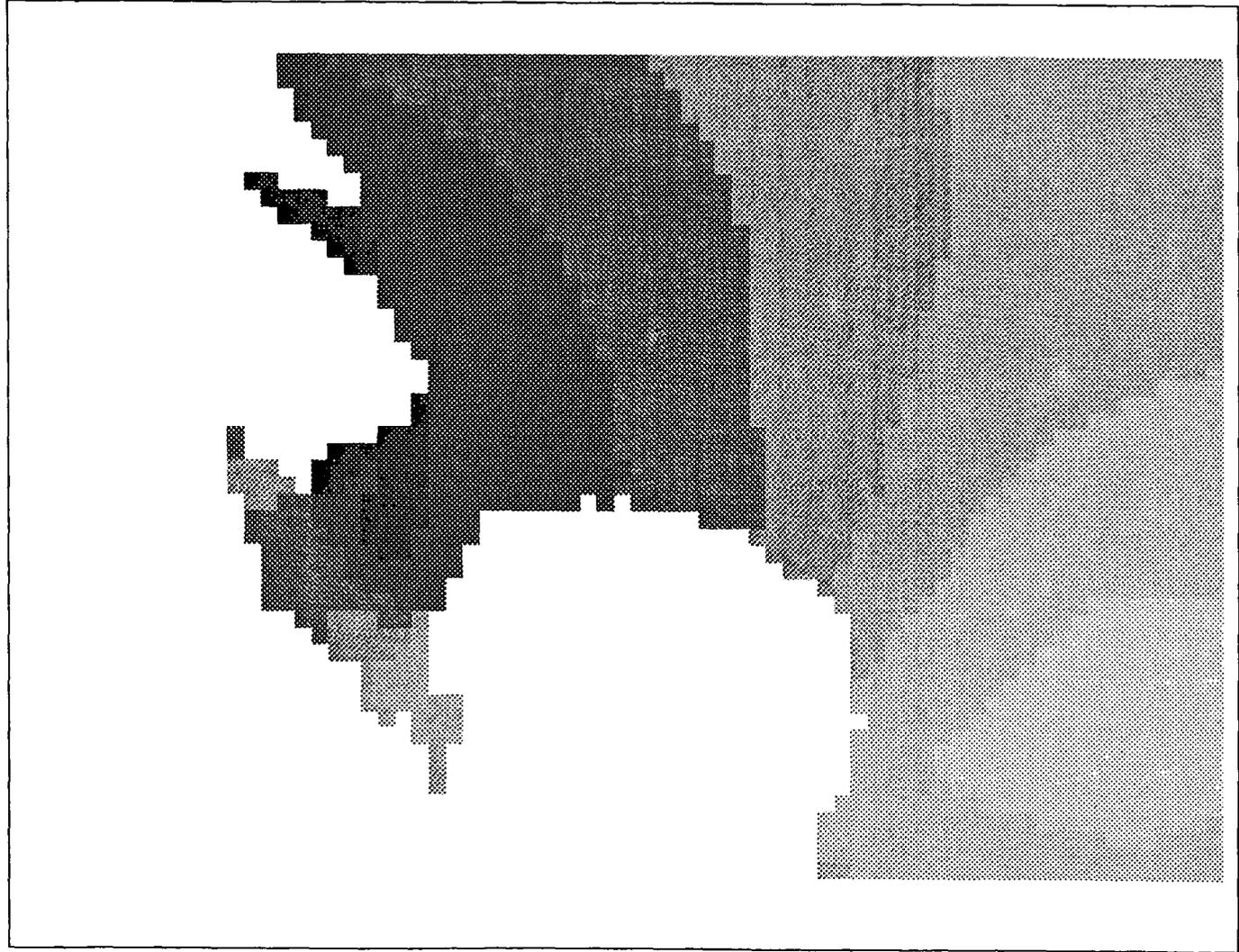
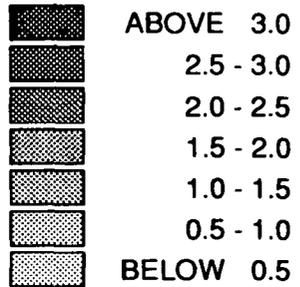


Figure 6.66. EC3 Model Histogram: 4,000 Years B.P. Coastline Simulation with data from Table 6.5.

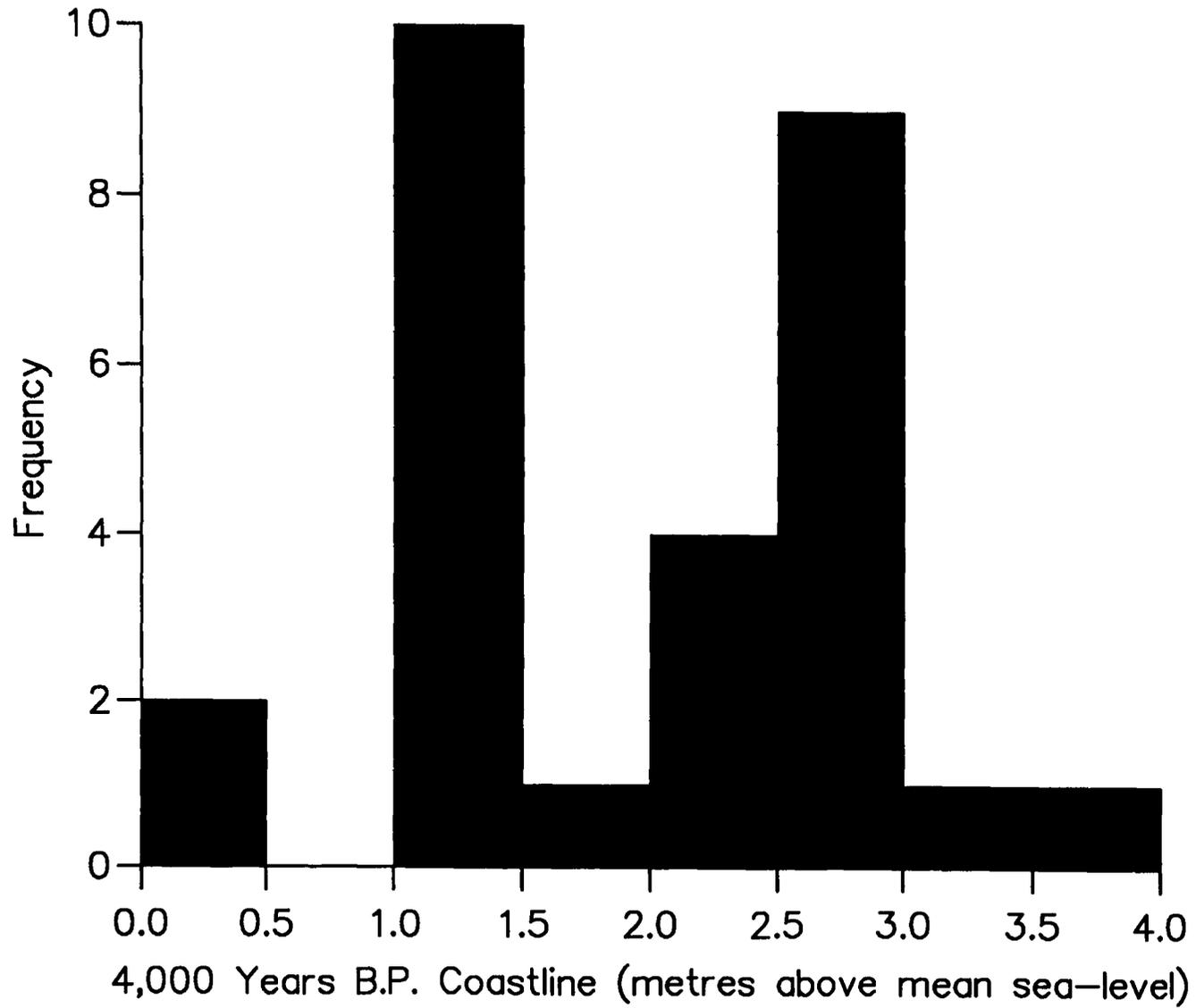


Figure 6.67. EAST COAST 3 MODEL 5,000 Years B.P. Coastline

Maximum Tidal Altitudes Difference (m.)

68

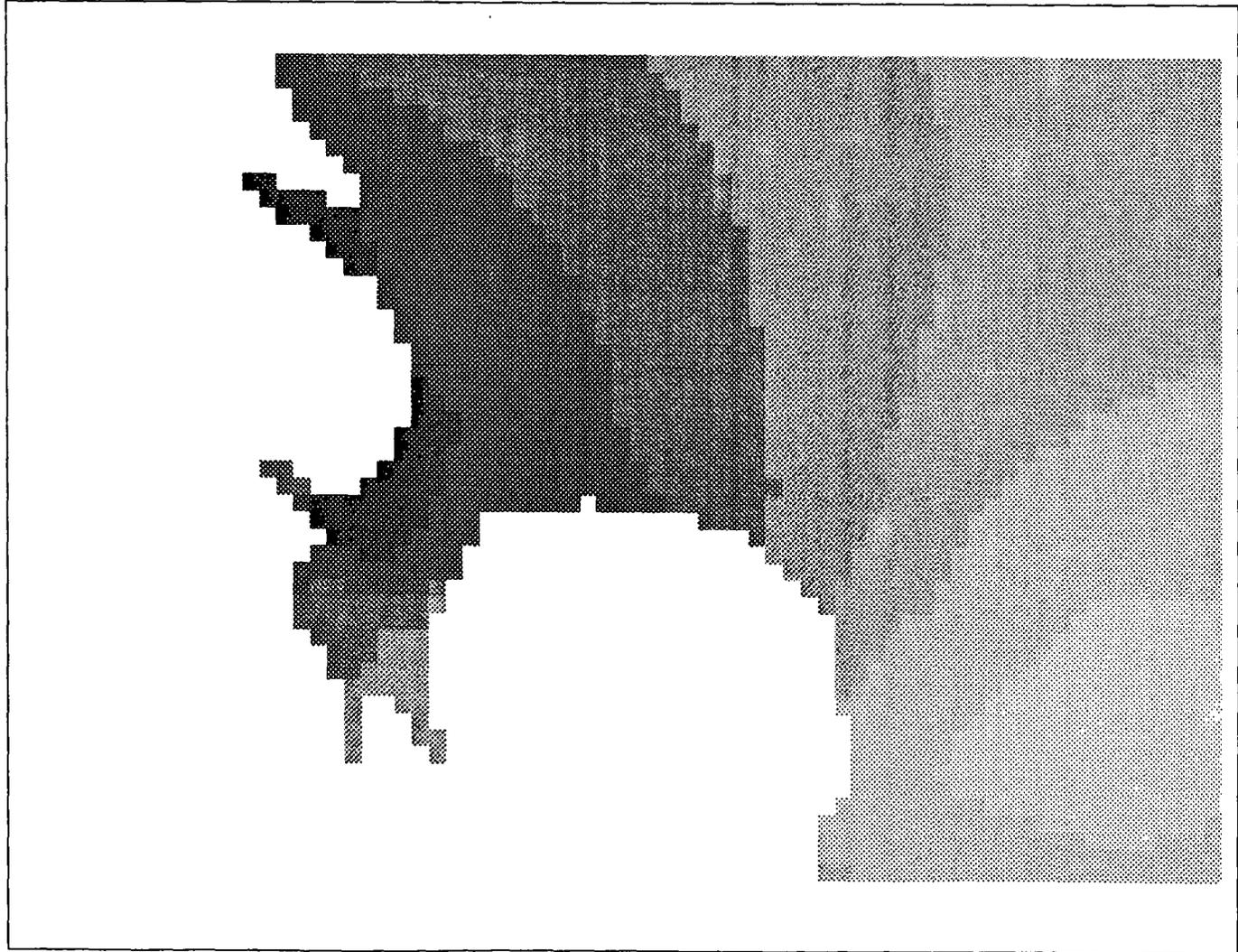
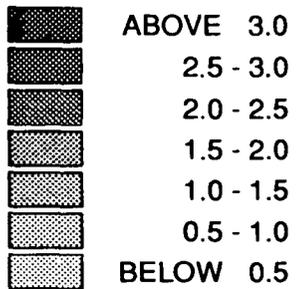


Figure 6.68. EC3 Model Histogram: 5,000 Years B.P. Coastline Simulation with data from

Table 6.5.

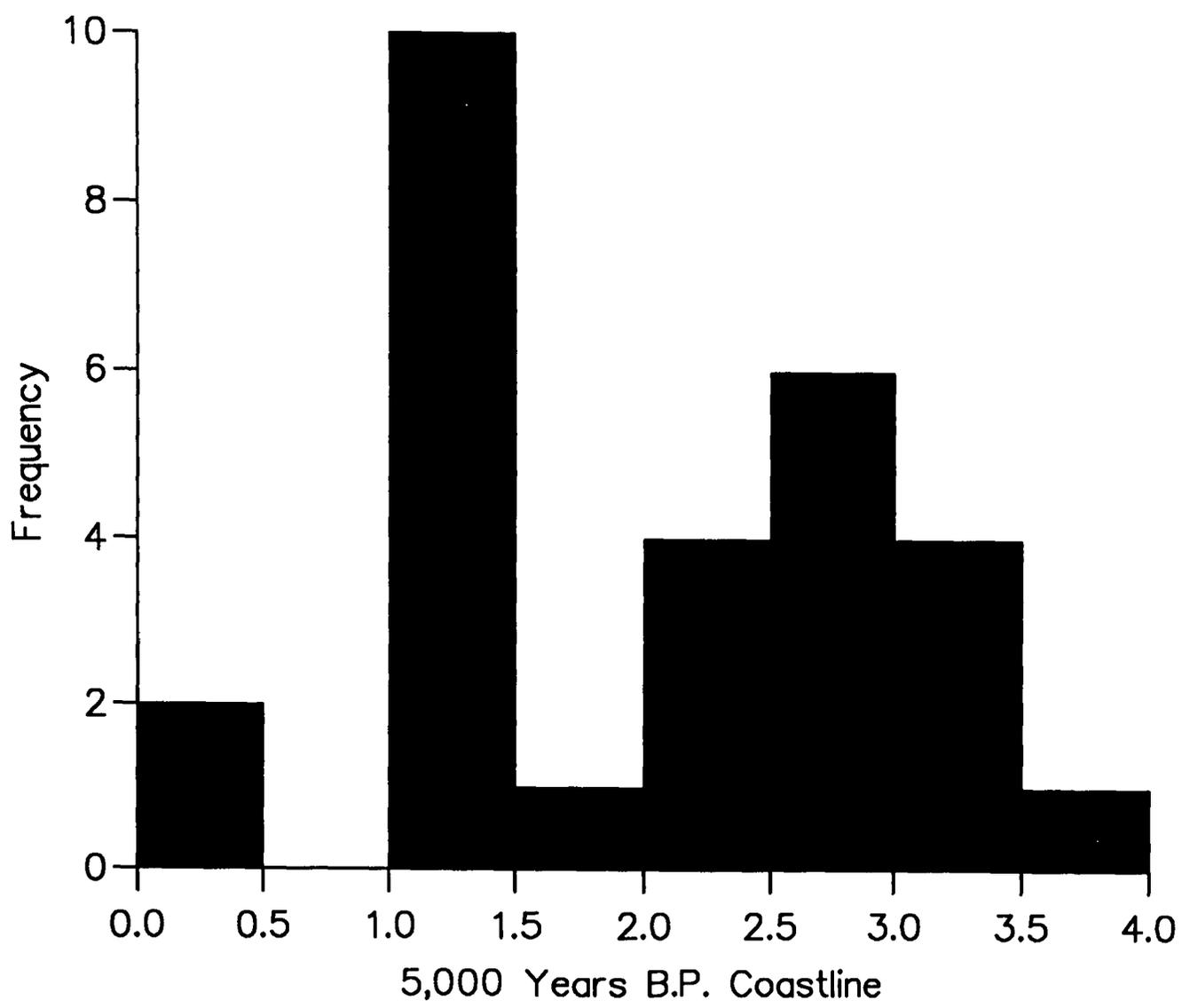
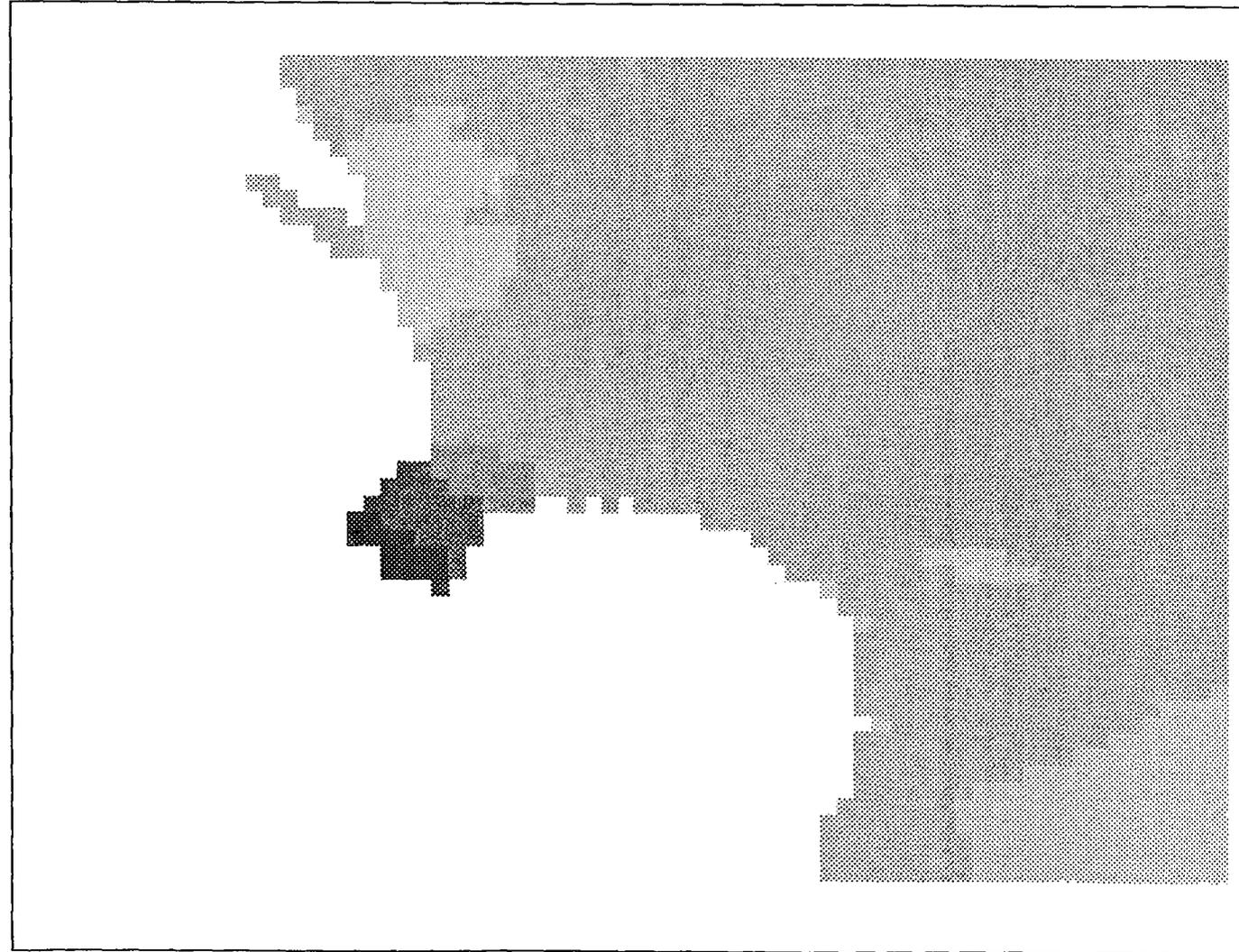


Figure 6.69. EAST COAST 3 MODEL

Maximum Tidal Altitudes Difference (m.)

Present Sea-Level Minus 3,000 Years B.P. Coastline



EAST COAST 3 MODEL

Maximum Tidal Altitudes Difference (m.)
Present Sea-Level Minus 4,000 Years B.P. Coastline

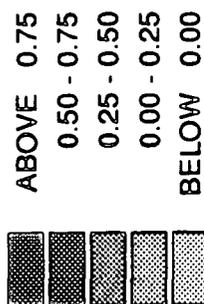
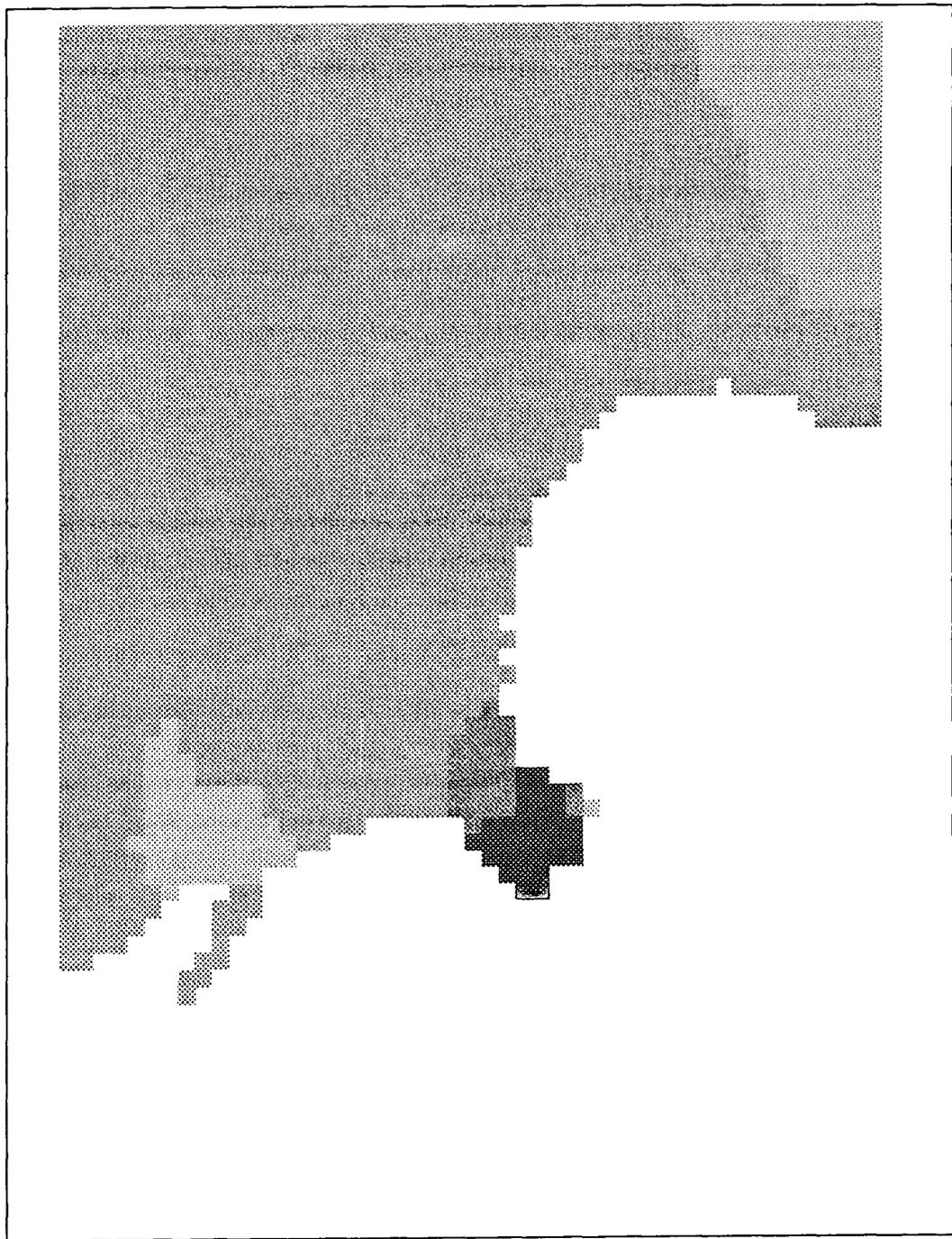


Figure 6.71. EAST COAST 3 MODEL

Maximum Tidal Altitudes Difference (m.)

Present Sea-Level Minus 5,000 Years B.P. Coastline

72

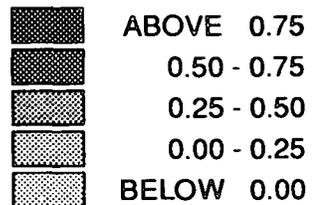


Figure 6.72. EC3 Model Scatter Plot: Present Sea-Level against Palaeocoastline Simulations with data from Table 6.5.

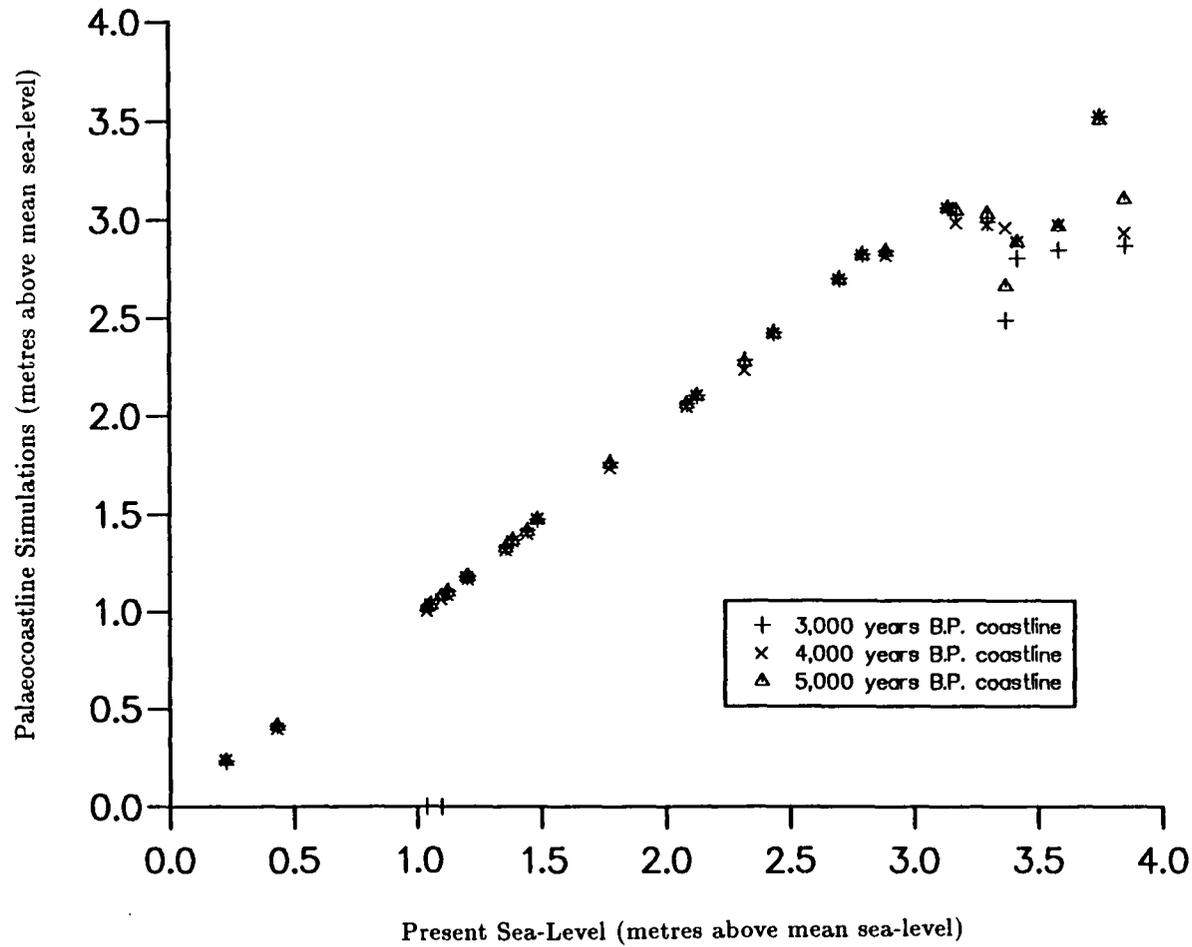


Figure 6.73. EAST COAST 3 MODEL 3,000 Years B.P. Coastline

Maximum Tidal Altitudes Difference (m.)
Minus 4,000 Years B.P. Coastline

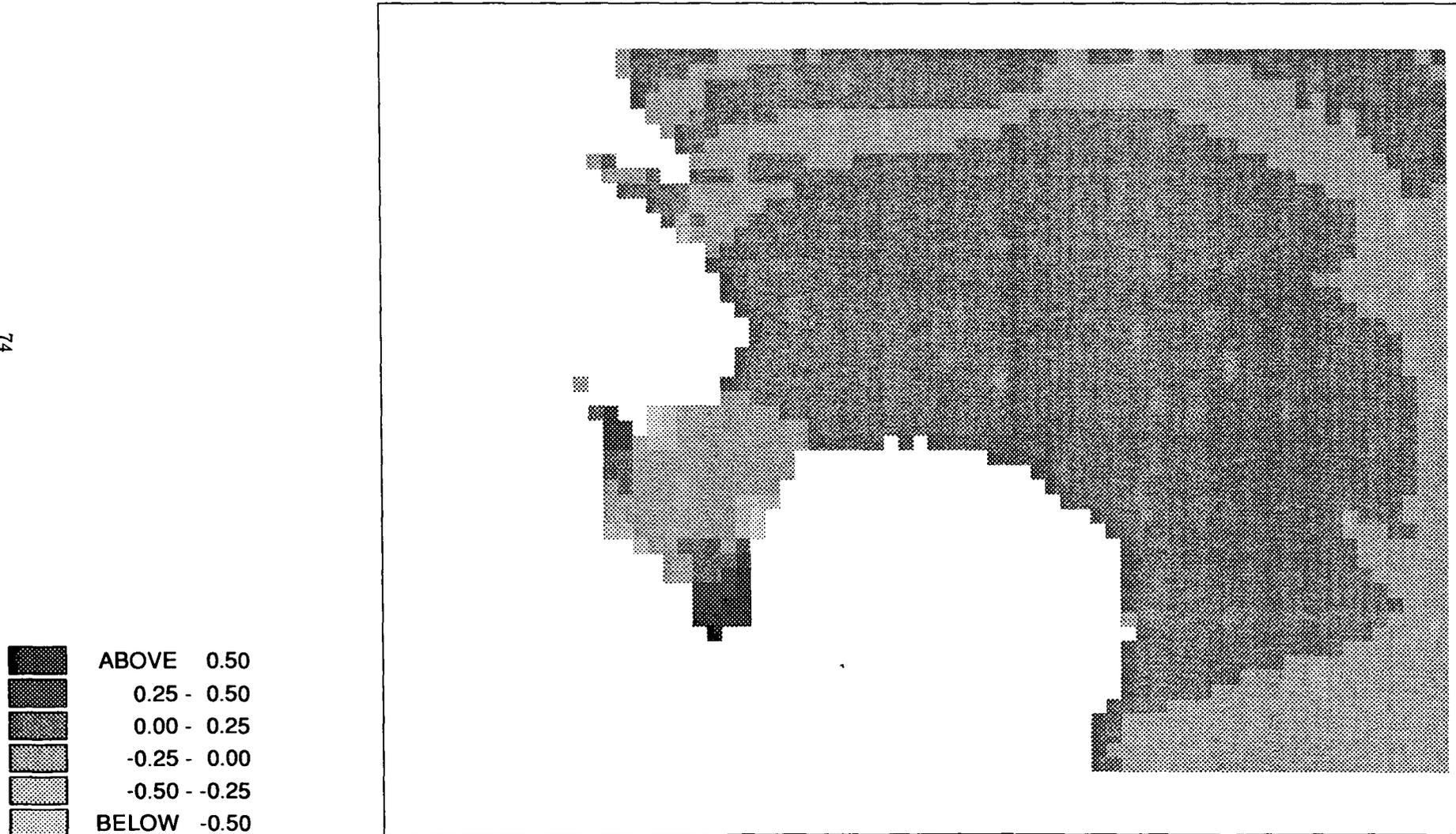


Figure 6.74. EAST COAST 3 MODEL 4,000 Years B.P. Coastline

Maximum Tidal Altitudes Difference (m.)
Minus 5,000 Years B.P. Coastline

75

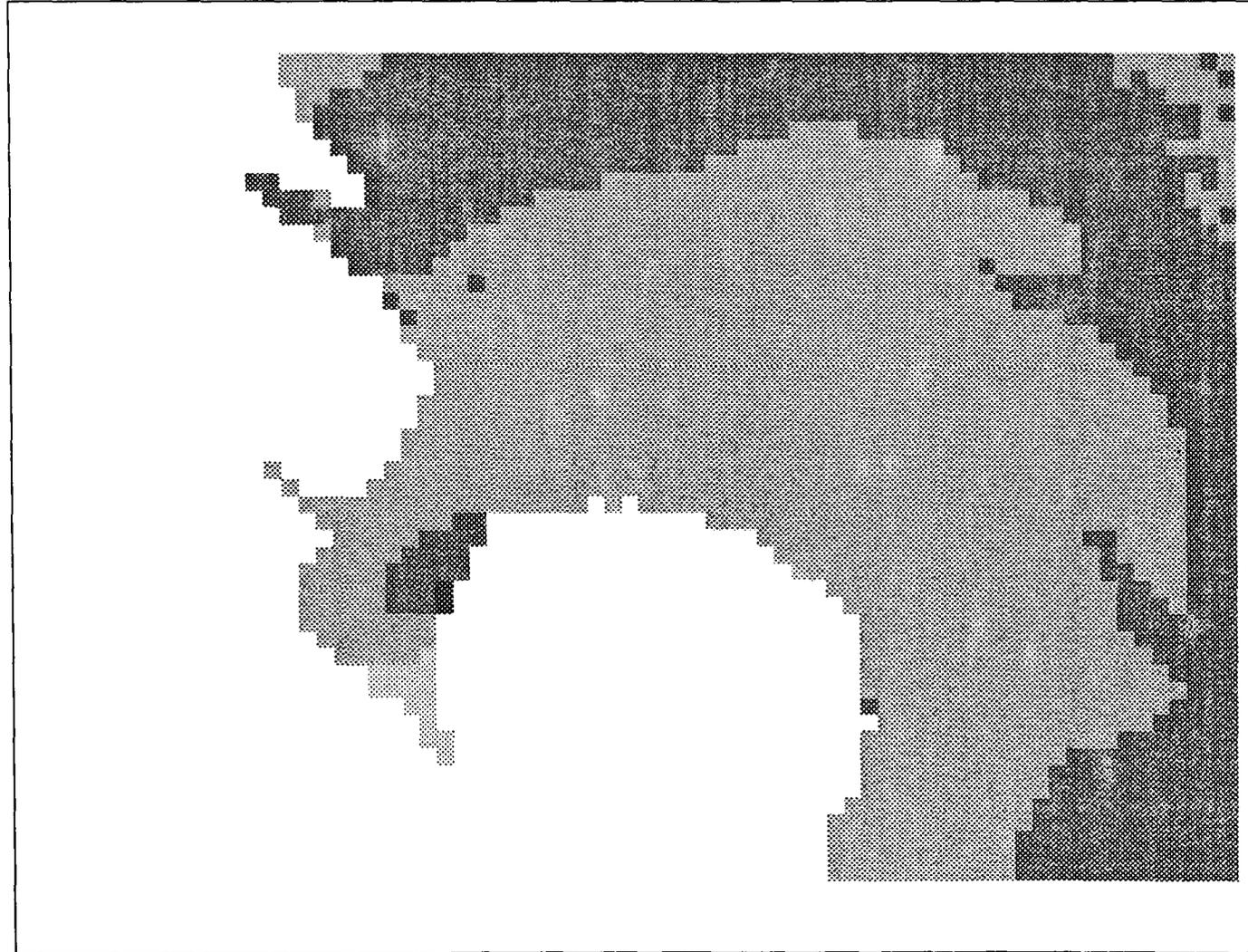
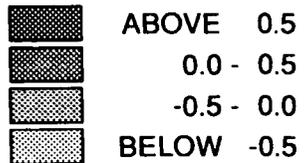


Figure 6.75. LIVERPOOL BAY MODEL 5,000 Years B.P. Coastline

Maximum Tidal Heights (m.)

76

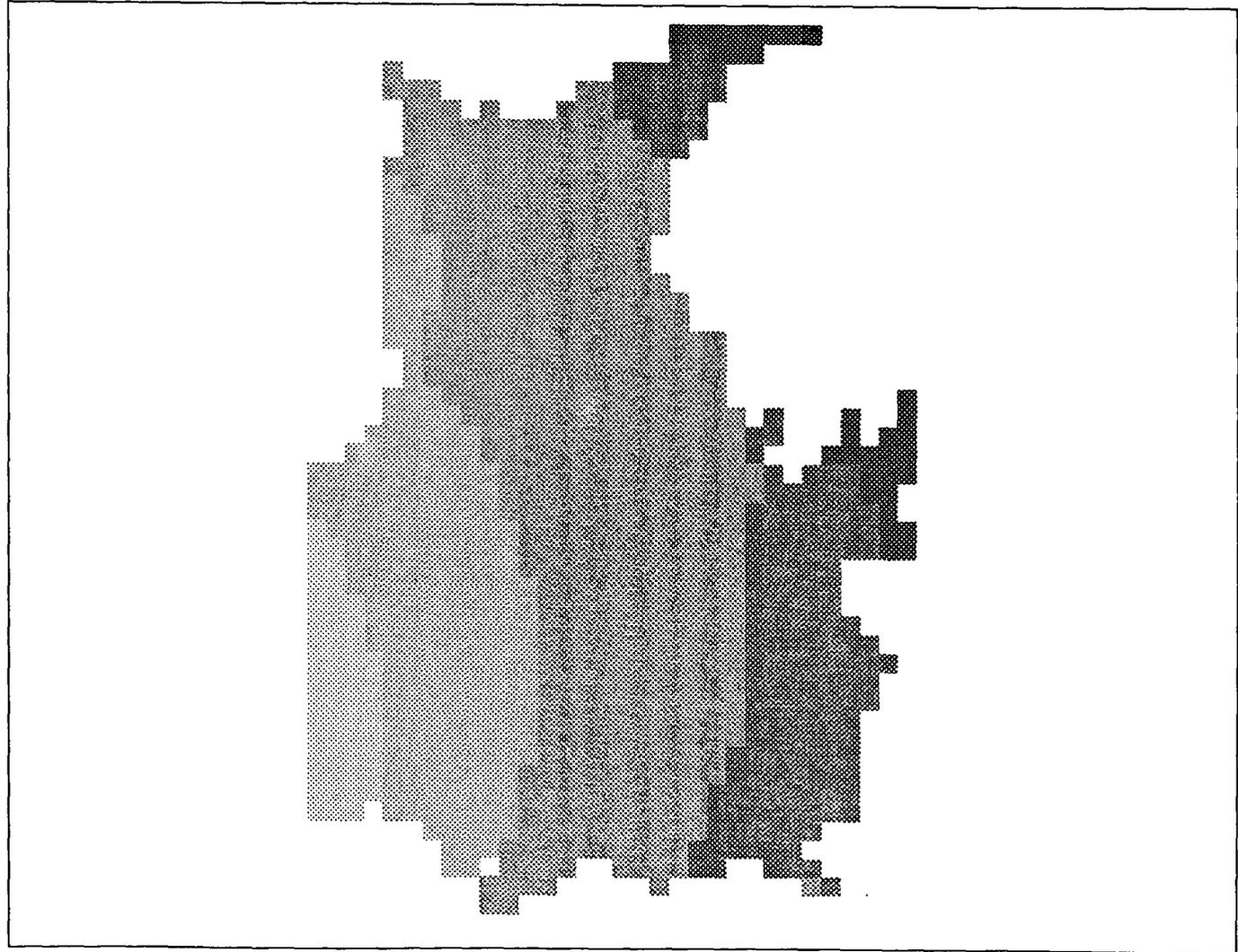
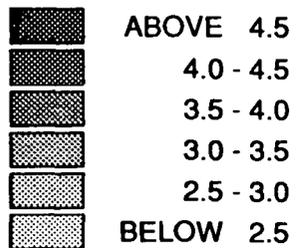


Figure 6.76. LBM Model Histogram: 5,000 Years B.P. Coastline Simulation with data from Table 6.9.

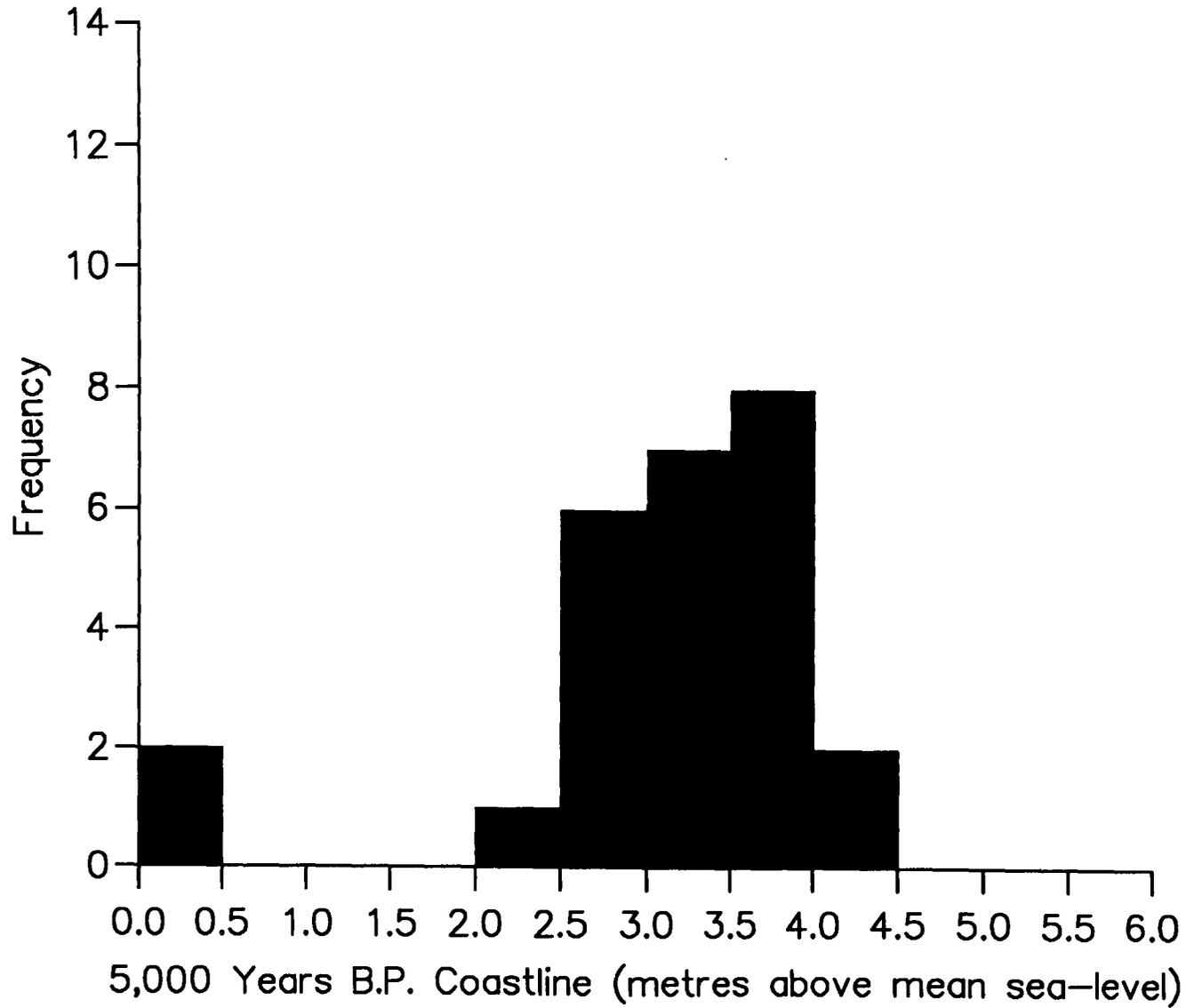


Figure 6.77. LIVERPOOL BAY MODEL 8,000 Years B.P. Coastline

Maximum Tidal Heights (m.)

78

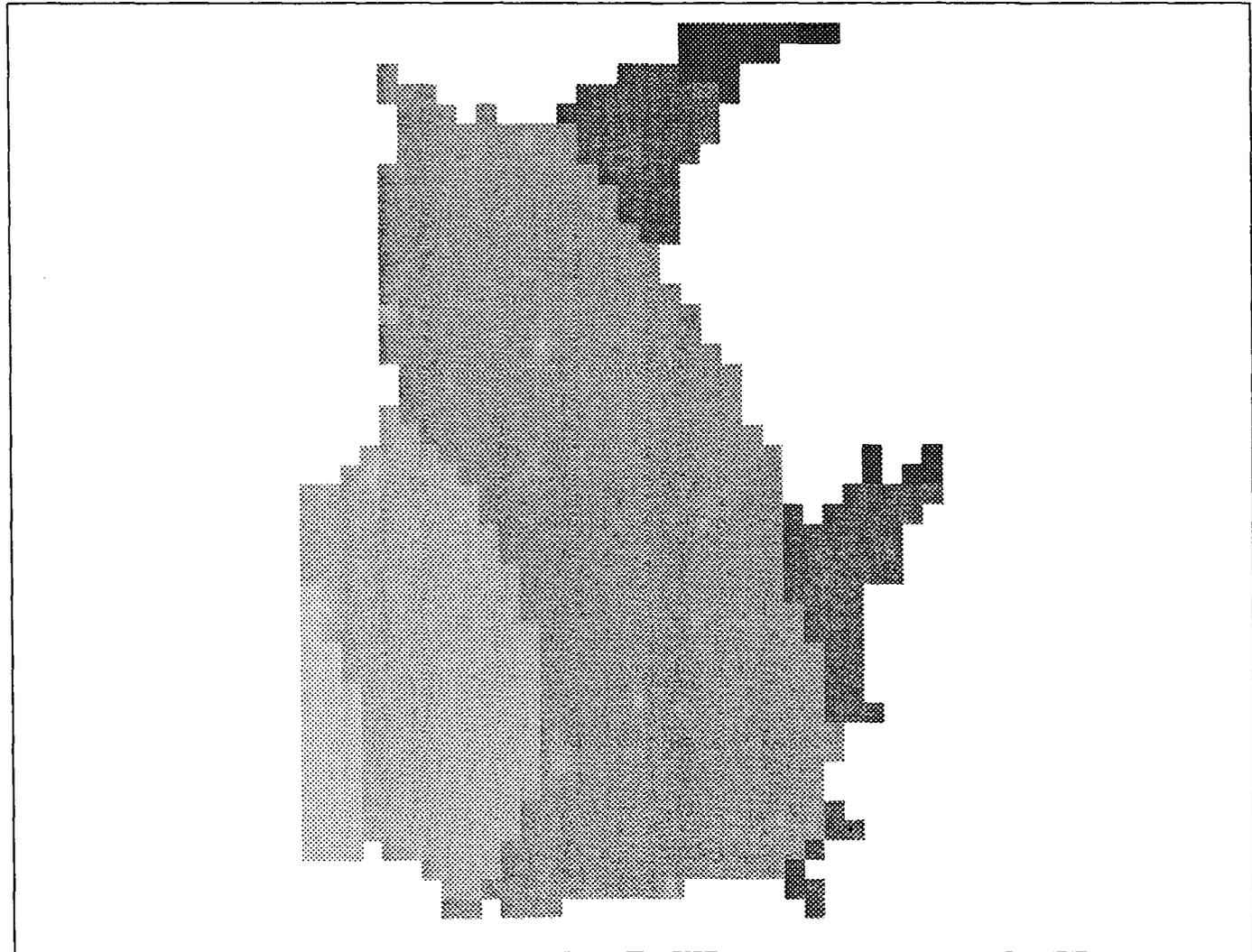
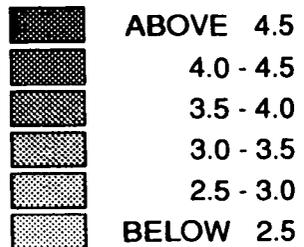


Figure 6.76. LBM Model Histogram: 8,000 Years B.P. Coastline Simulation with data from

Table 6.9.

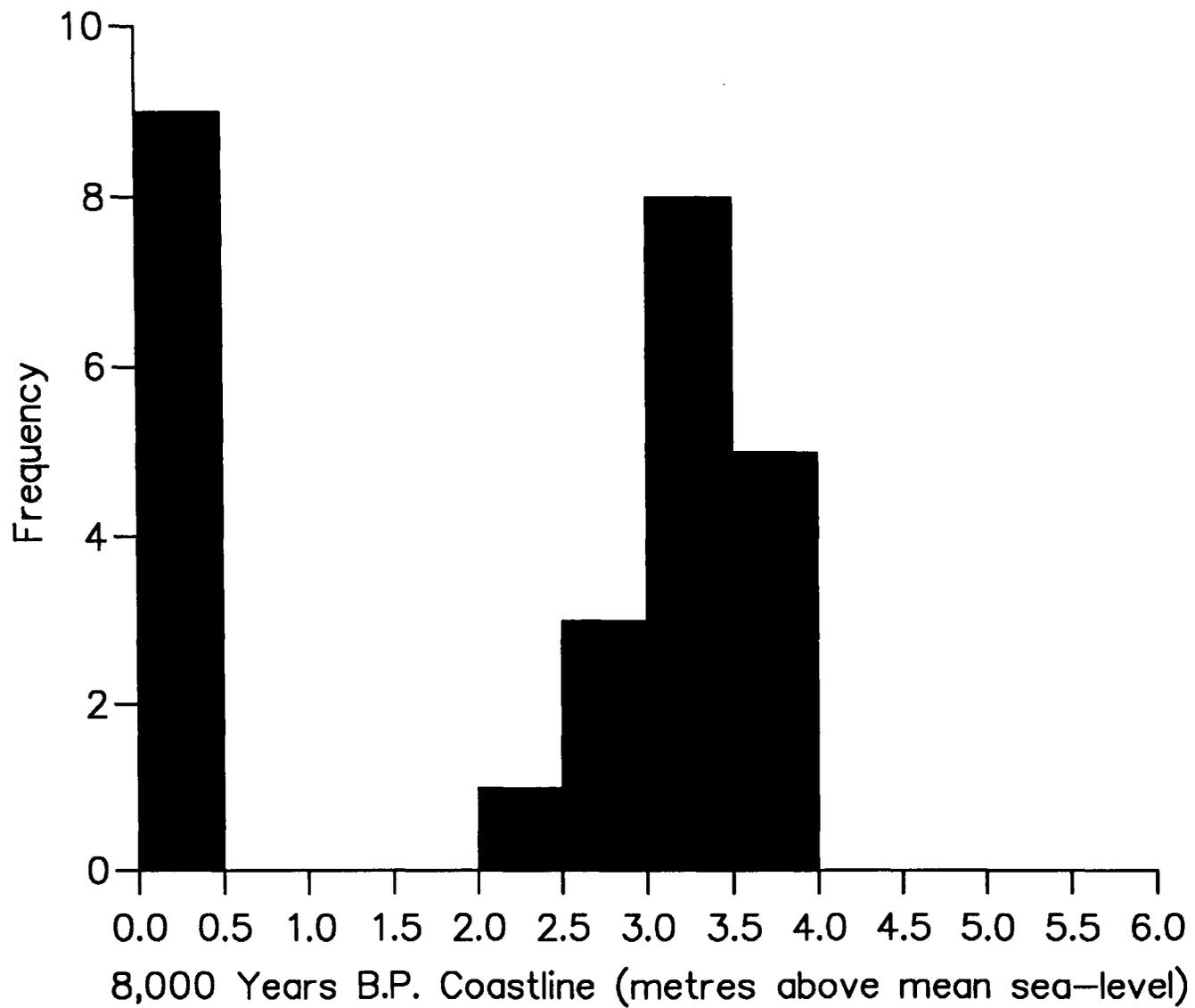


Figure 6.79. LIVERPOOL BAY MODEL Present Sea-Level Minus

5,000 Years B.P. Coastline

Maximum Tidal Heights (m.)

80

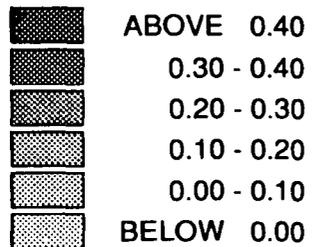


Figure 6.80. LIVERPOOL BAY MODEL Present Sea-Level Minus

8,000 Years B.P. Coastline

Maximum Tidal Heights (m.)

18

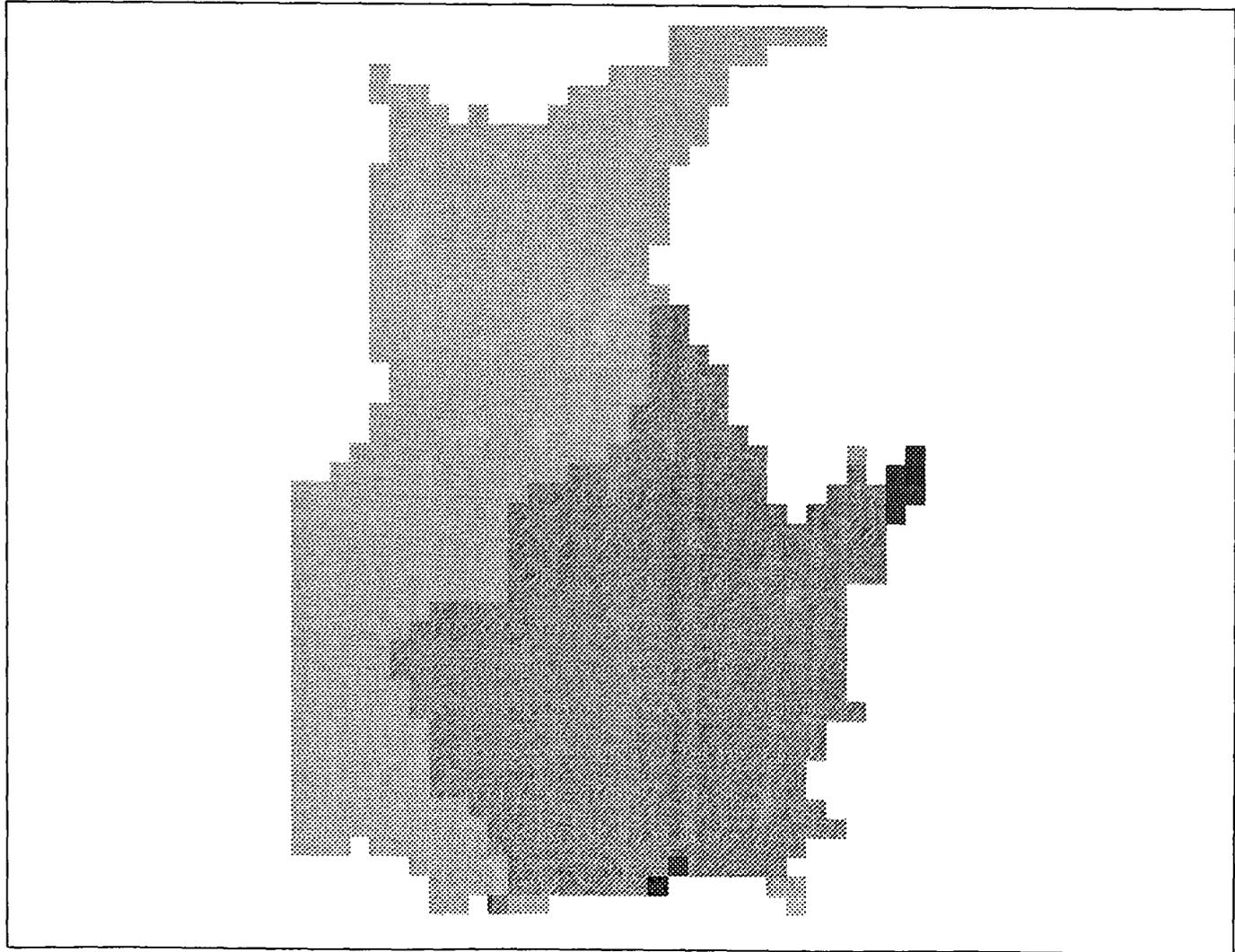
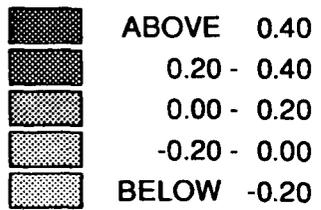


Figure 6.81. LBM Model Scatter Plot: Present Sea-Level against Palaeocoastline Simulations

with data from Table 6.9.

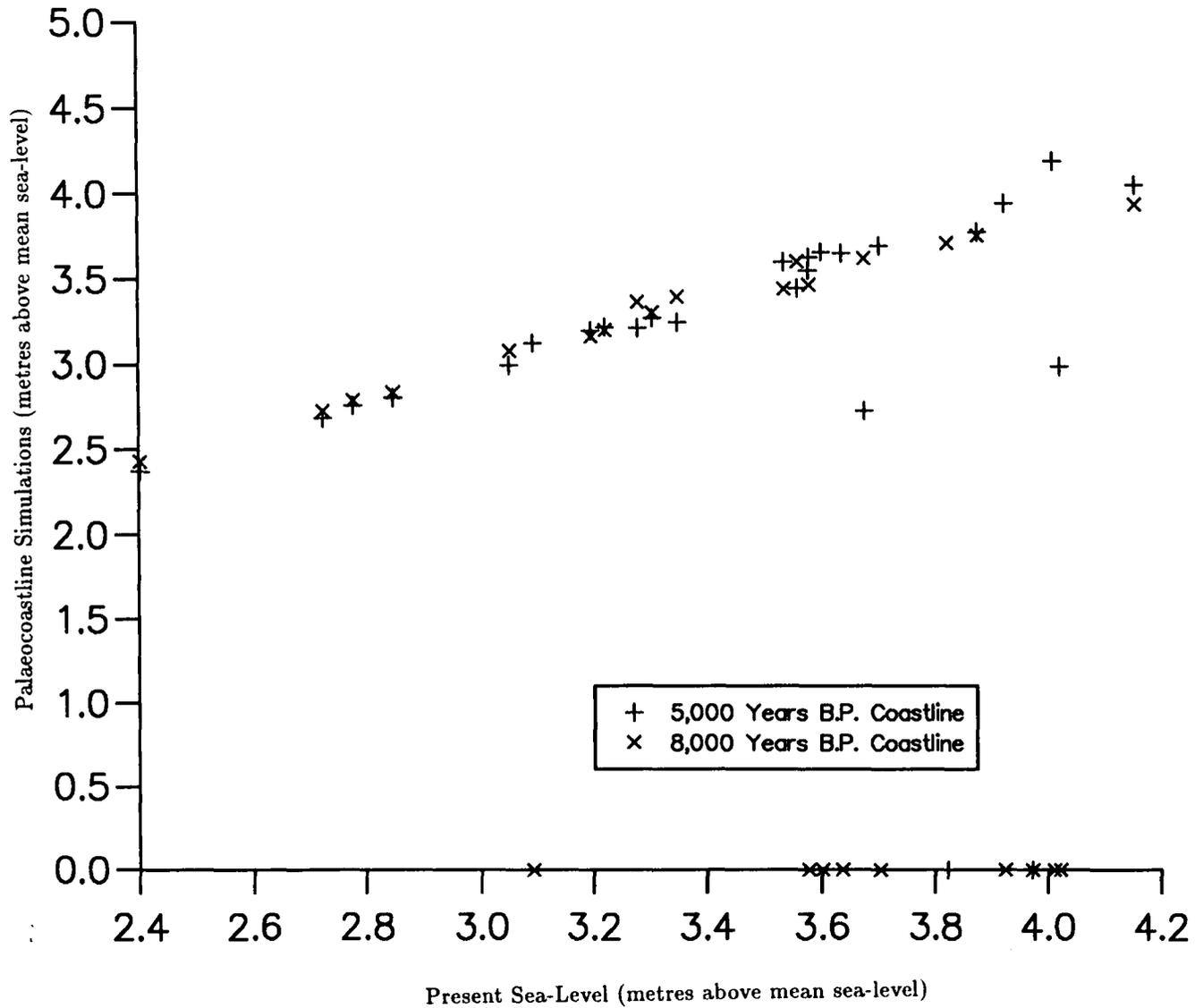


Figure 6.82. LIVERPOOL BAY MODEL 5,000 Years B.P. Coastline

Minus 8,000 Years B.P. Coastline

Maximum Tidal Heights (m.)

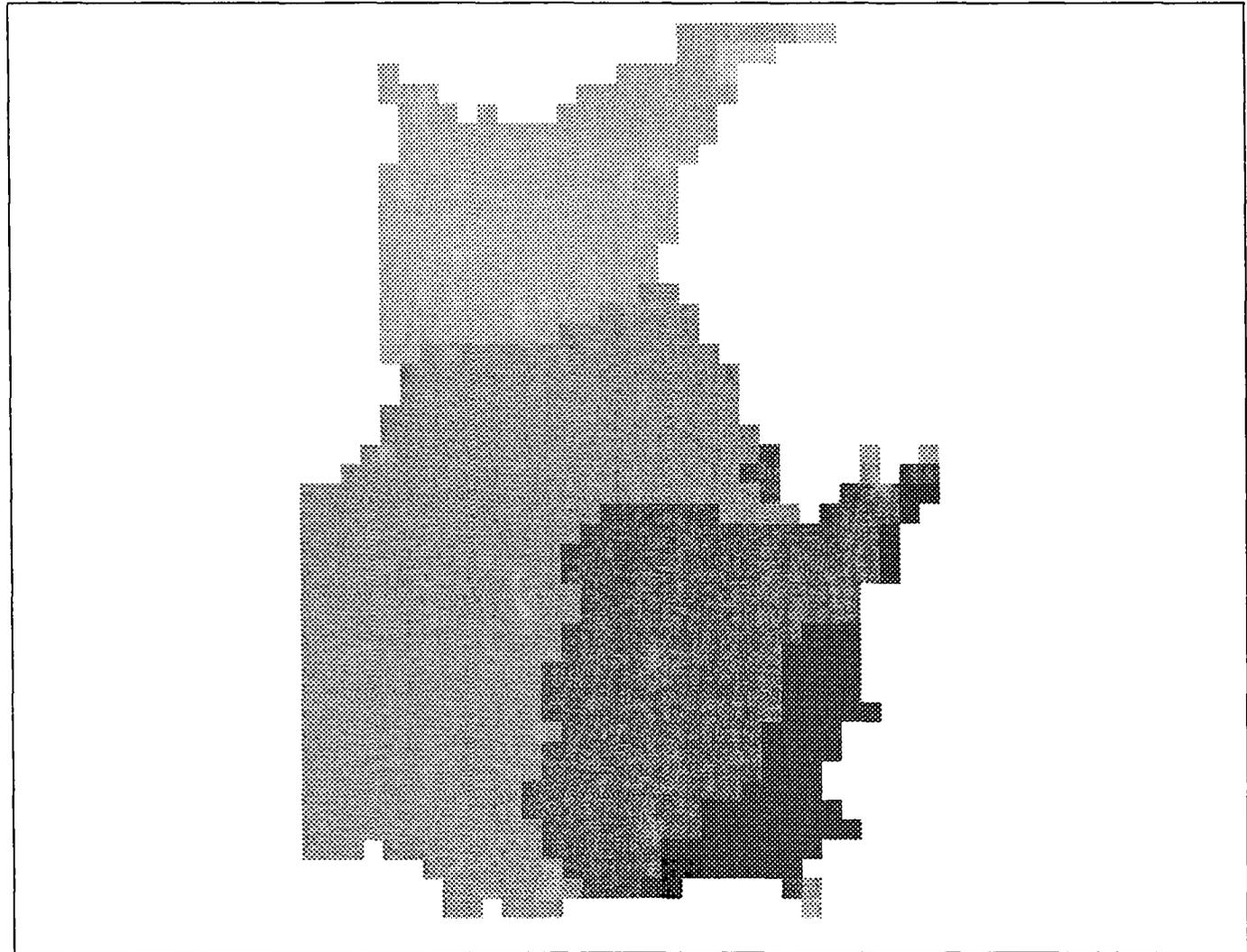
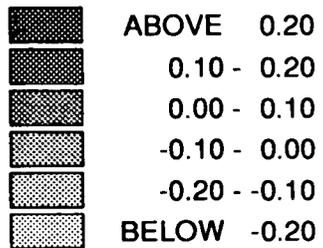


Figure 6.83. EAST COAST 3 MODEL

Maximum Tidal Altitudes (m.)
3,000 Years B.P.

84

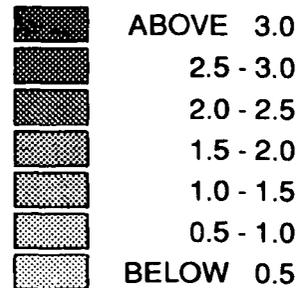


Figure 6.84. EAST COAST 3 MODEL

Maximum Tidal Altitudes Difference (m.)

Present Sea-Level Minus 3,000 Years B.P. Palaeogeography

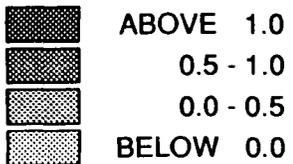
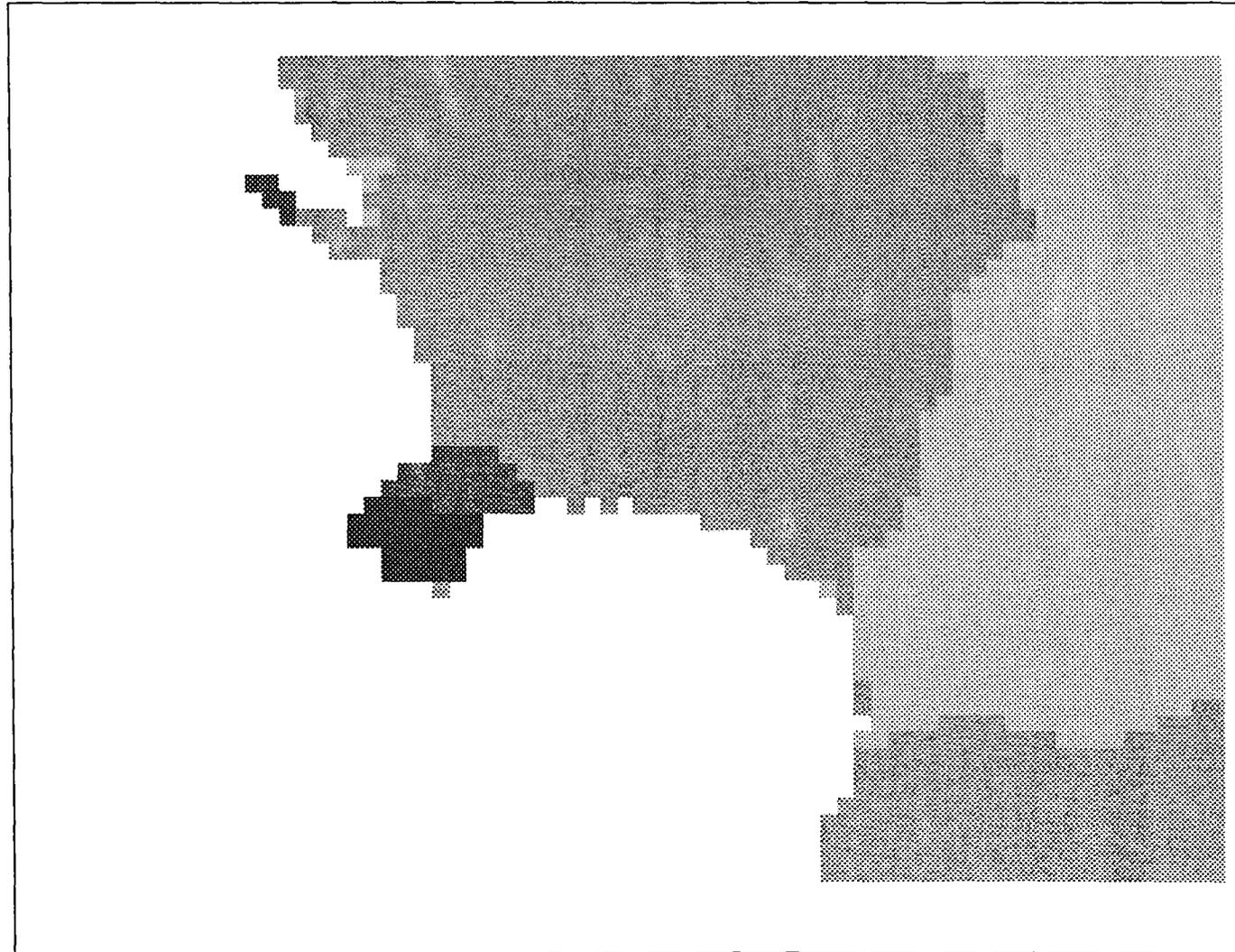


Figure 6.85. EC3 Model Histogram: 3,000 Years B.P. Palaeogeography Simulation with data from Table 6.5.

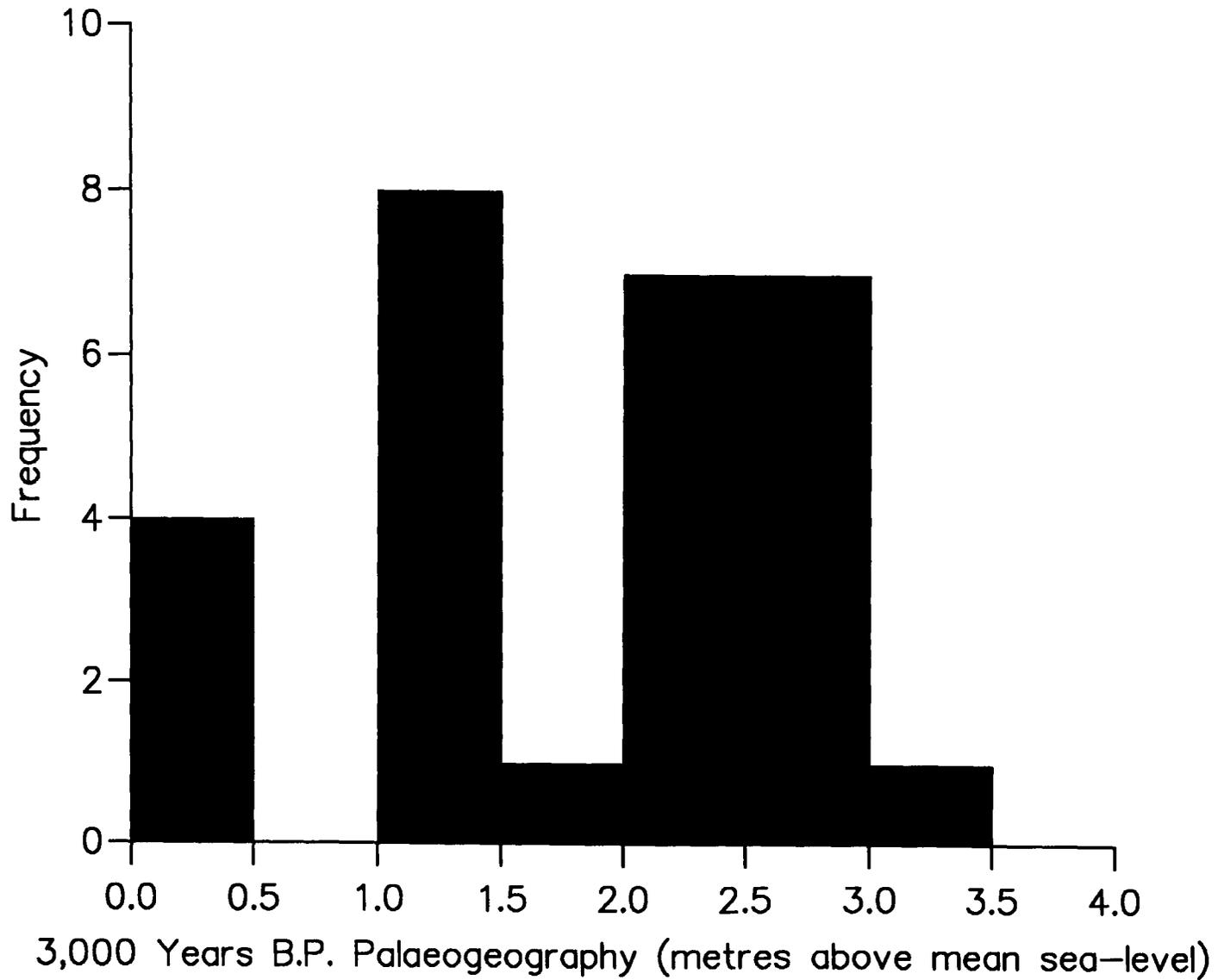


Figure 6.86. EC3 Model Scatter Plot: Present Sea-Level against Palaeogeographic Simulations with data from Table 6.5.

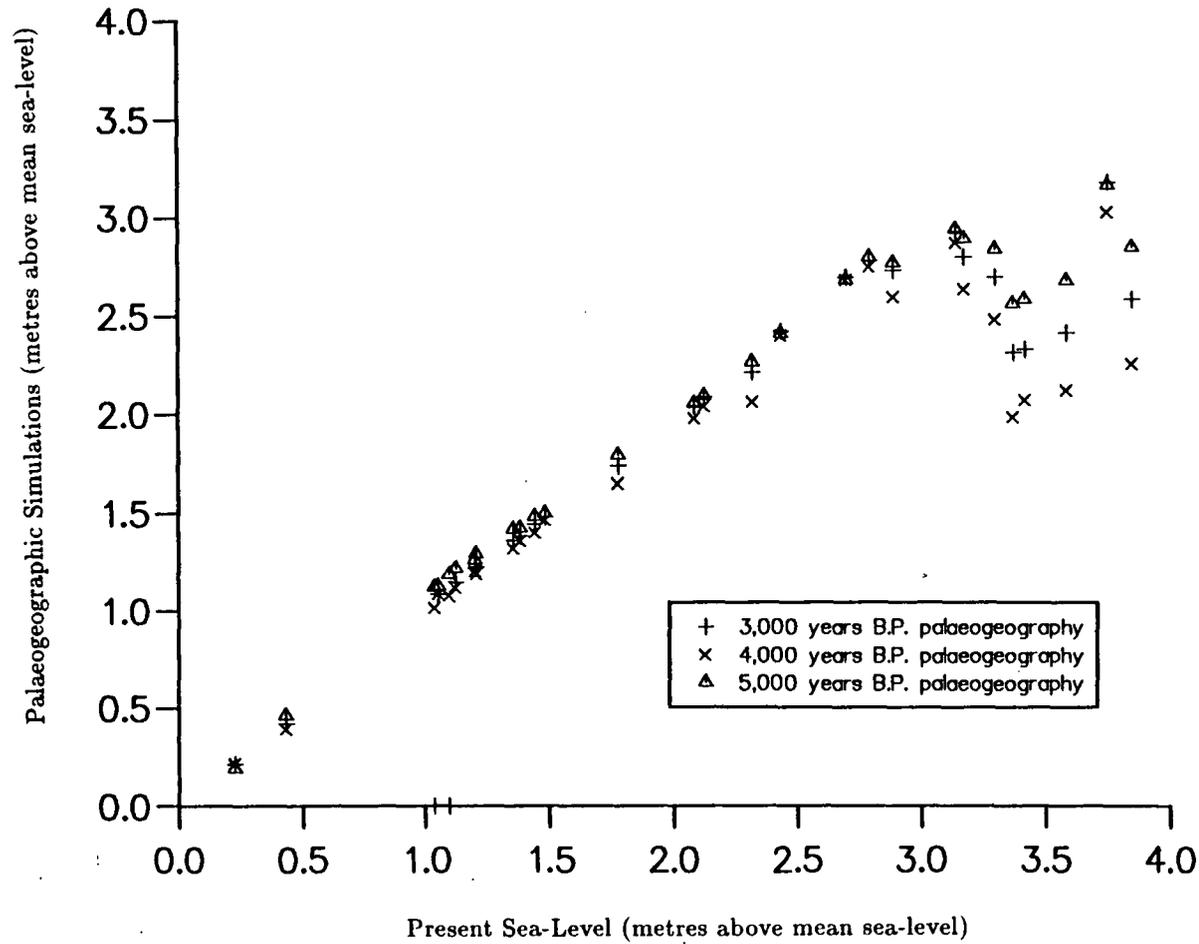


Figure 6.87. WASH MODEL 3,000 Years B.P. Palaeogeography

Maximum Tidal Heights (m.)

88

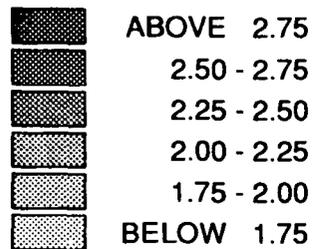


Figure 6.88. WASH MODEL Present Sea-Level Minus 3,000 Years B.P.

Palaeogeography

Maximum Tidal Heights (m.)

68

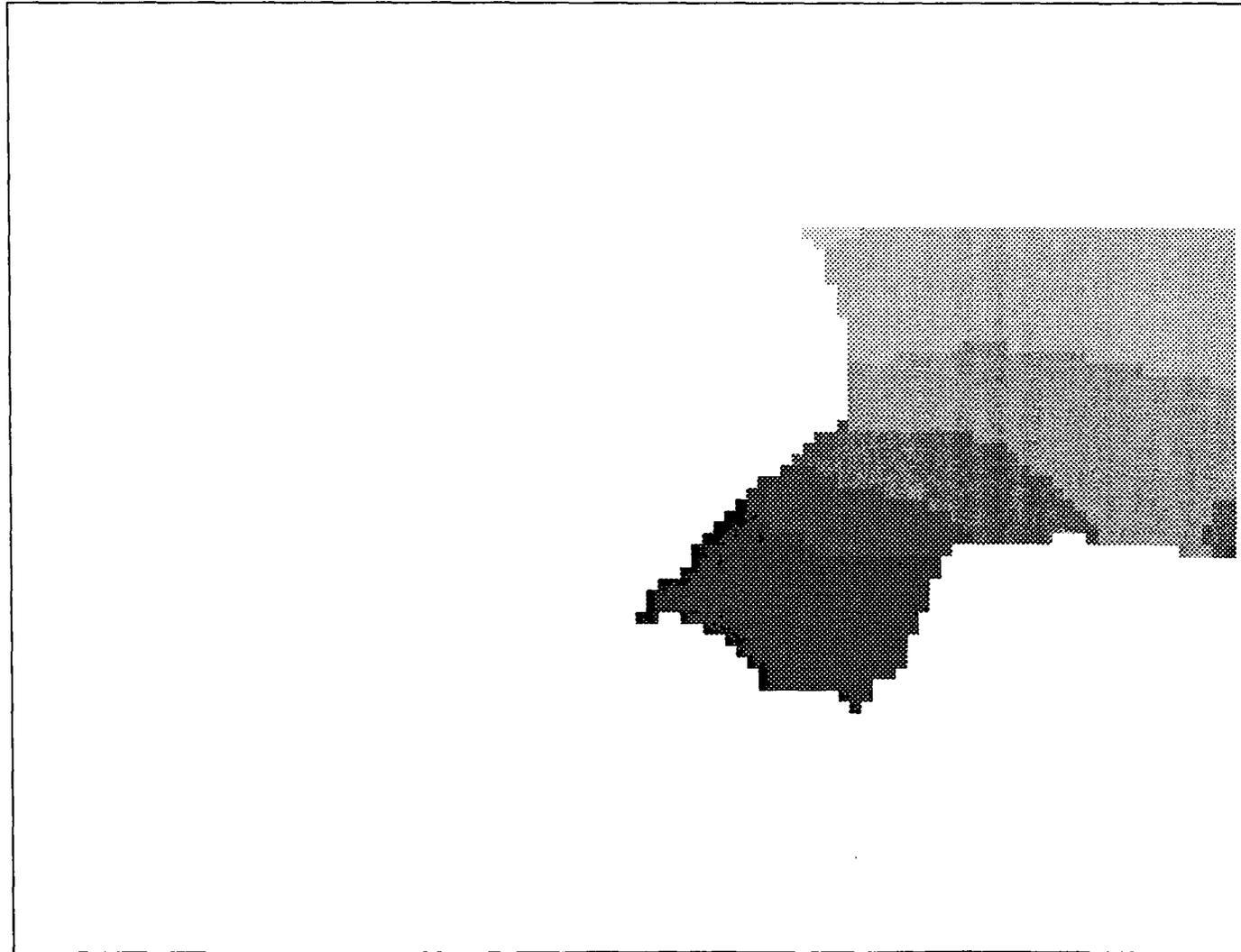
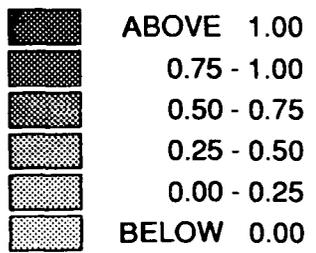


Figure 6.89. WASH Model Histogram: 3,000 Years B.P. Palaeogeography Simulation with data from Table 6.7.

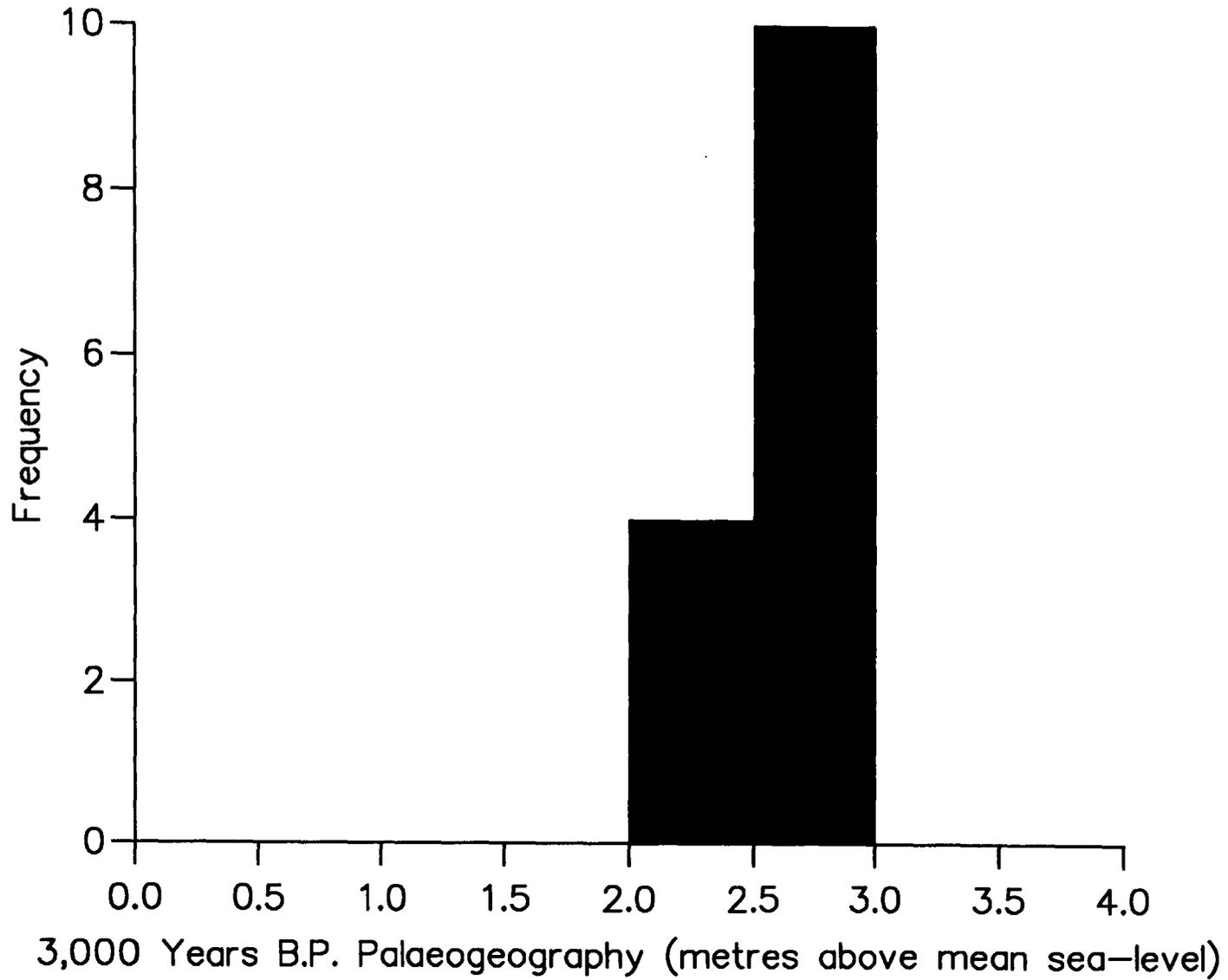


Figure 6.90. WASH Model Scatter Plot: Present Sea-Level against Palaeogeographic Simulations with data from Table 6.7.

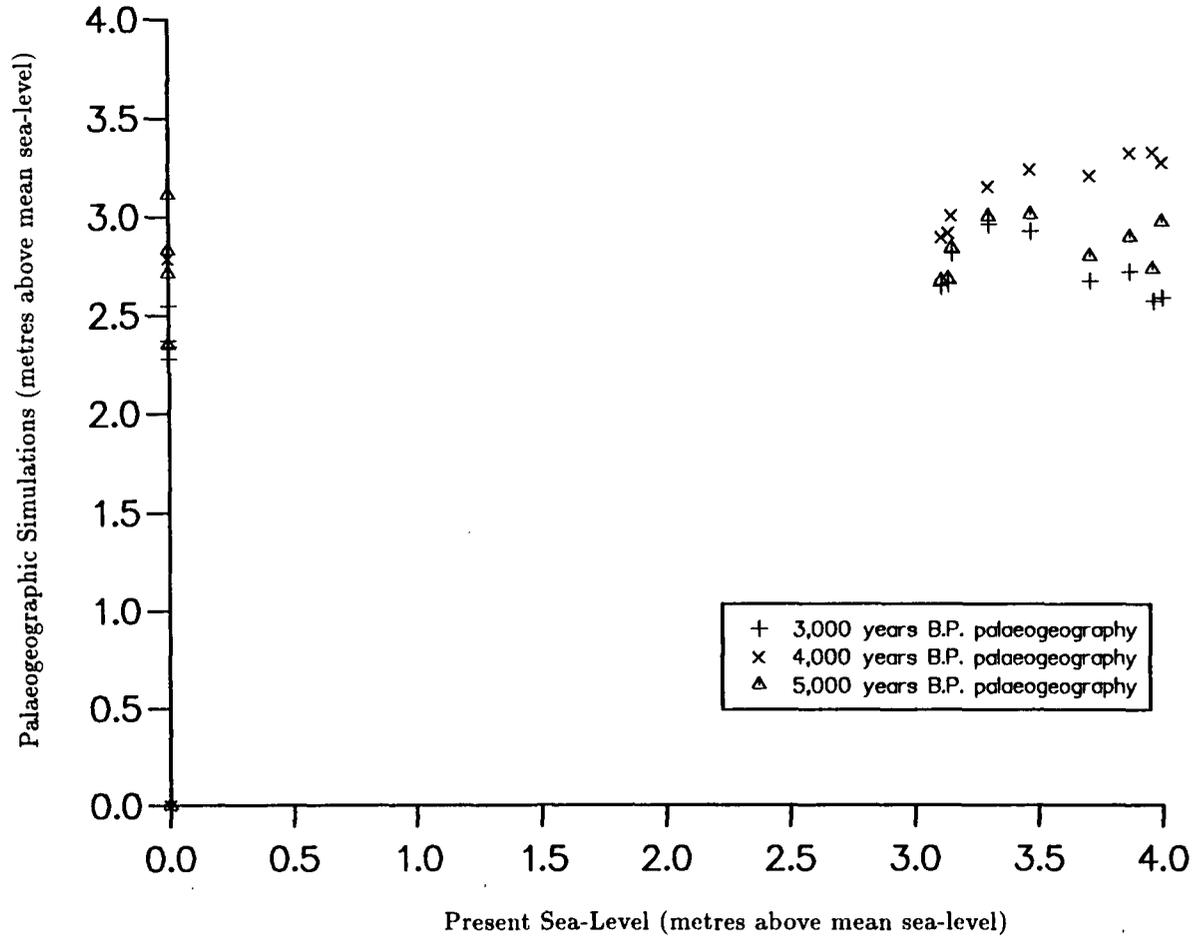


Figure 6.91. EAST COAST 3 MODEL

Maximum Tidal Altitudes (m.)
4,000 Years B.P.

92

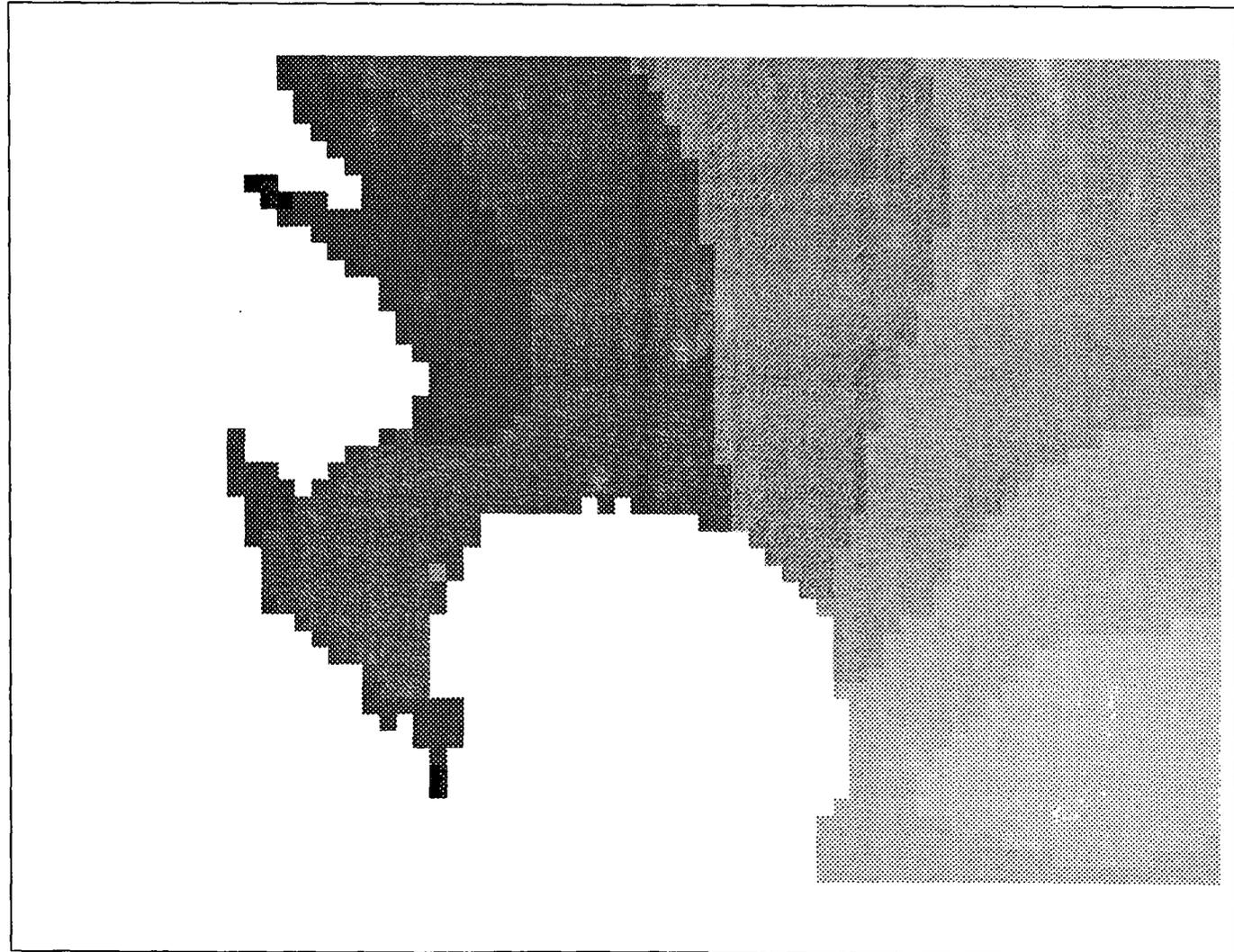
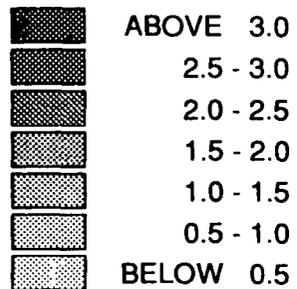


Figure 6.92. EAST COAST 3 MODEL

Maximum Tidal Altitudes Difference (m.)

Present Sea-Level Minus 4,000 Years B.P. Palaeogeography

93

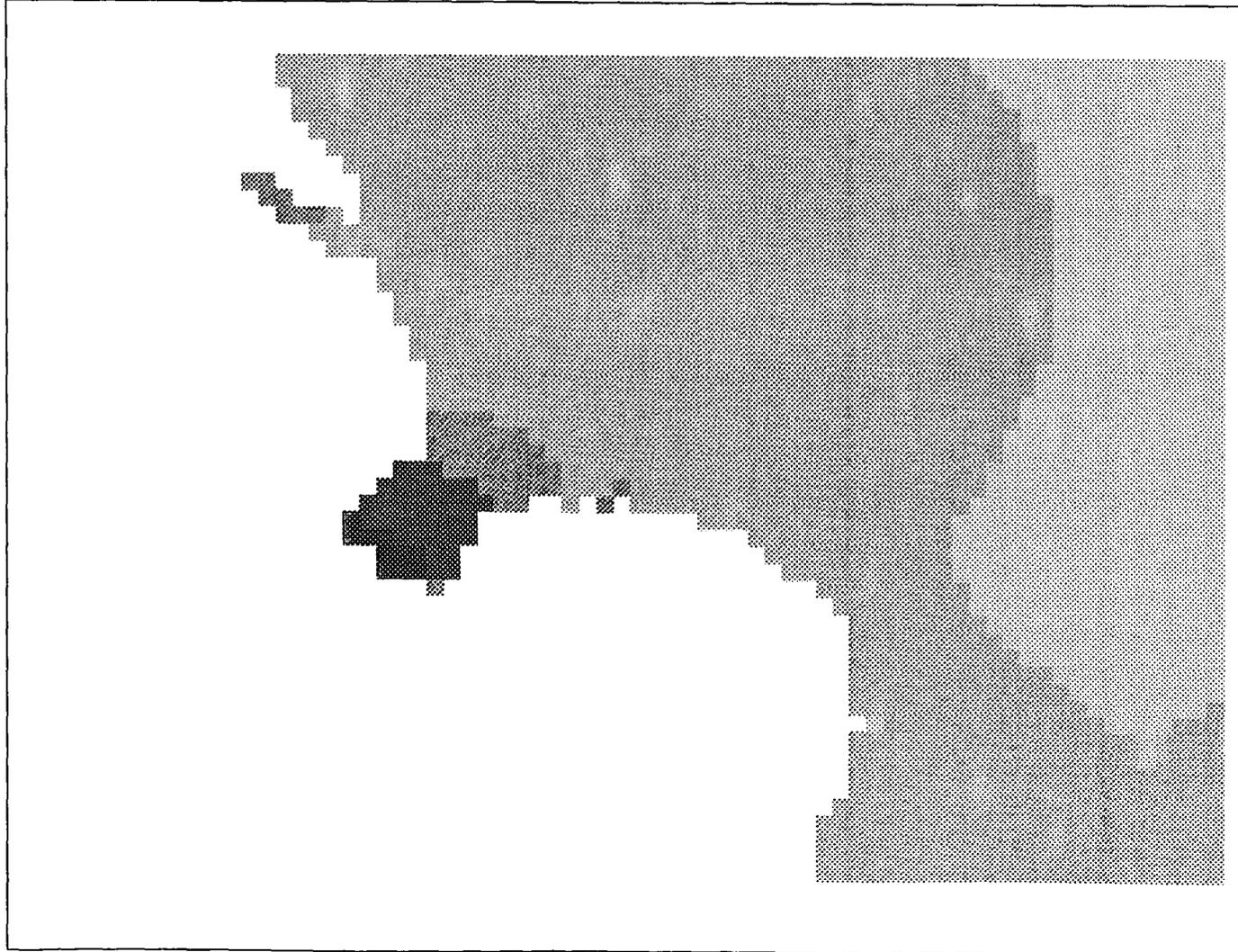
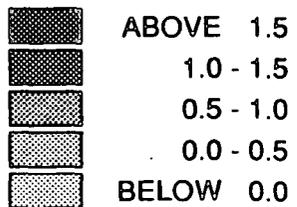


Figure 6.93. EAST COAST 3 MODEL

Maximum Tidal Altitudes (m.)

3,000 Years B.P. Minus 4,000 Years B.P. Palaeogeography

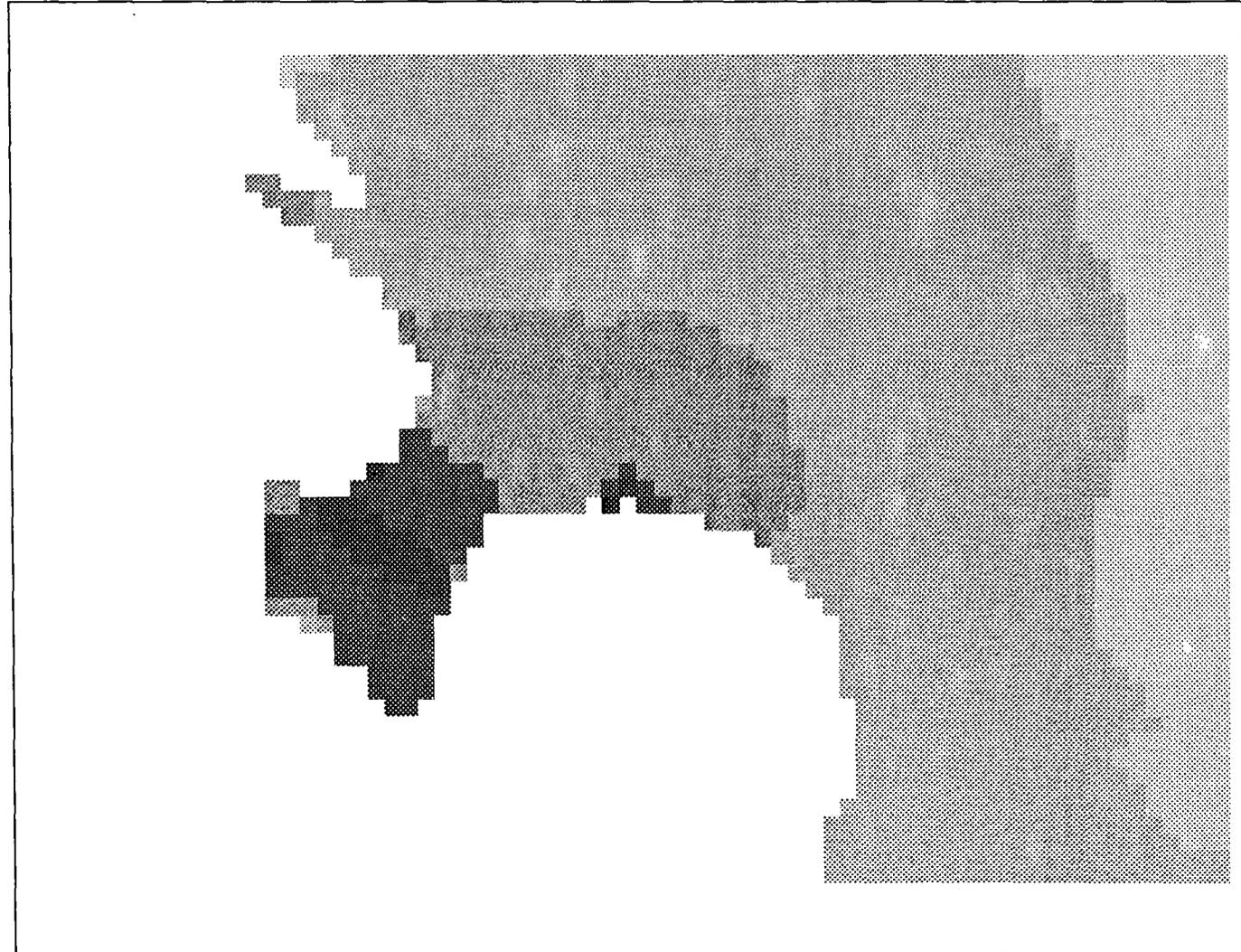


Figure 6.94. EC3 Model Histogram: 4,000 Years B.P. Palaeogeography Simulation with data

from Table 6.5.

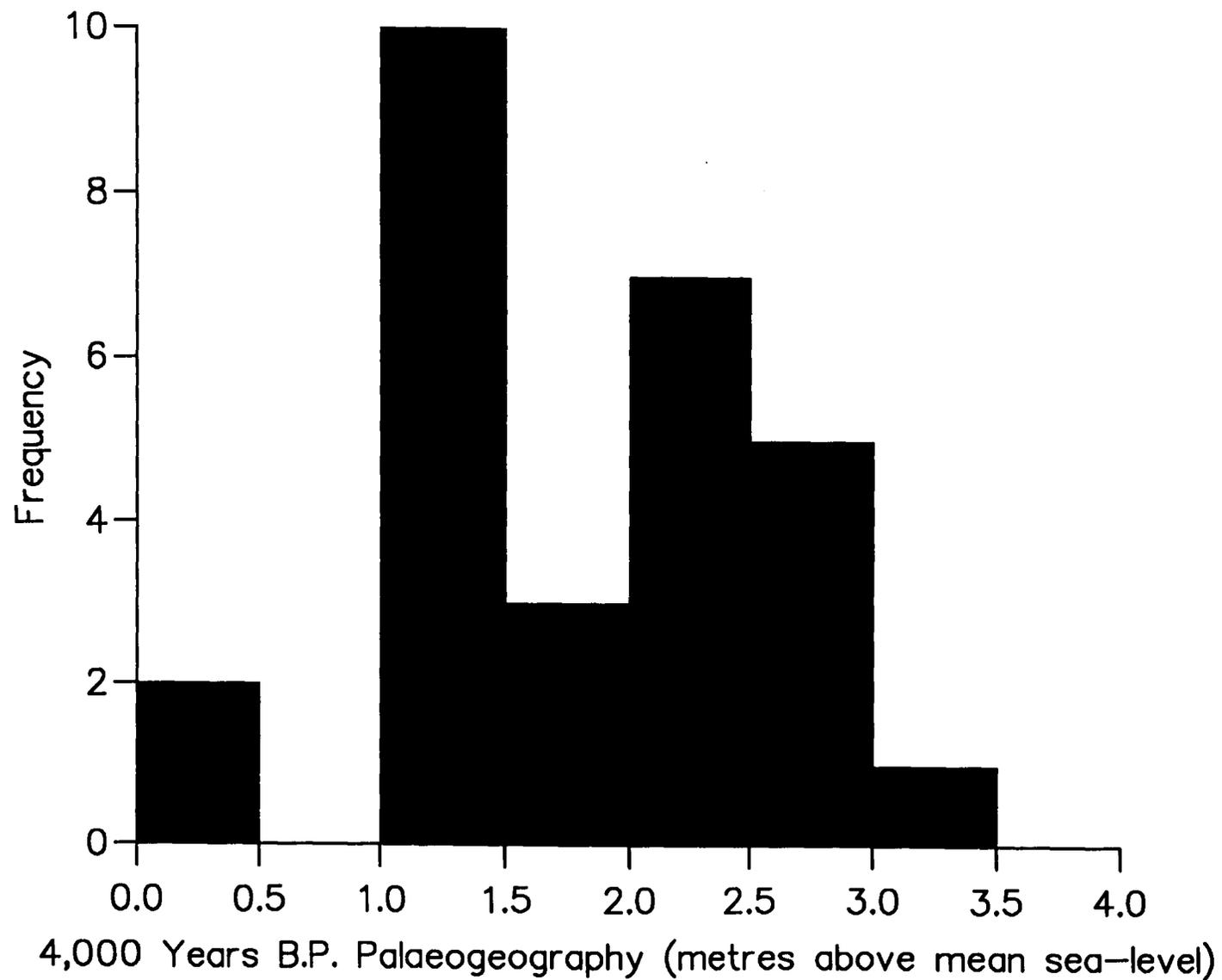


Figure 6.95. WASH MODEL 4,000 Years B.P. Palaeogeography

Maximum Tidal Heights (m.)

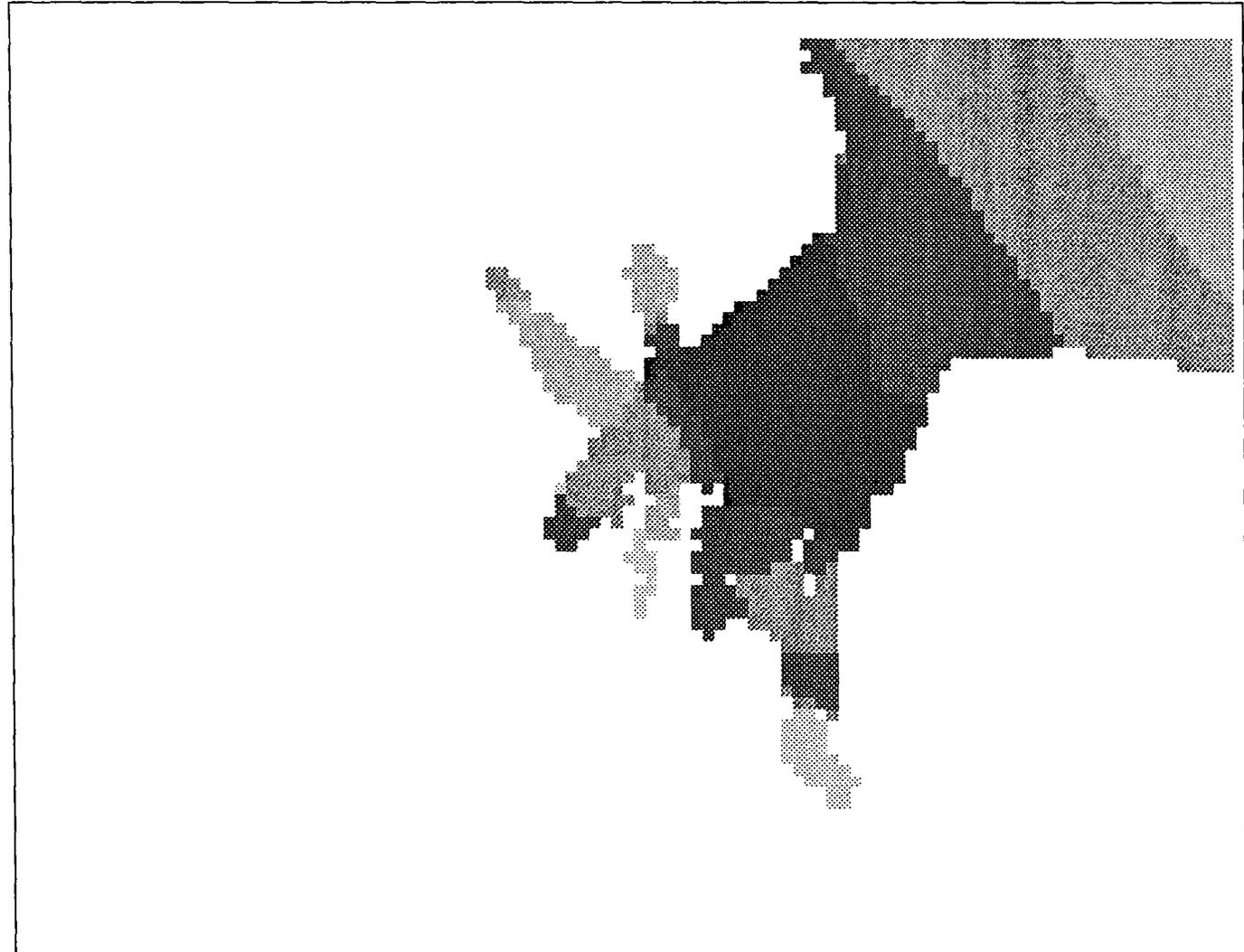


Figure 6.96. WASH MODEL Present Sea-Level Minus 4,000 Years B.P.

Palaeogeography

Maximum Tidal Heights (m.)

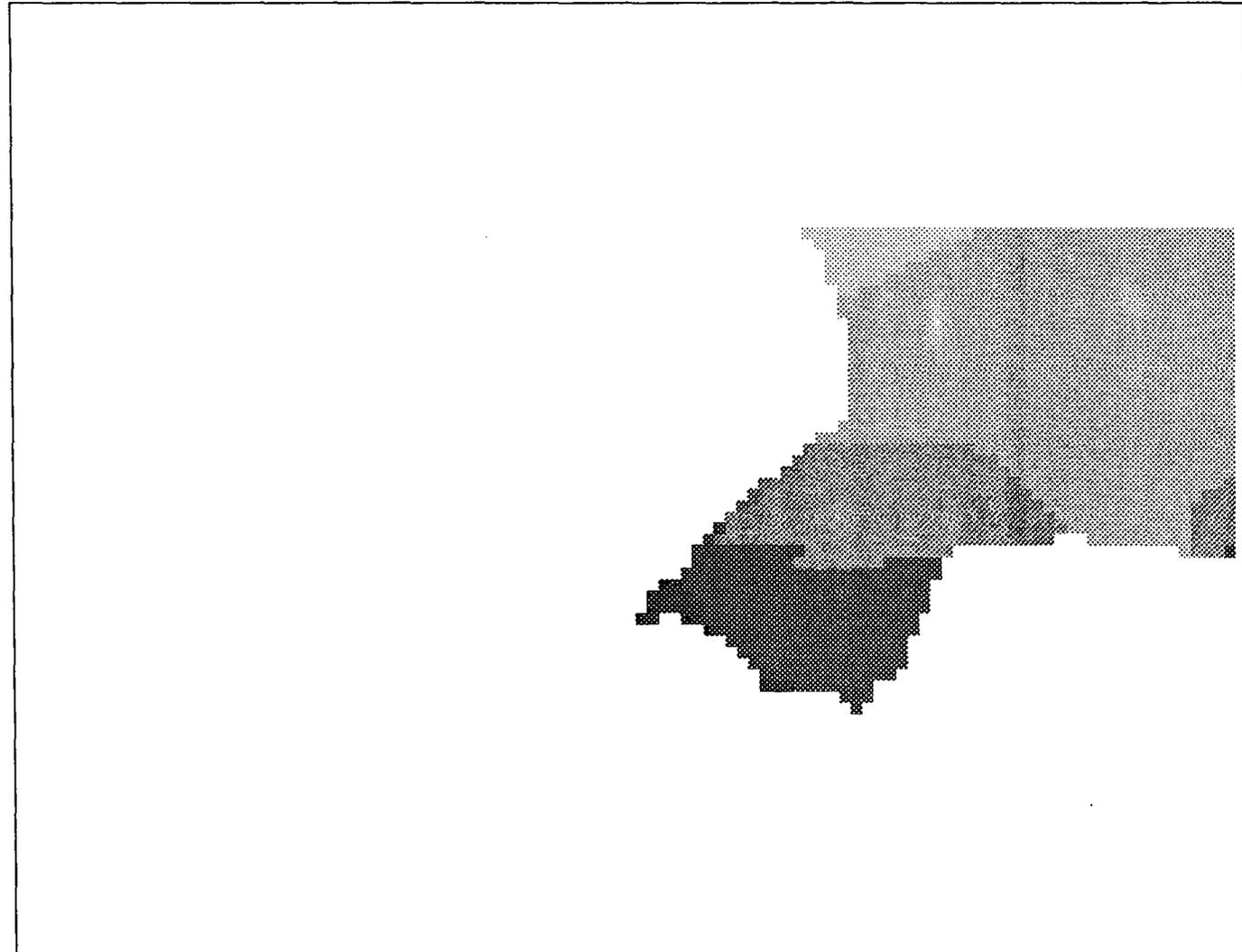
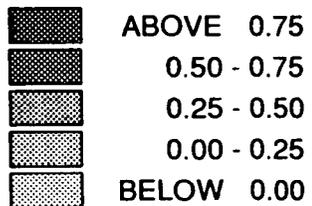


Figure 6.97. WASH MODEL 3,000 Years B.P. Minus 4,000 Years B.P.

Palaeogeography

Maximum Tidal Heights (m.)

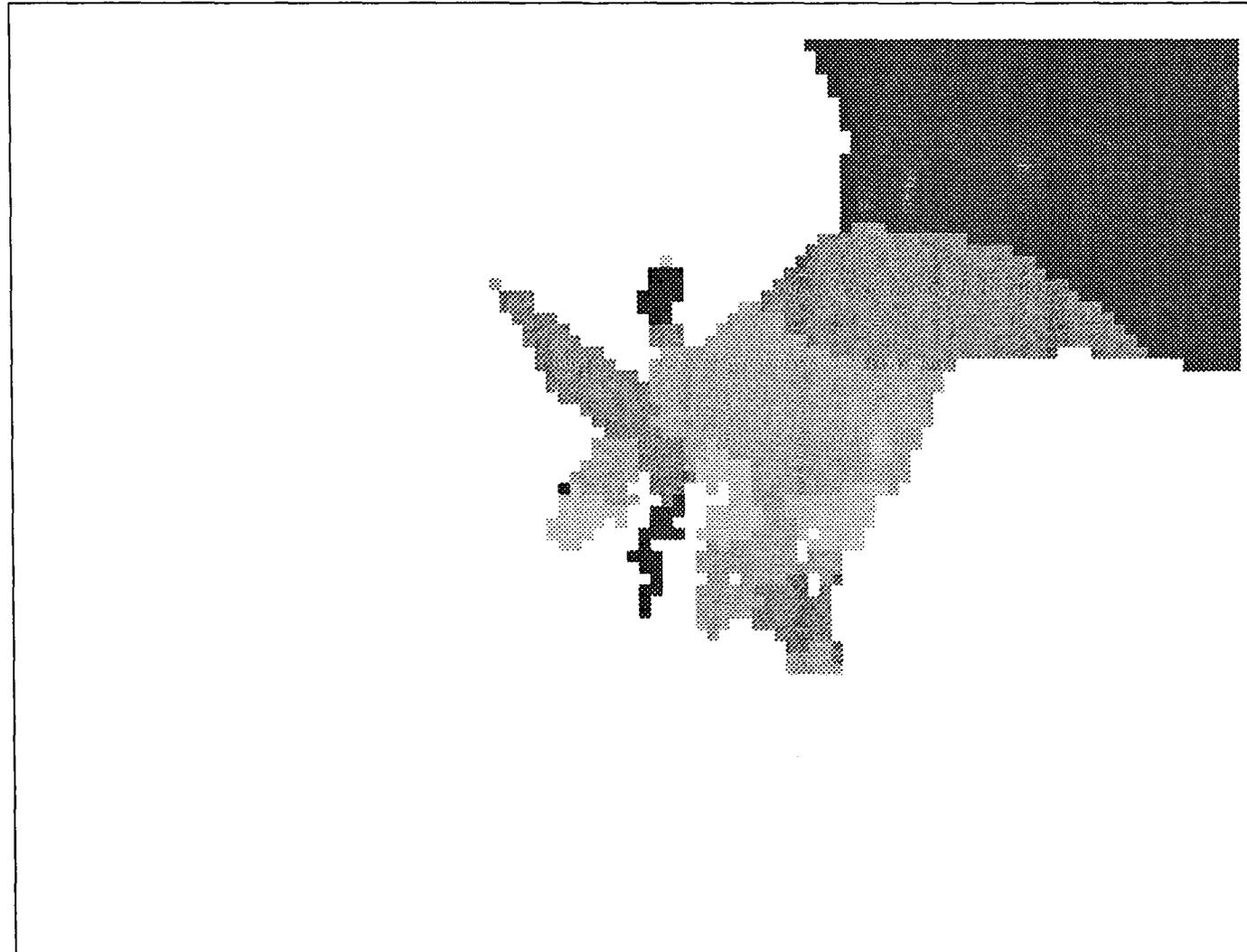


Figure 6.98. WASH Model Histogram: 4,000 Years B.P. Palaeogeography Simulation with data from Table 6.7.

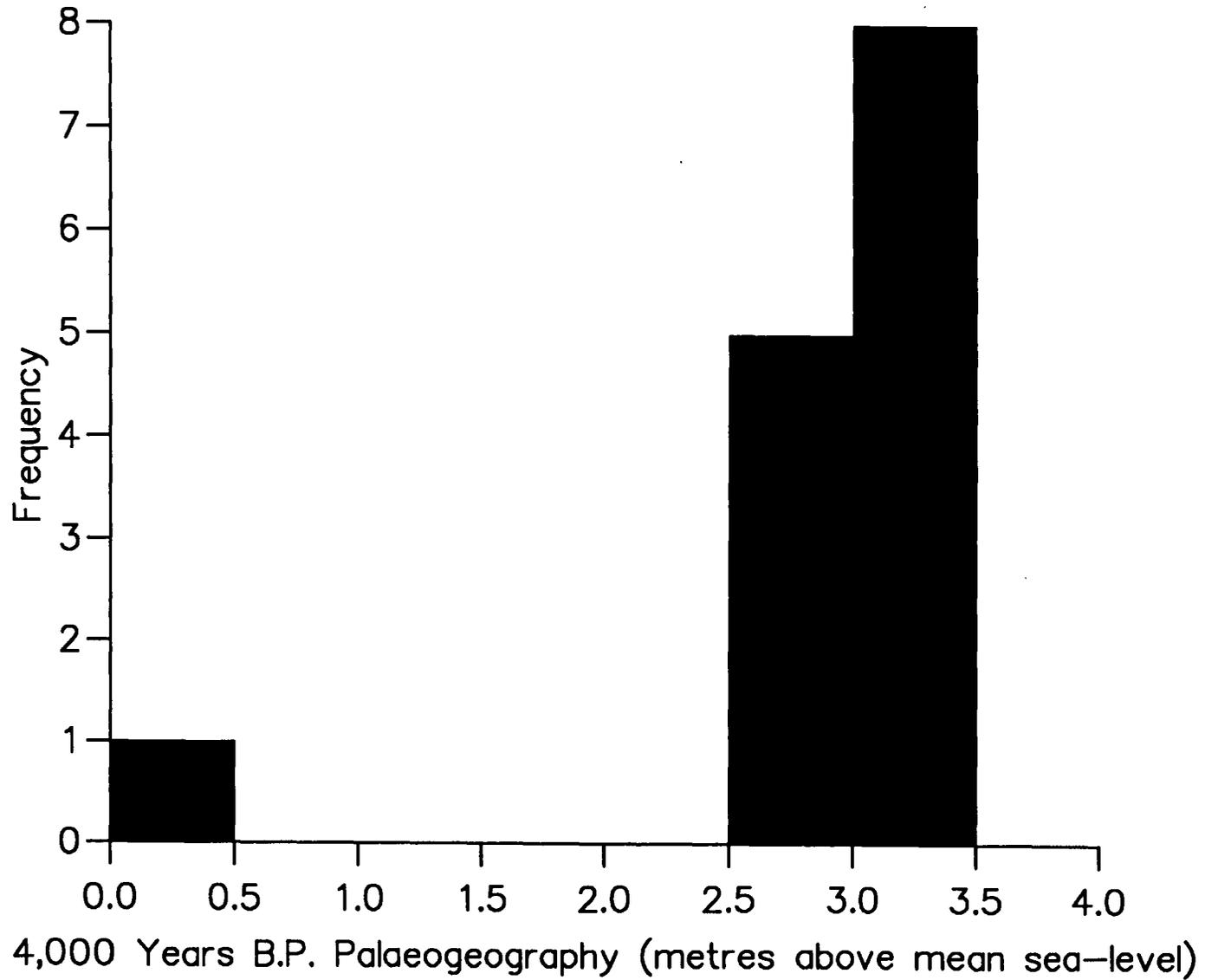


Figure 6.99. EAST COAST 3 MODEL

Maximum Tidal Altitudes (m.)
5,000 Years B.P.

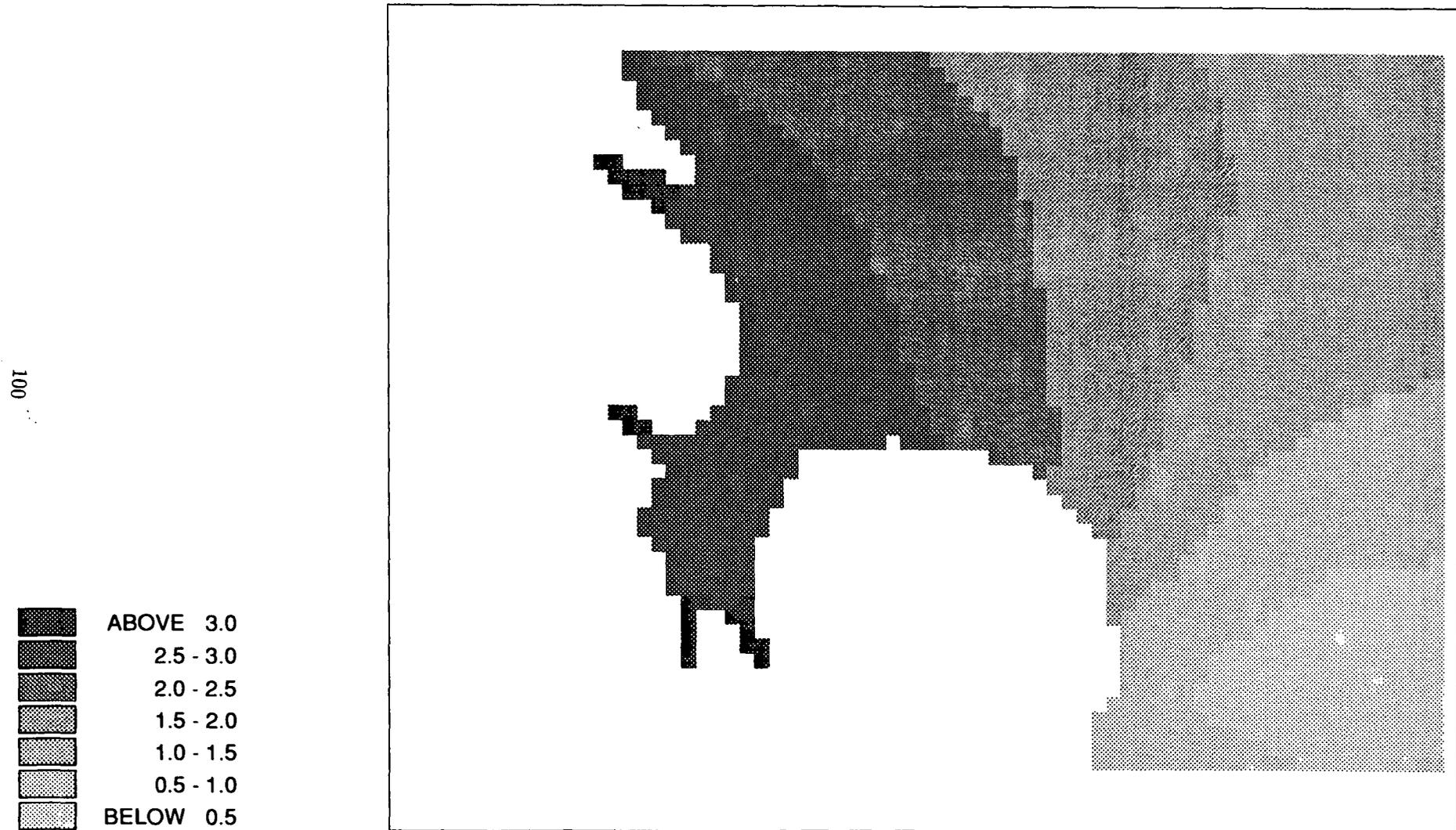


Figure 6.100. EAST COAST 3 MODEL

Maximum Tidal Altitudes Difference (m.)

Present Sea-Level Minus 5,000 Years B.P. Palaeogeography

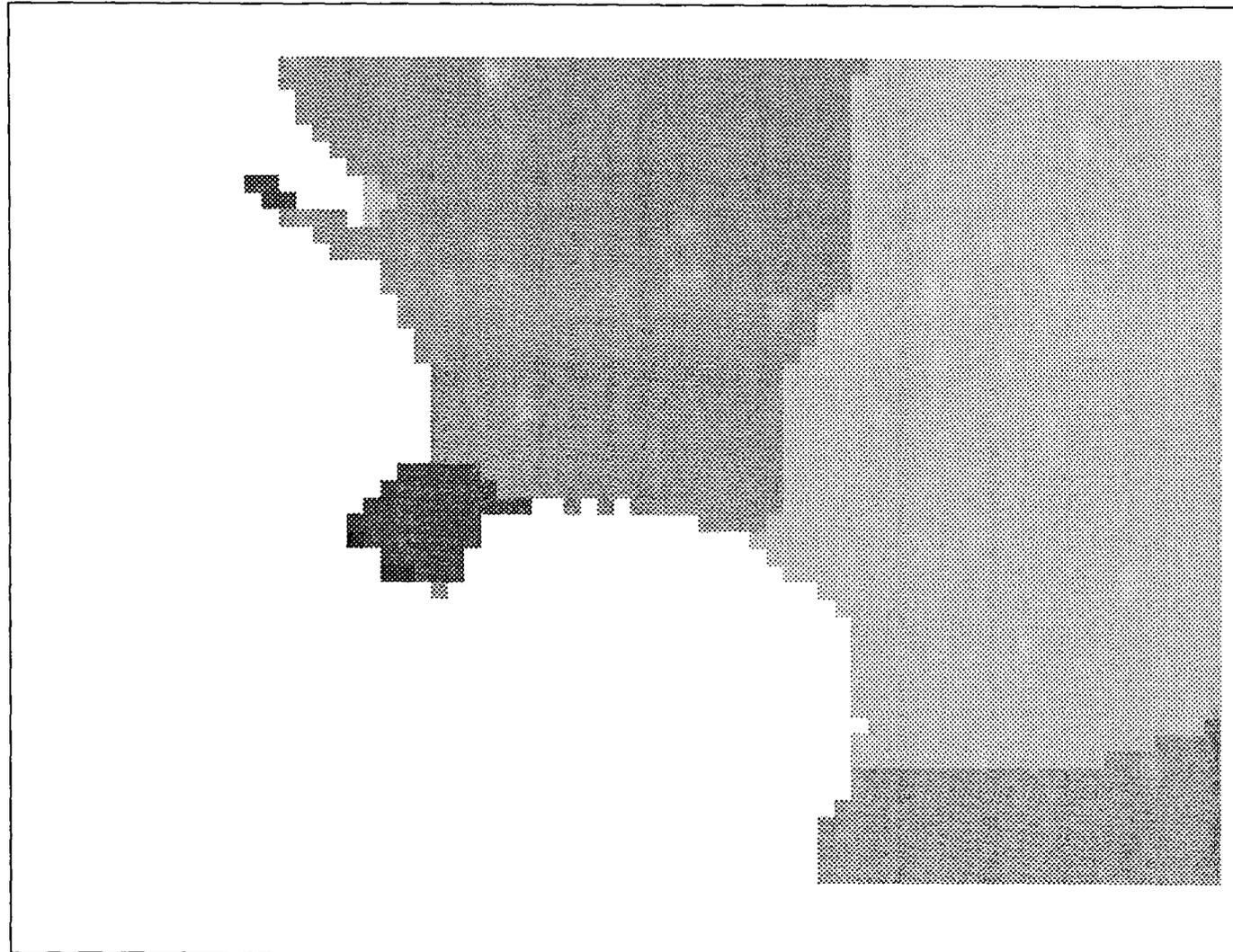


Figure 6.101.

EAST COAST 3 MODEL

Maximum Tidal Altitudes (m.)

4,000 Years B.P. Minus 5,000 Years B.P. Palaeogeography

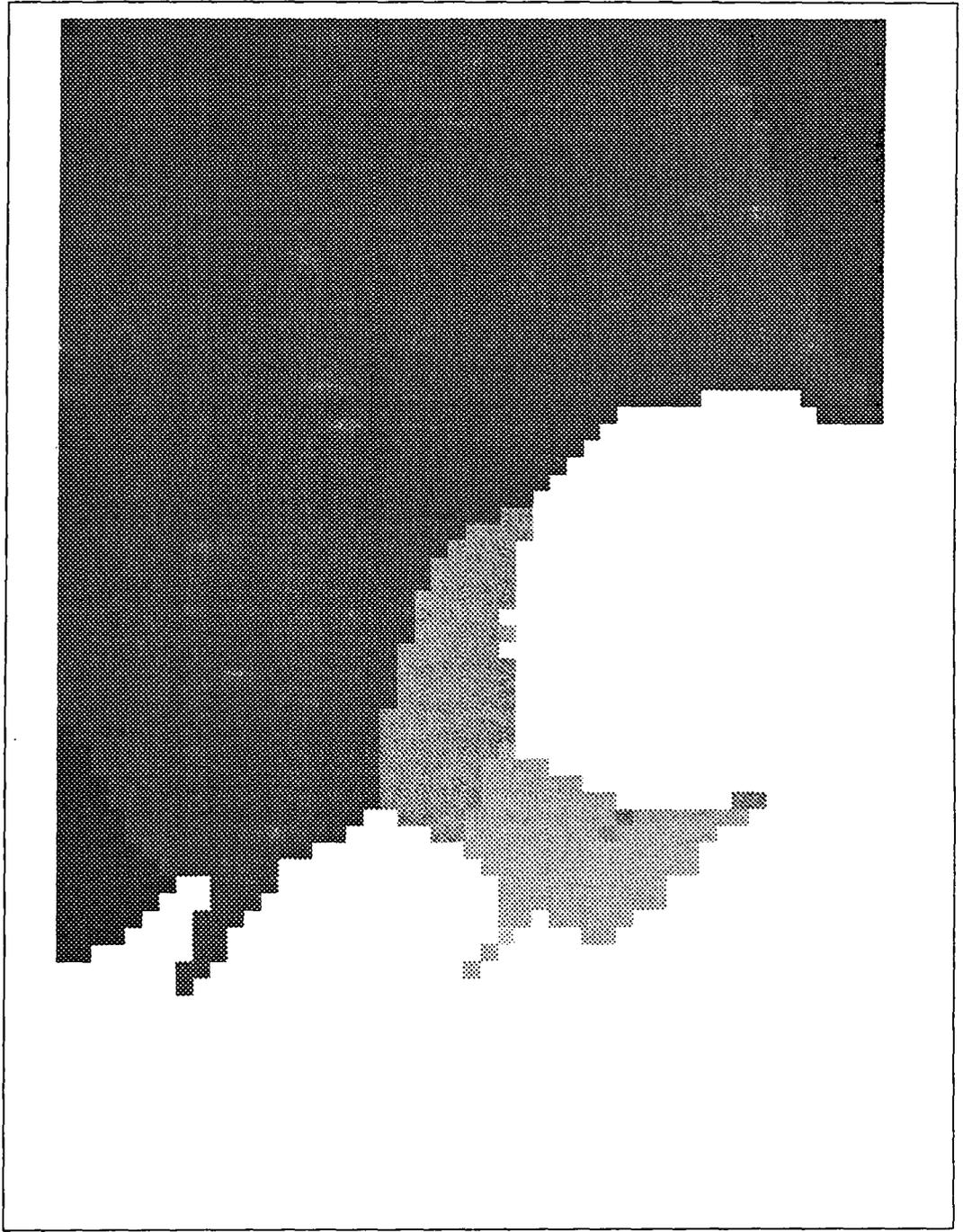


Figure 6.102. EC3 Model Histogram: 5,000 Years B.P. Palaeogeography with data from Table 6.5.

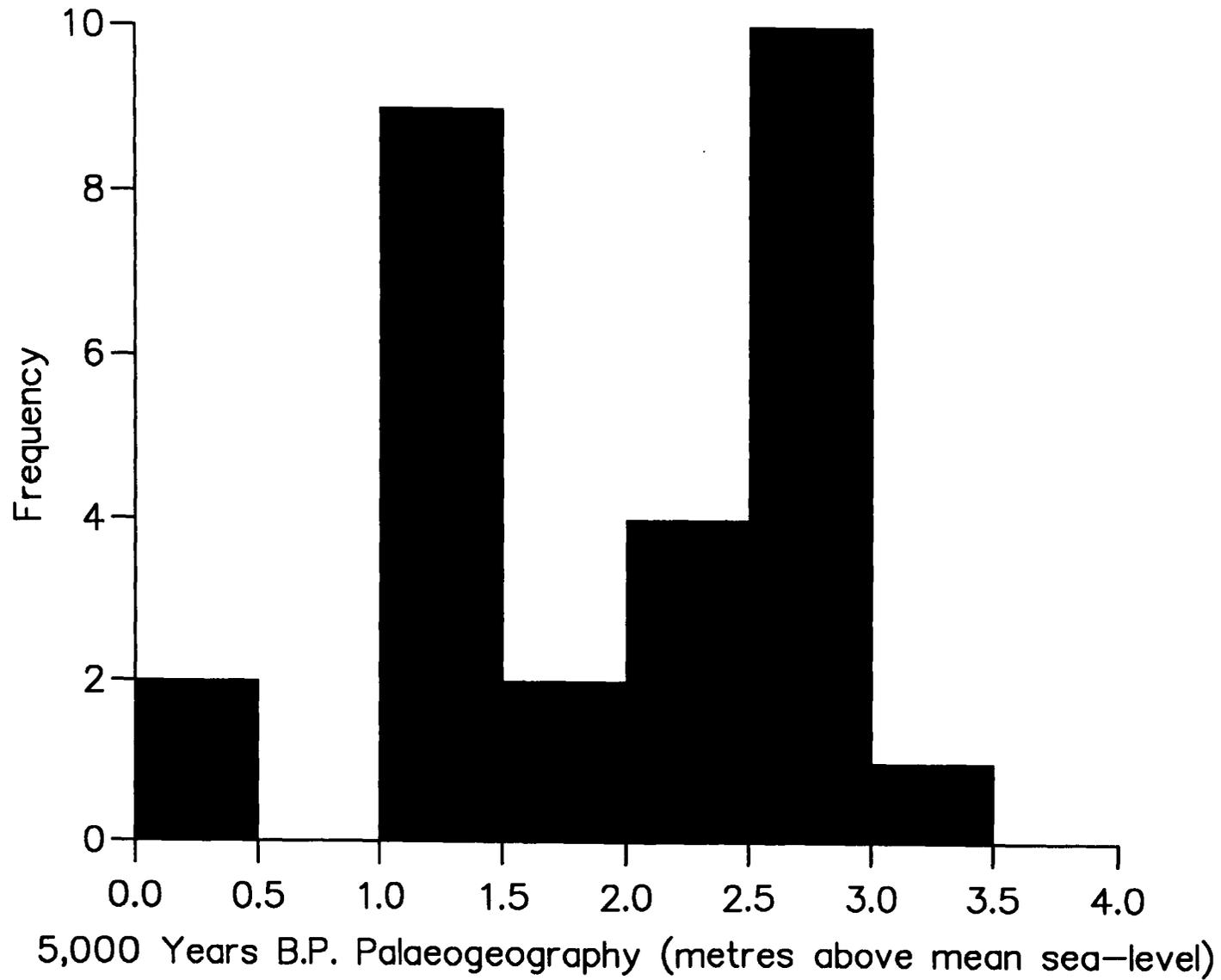


Figure 6.103. WASH MODEL 5,000 Years B.P. Palaeogeography

Maximum Tidal Heights (m.)

104

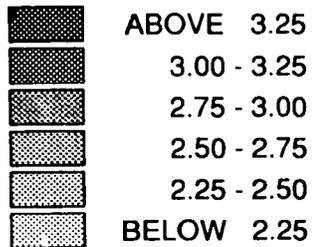


Figure 6.104. WASH MODEL Present Sea-Level Minus 5,000 Years B.P.

Palaeogeography

Maximum Tidal Heights (m.)

105

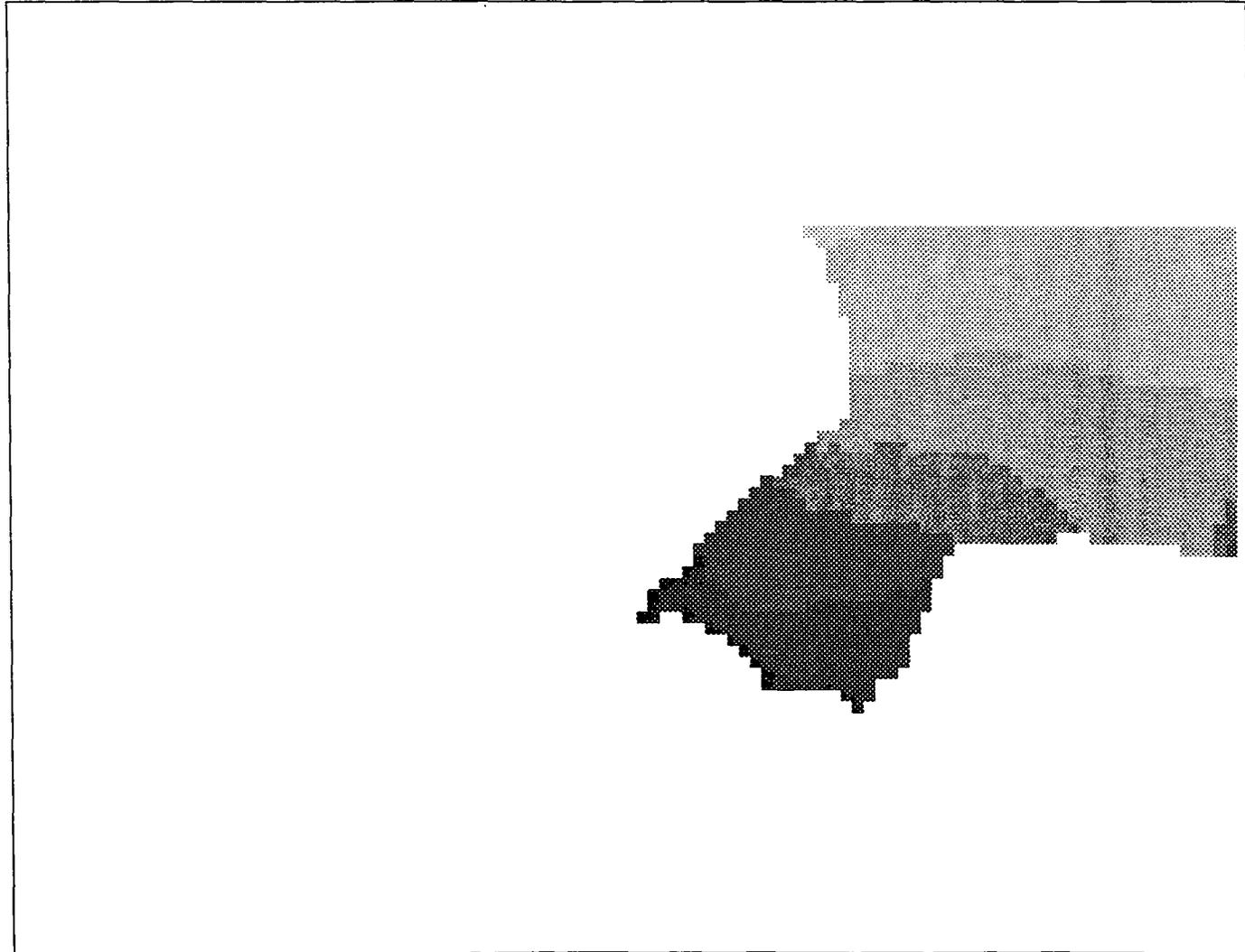
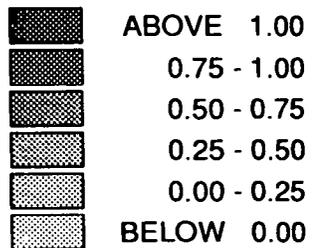


Figure 6.105. WASH MODEL 4,000 Years B.P. Palaeogeography Minus

5,000 Years B.P. Palaeogeography

Maximum Tidal Heights (m.)

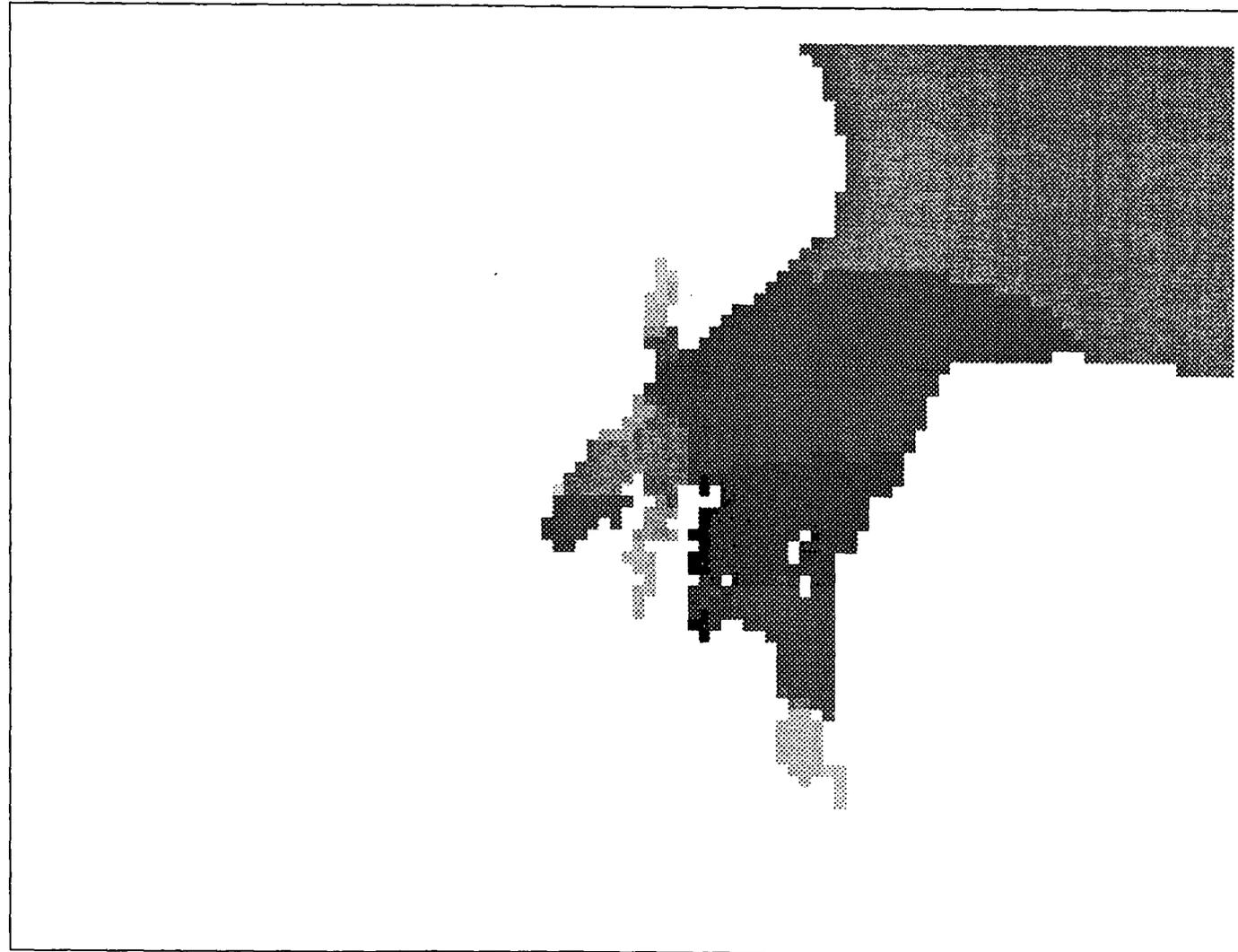
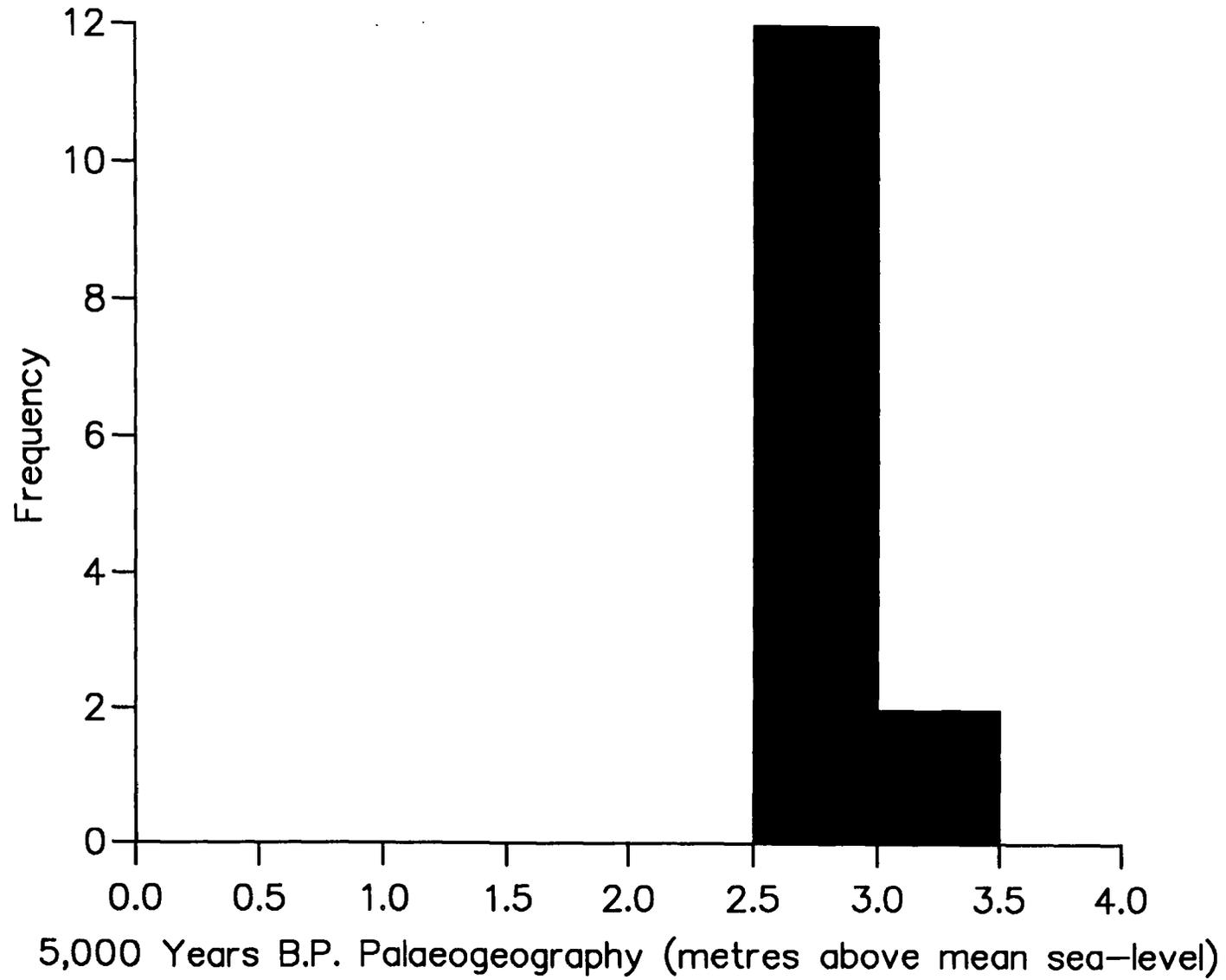


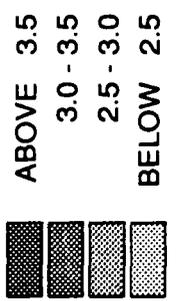
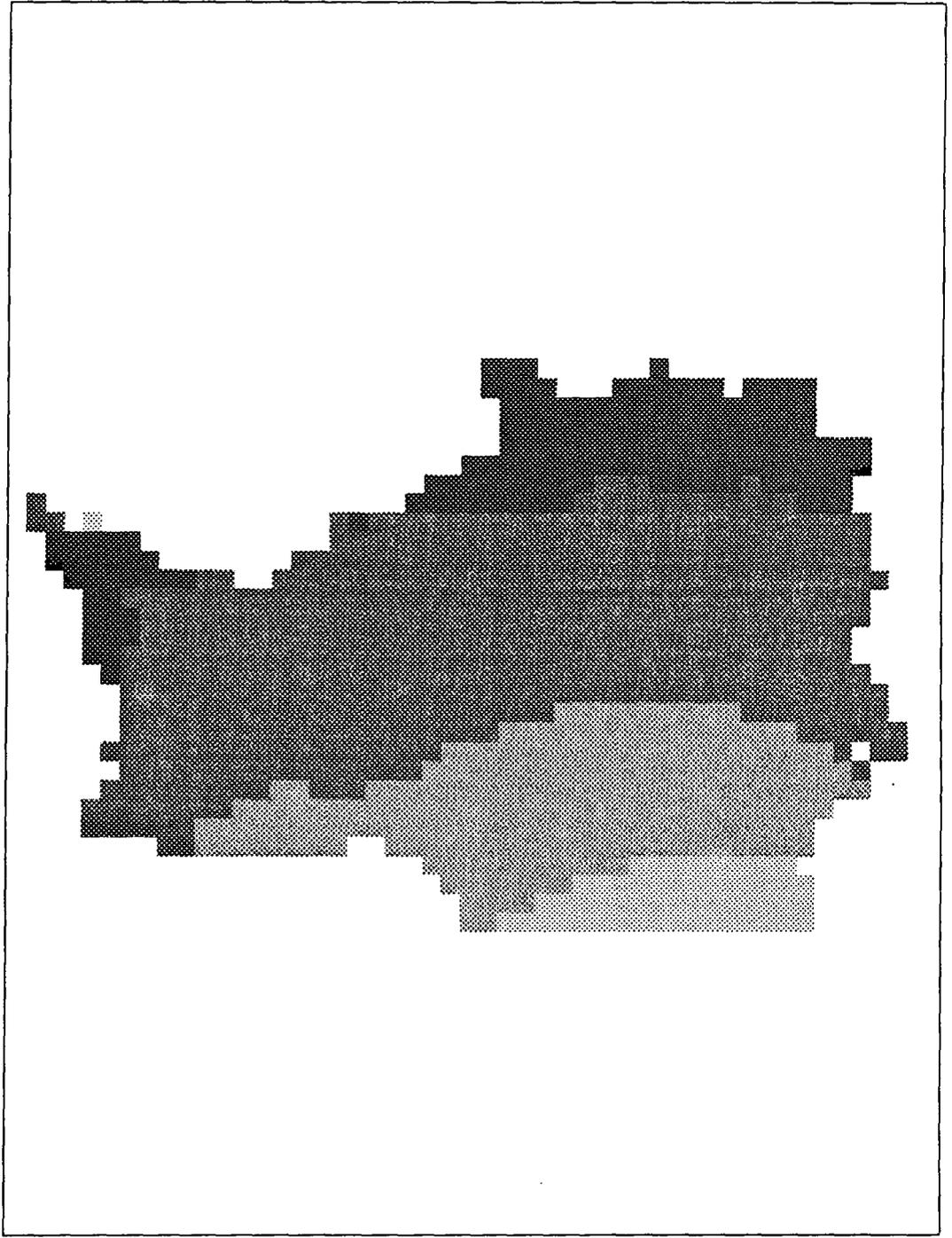
Table 6.7.



LIVERPOOL BAY MODEL 5,000 Years B.P. Palaeogeography

Figure 6.107.

Maximum Tidal Heights (m.)



LIVERPOOL BAY MODEL Present Sea-Level Minus

5,000 Years B.P. Palaeogeography

Maximum Tidal Heights (m.)

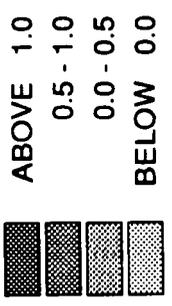
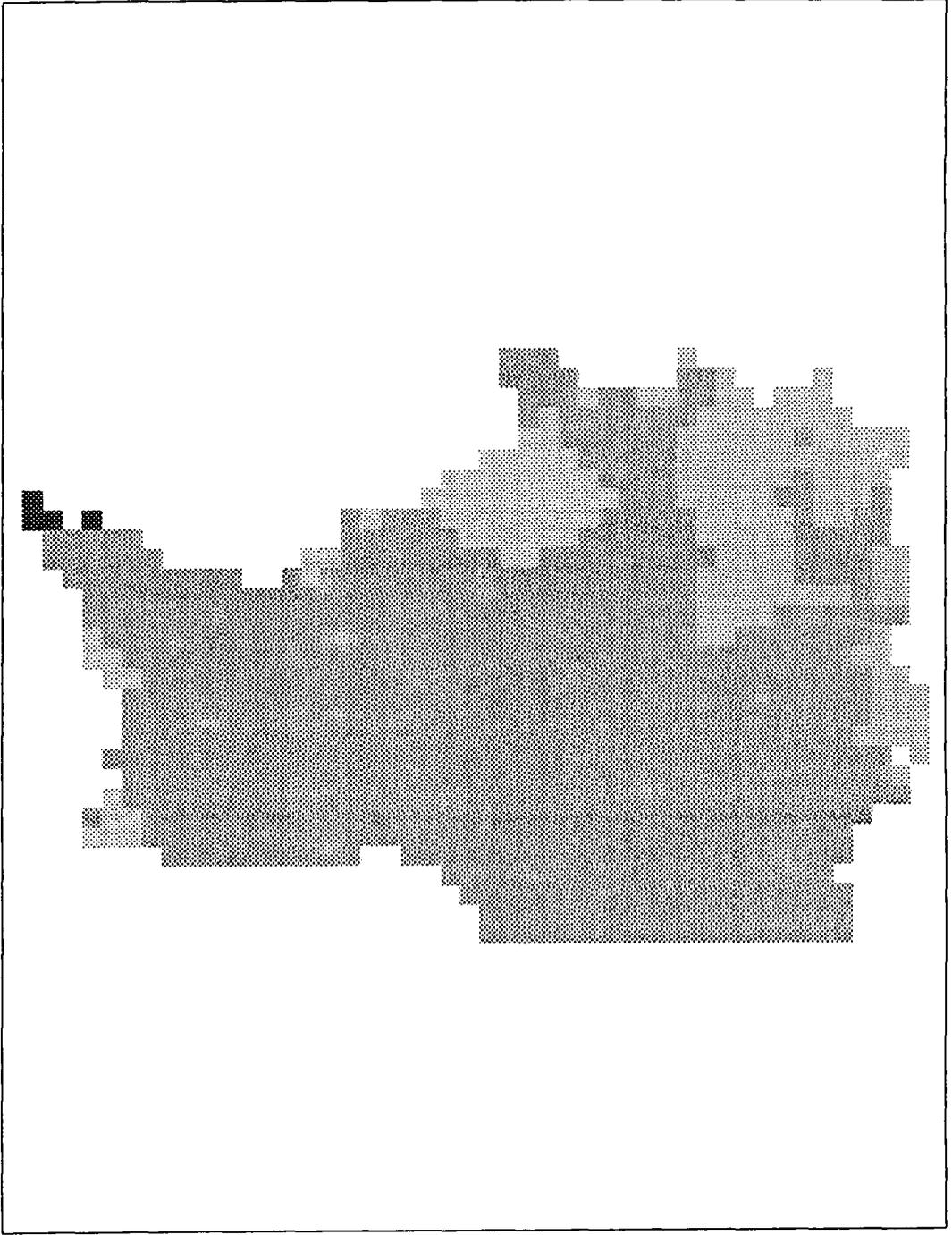


Figure 6.108.

Figure 6.109. LBM Model Scatter Plot: Present Sea-Level against Palaeogeographic Simulations with data from Table 6.9.

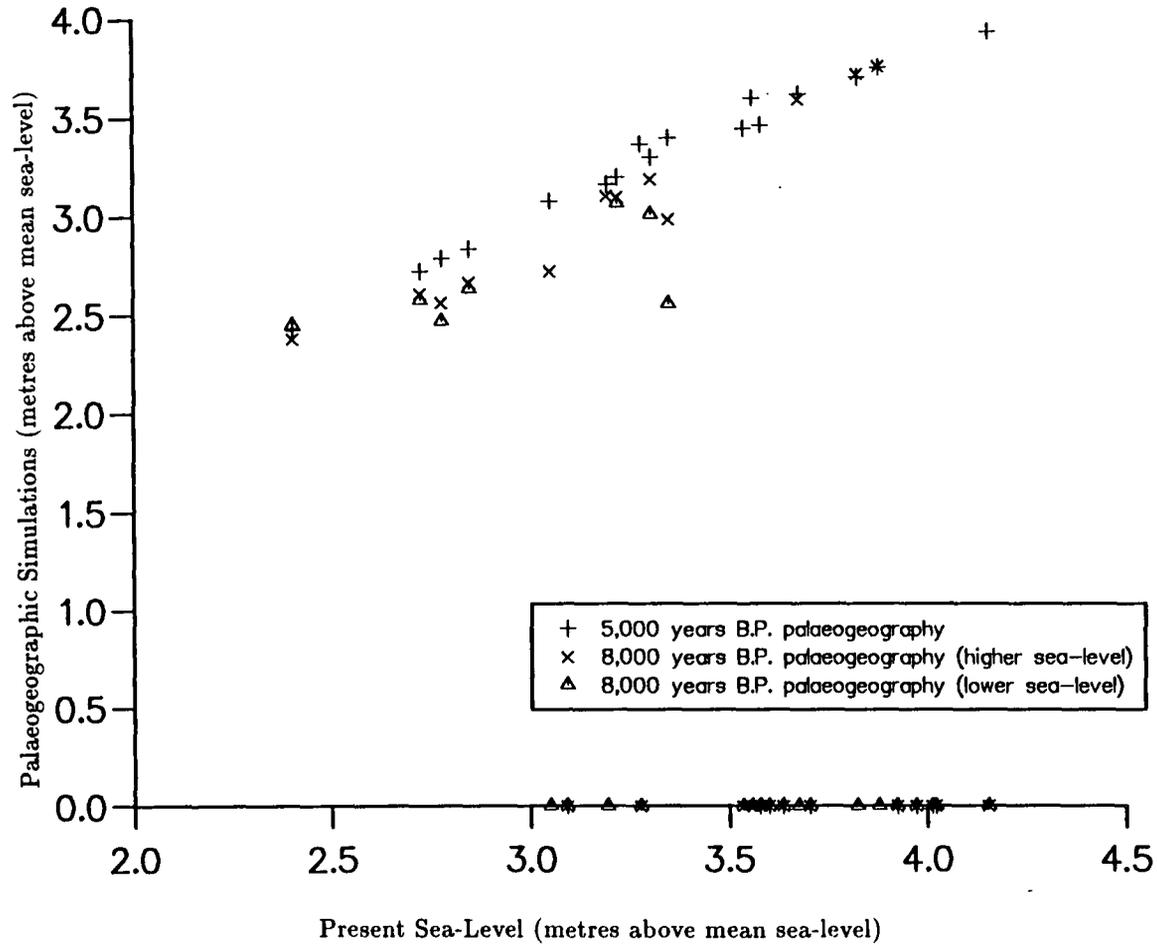


Table 6.9.

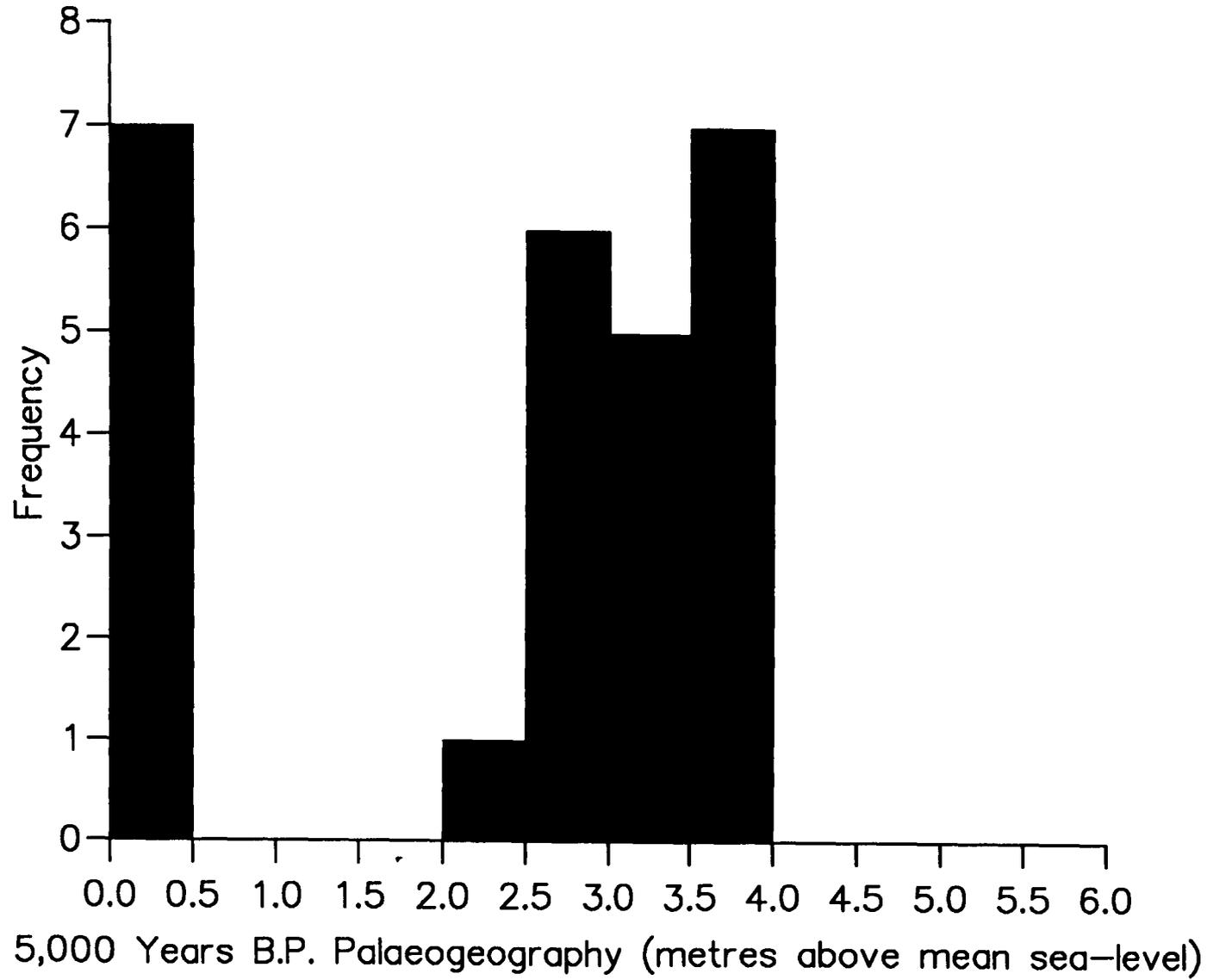


Figure 6.111. MORECAMBE BAY MODEL 5,000 Years B.P. Palaeogeography

Maximum Tidal Heights (m.)

112

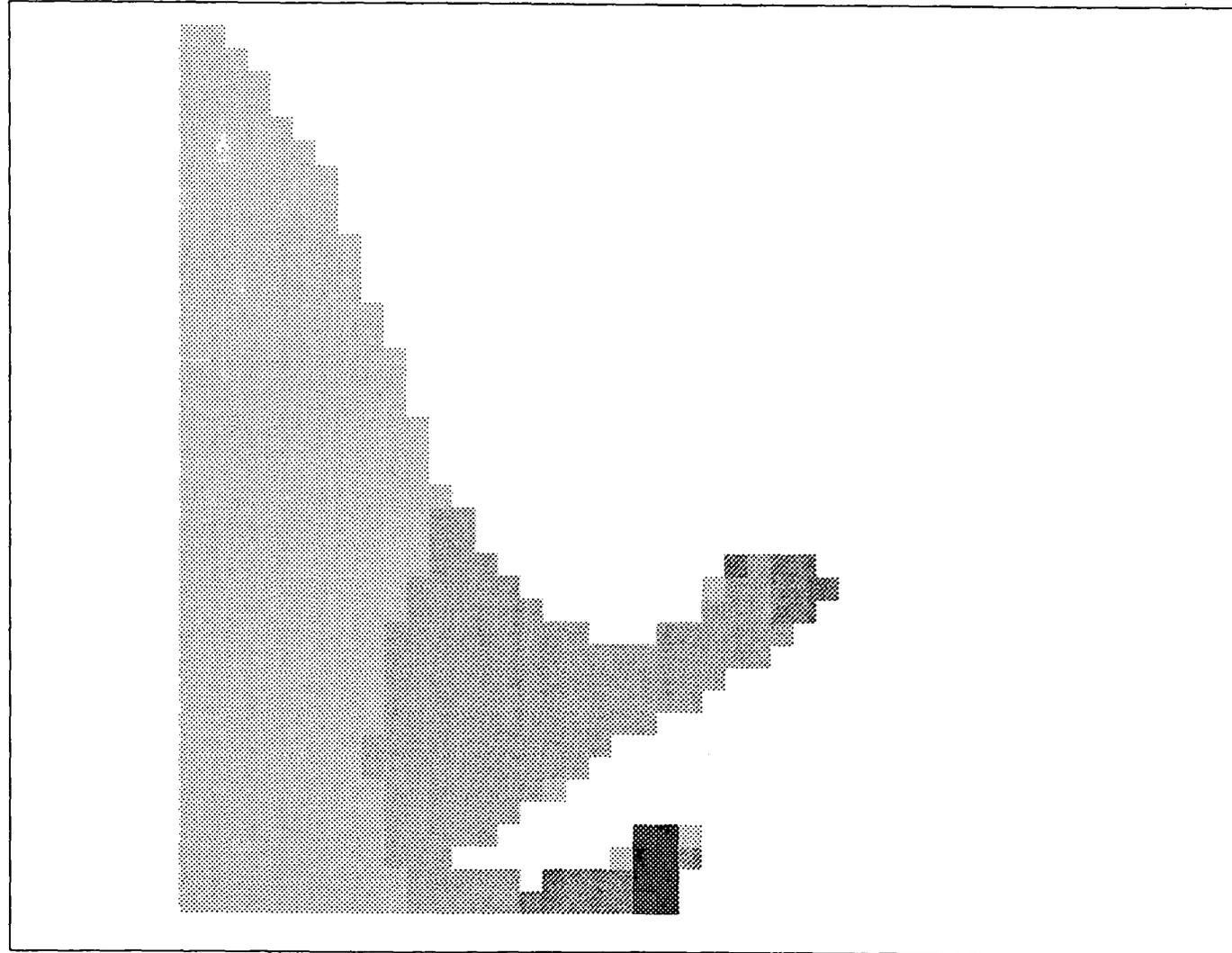
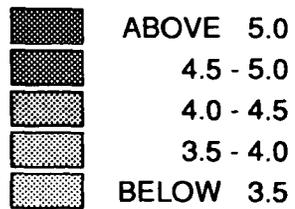


Figure 6.112. MORECAMBE BAY MODEL Difference Present Sea-Level

Minus 5,000 Years B.P. Palaeogeography
Maximum Tidal Heights (m.)

113

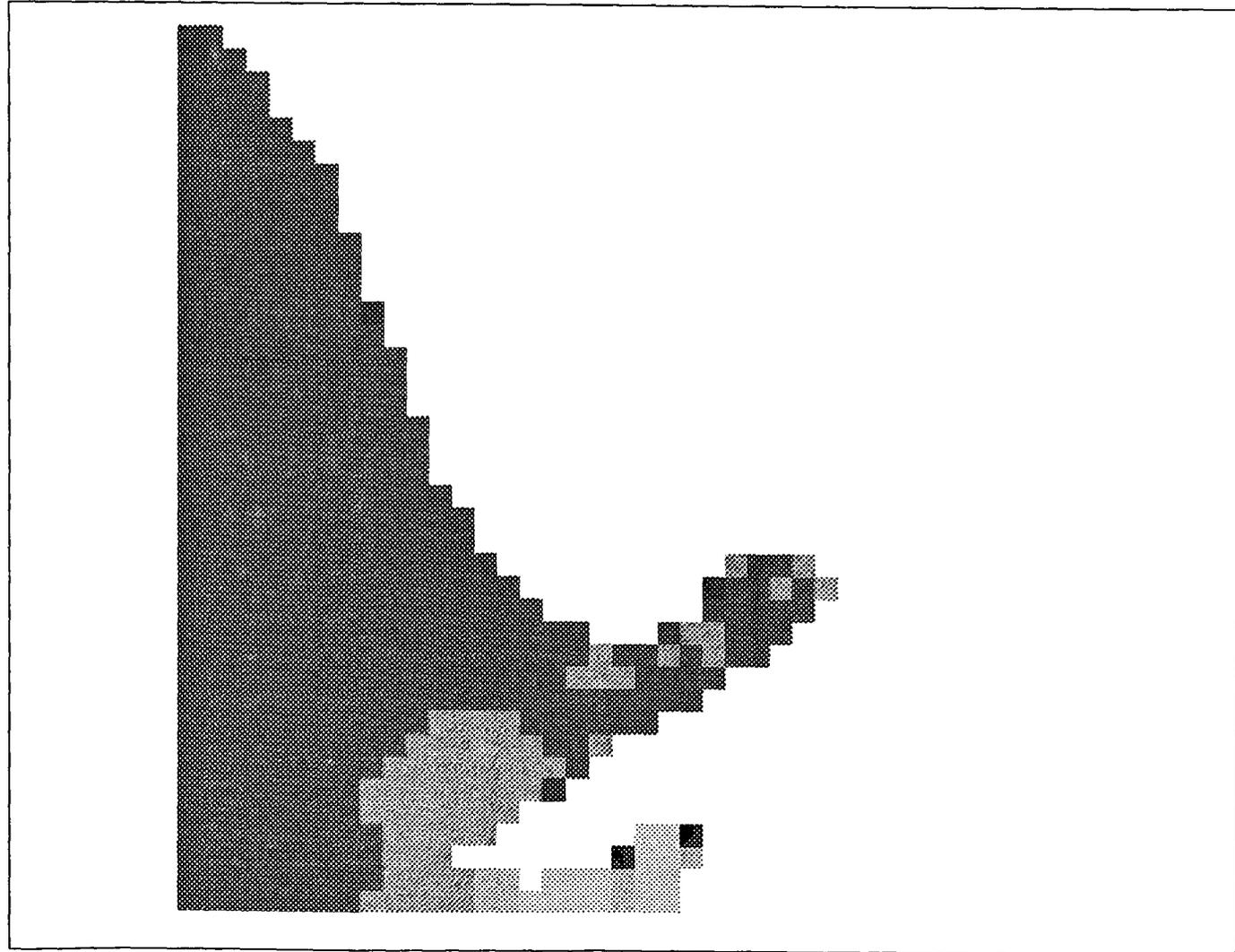
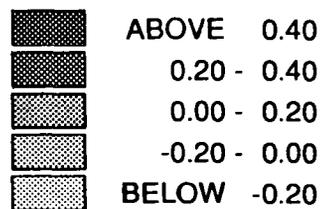


Figure 6.114. MBM Model Histogram: 5,000 Years B.P. Palaeogeography with data from

Table 6.11.

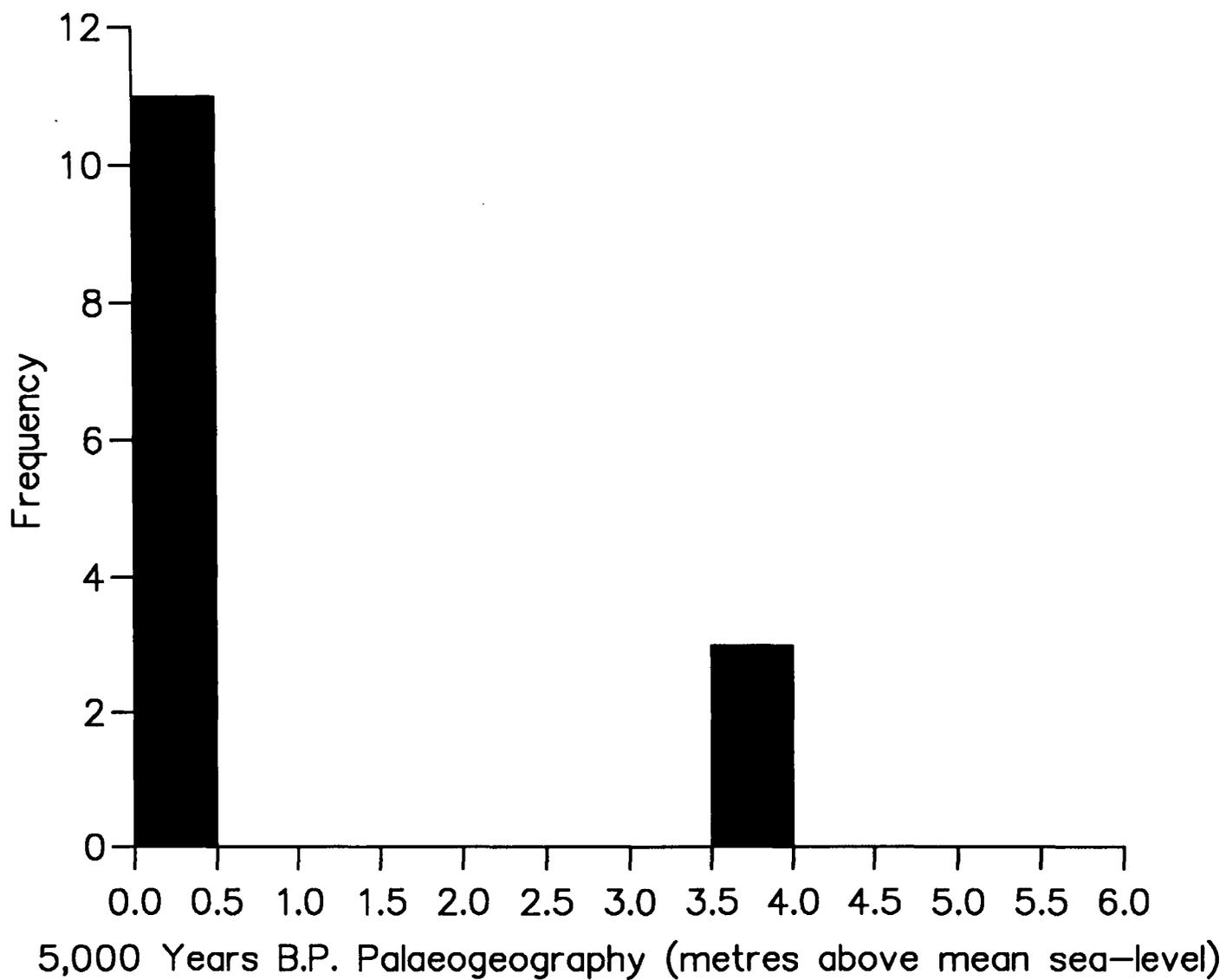


Figure 6.115.

LIVERPOOL BAY MODEL 8,000 Years B.P. Palaeogeography

Higher Sea-Level

Maximum Tidal Heights (m.)

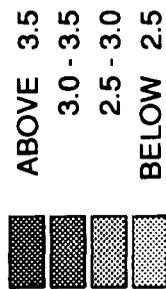
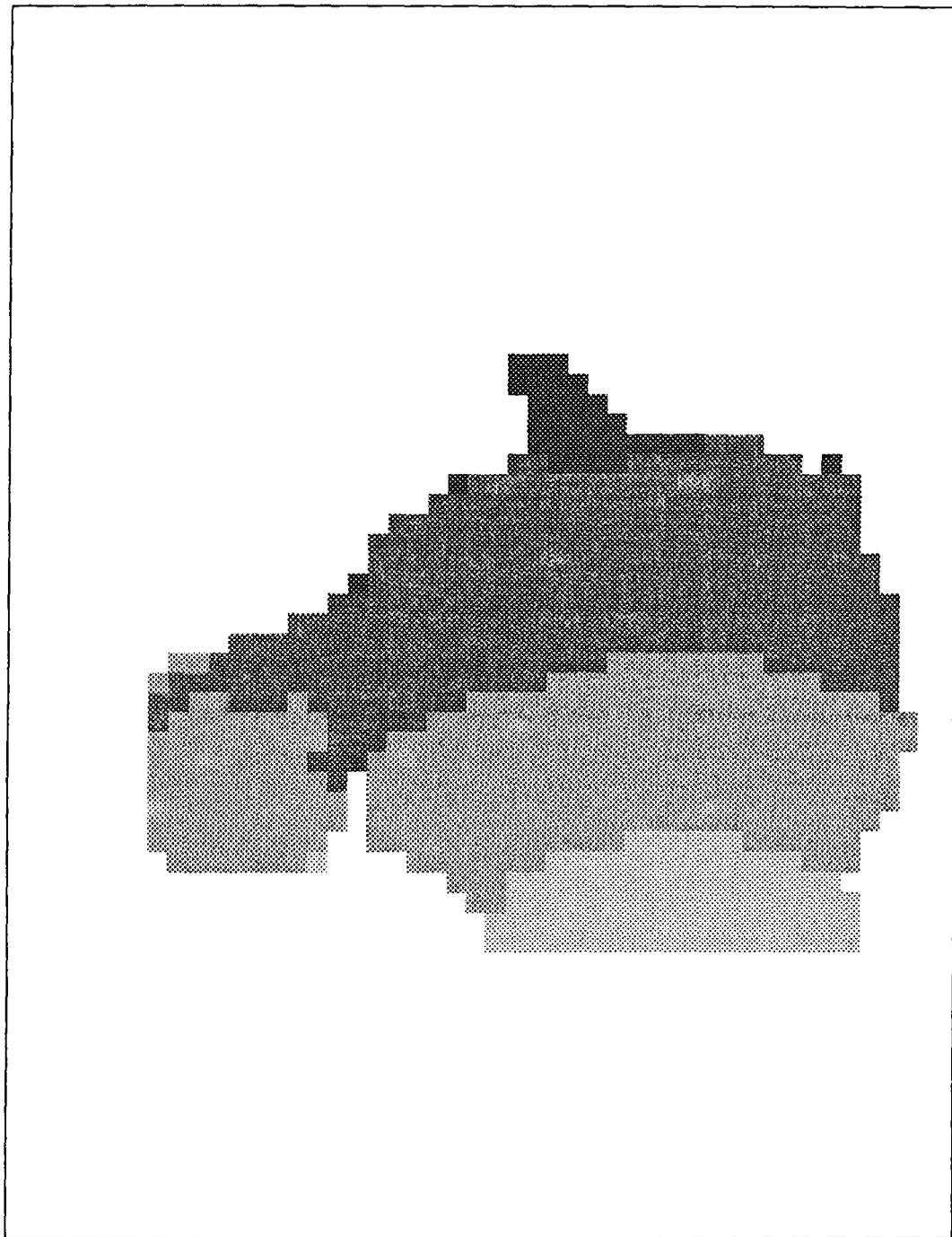


Figure 6.116.

**LIVERPOOL BAY MODEL Present Sea-Level Minus
8,000 Years B.P. Palaeogeography (Higher Sea-Level)
Maximum Tidal Heights (m.)**

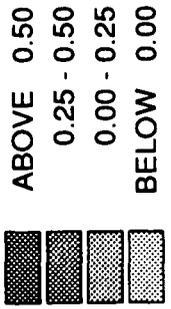
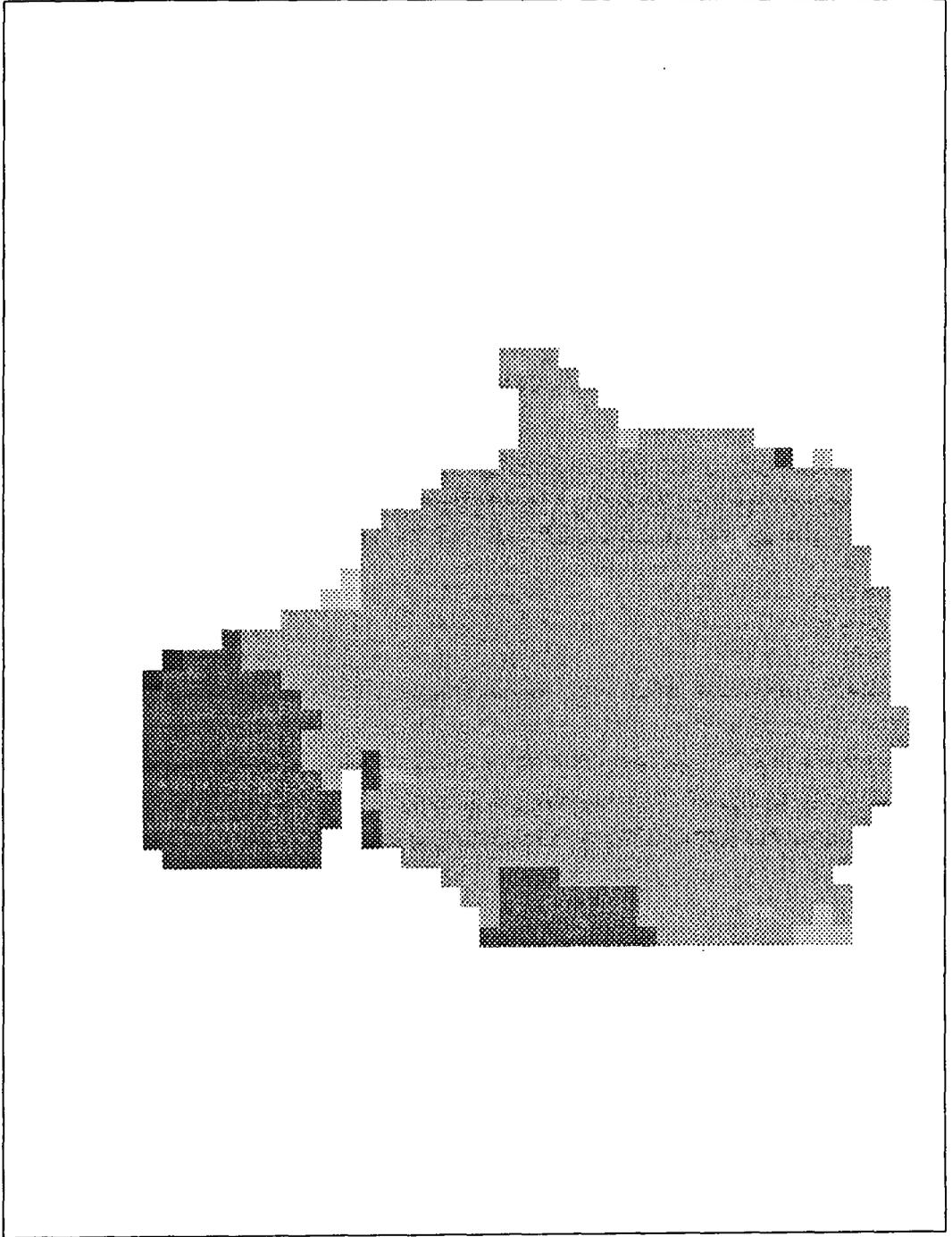


Figure 6.117.

LIVERPOOL BAY MODEL 5,000 Years B.P. Palaeogeography

Minus 8,000 Years B.P. Palaeogeography Higher Sea-Level Maximum Tidal Heights (m.)

118

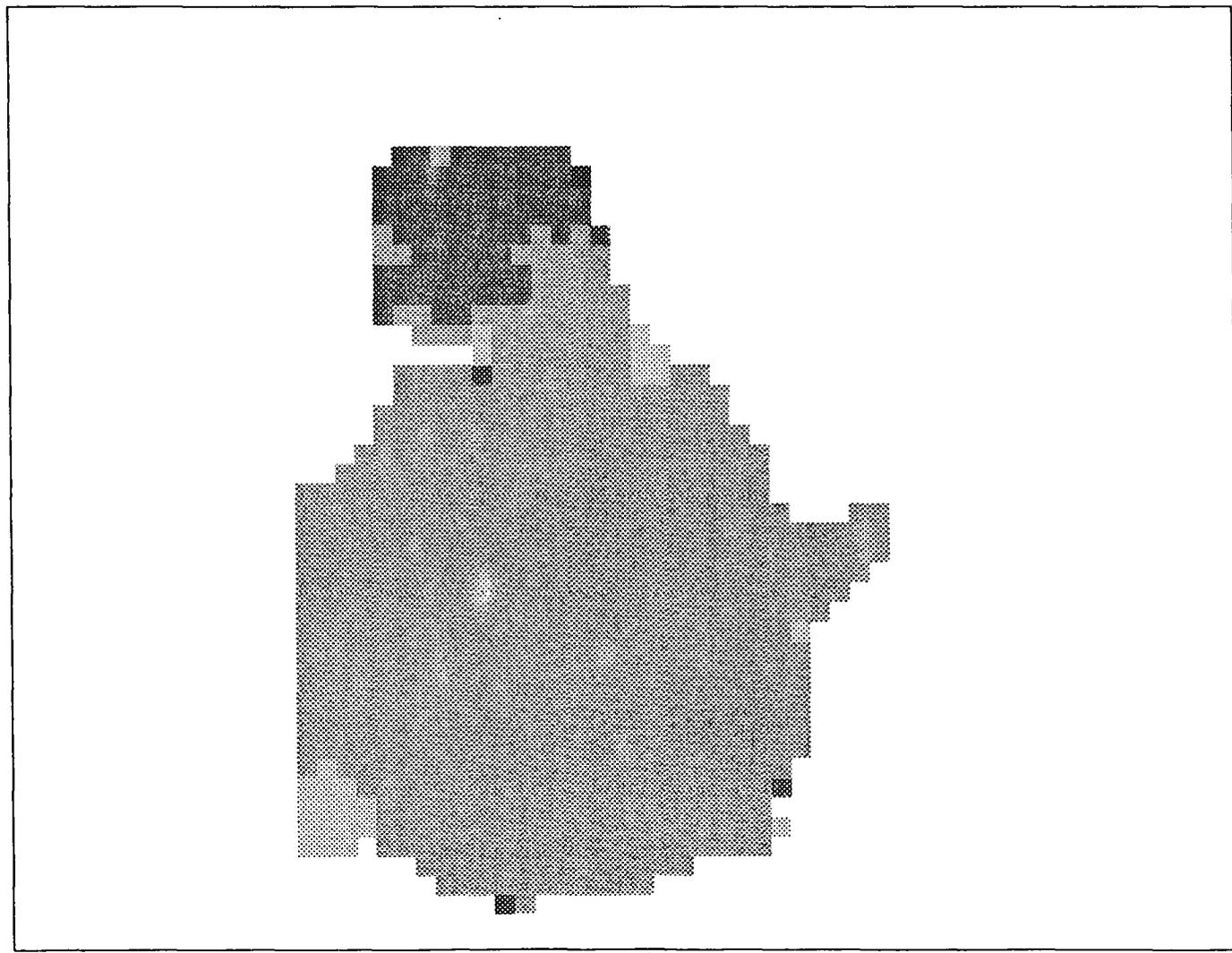
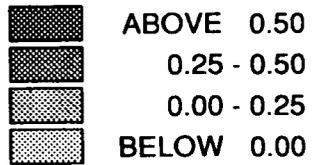
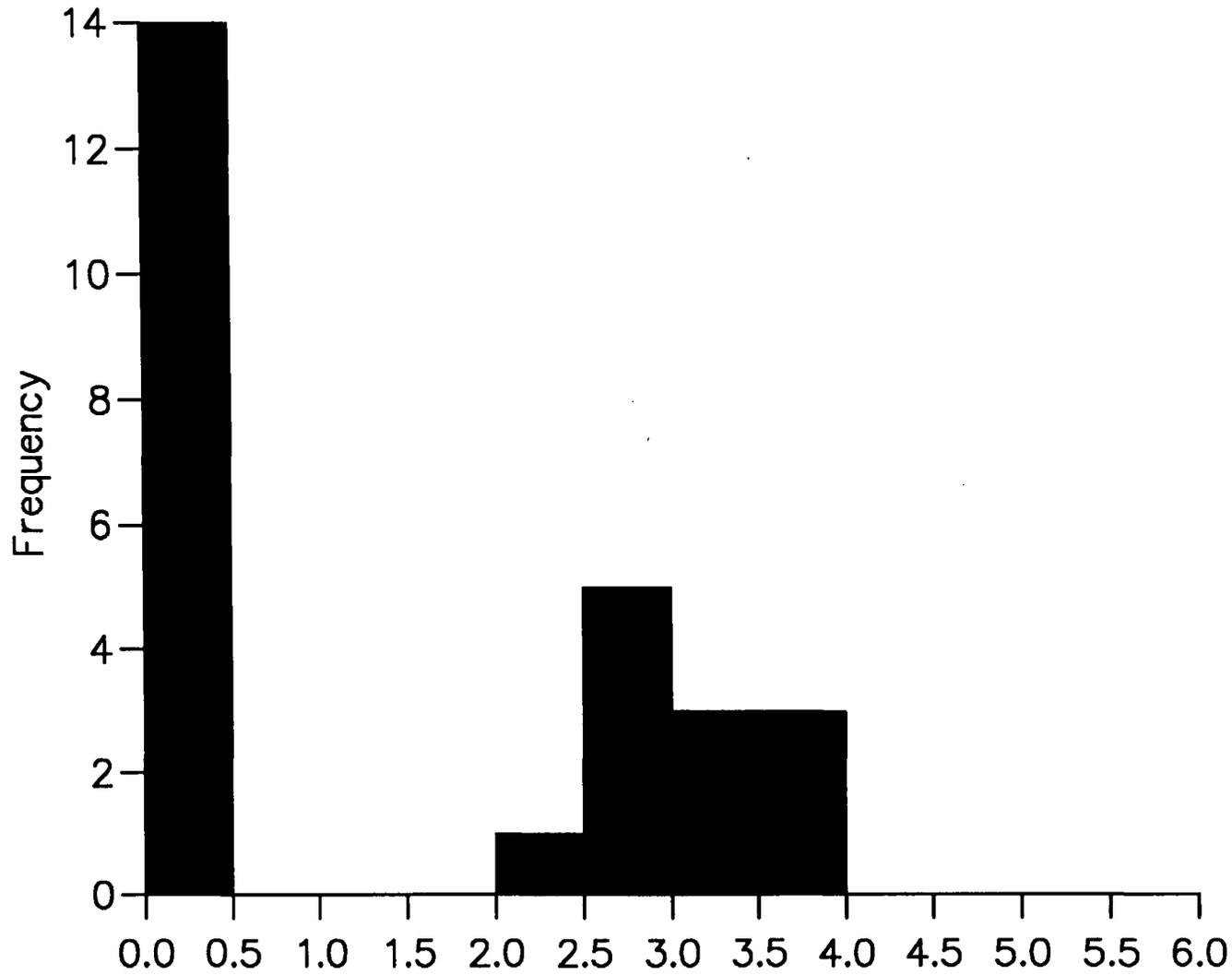


Figure 6.118. LBM Model Histogram: 8,000 Years B.P. Palaeogeography - Higher Sea-Level
with data from Table 6.9.



8,000 Years B.P. Palaeogeography - Higher Sea-Level (metres above mean sea-level)

Figure 6.119. MORECAMBE BAY MODEL 8,000 Years B.P. Palaeogeography

Maximum Tidal Heights (m.)

Higher Sea-Level

120

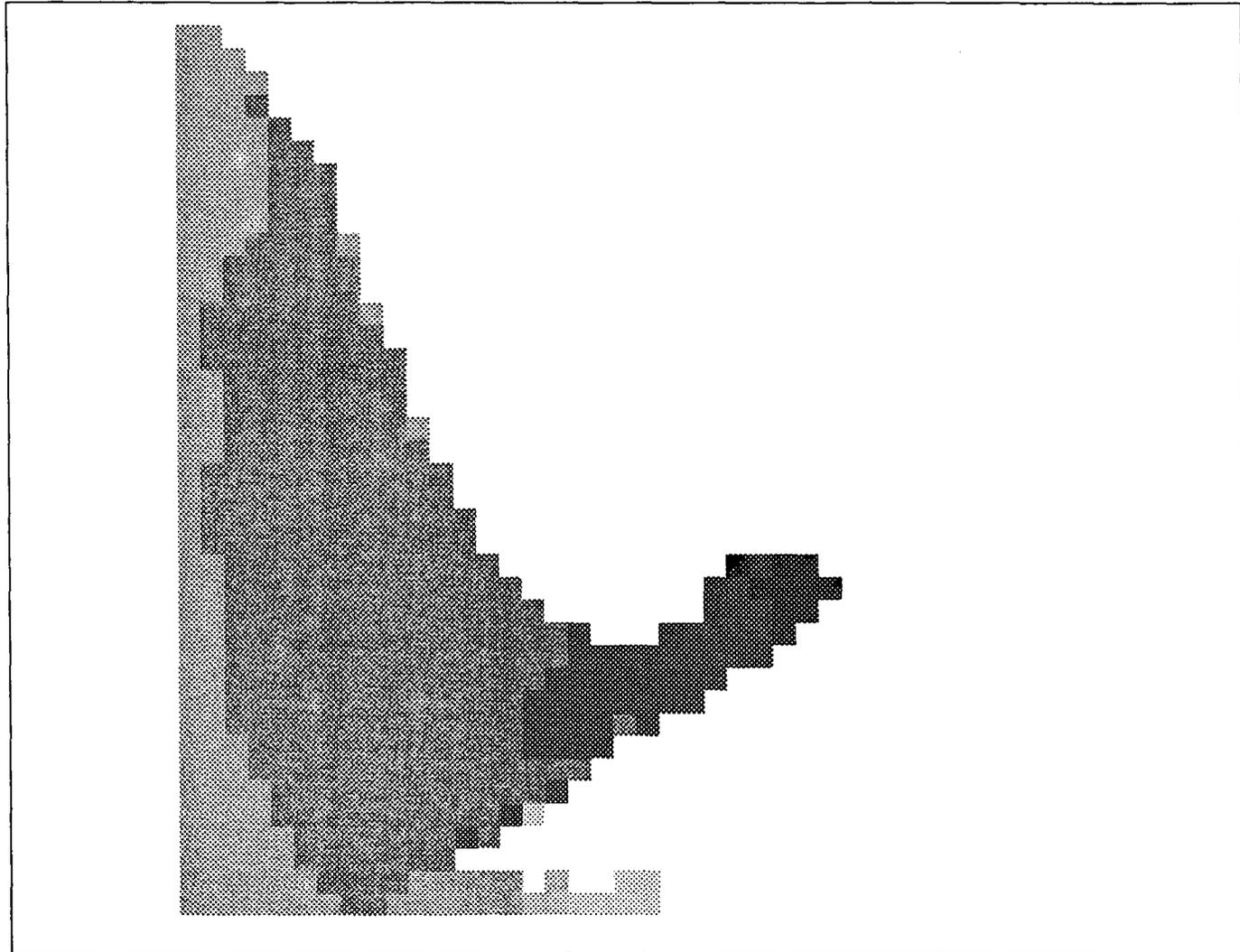
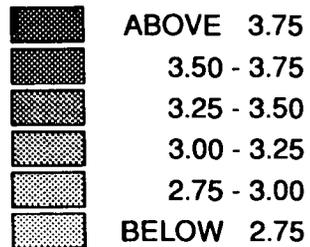


Figure 6.120.

MORECAMBE BAY MODEL Difference Present Minus 8,000

Years B.P. Palaeogeography Higher Sea-Level
Maximum Tidal Heights (m.)

121

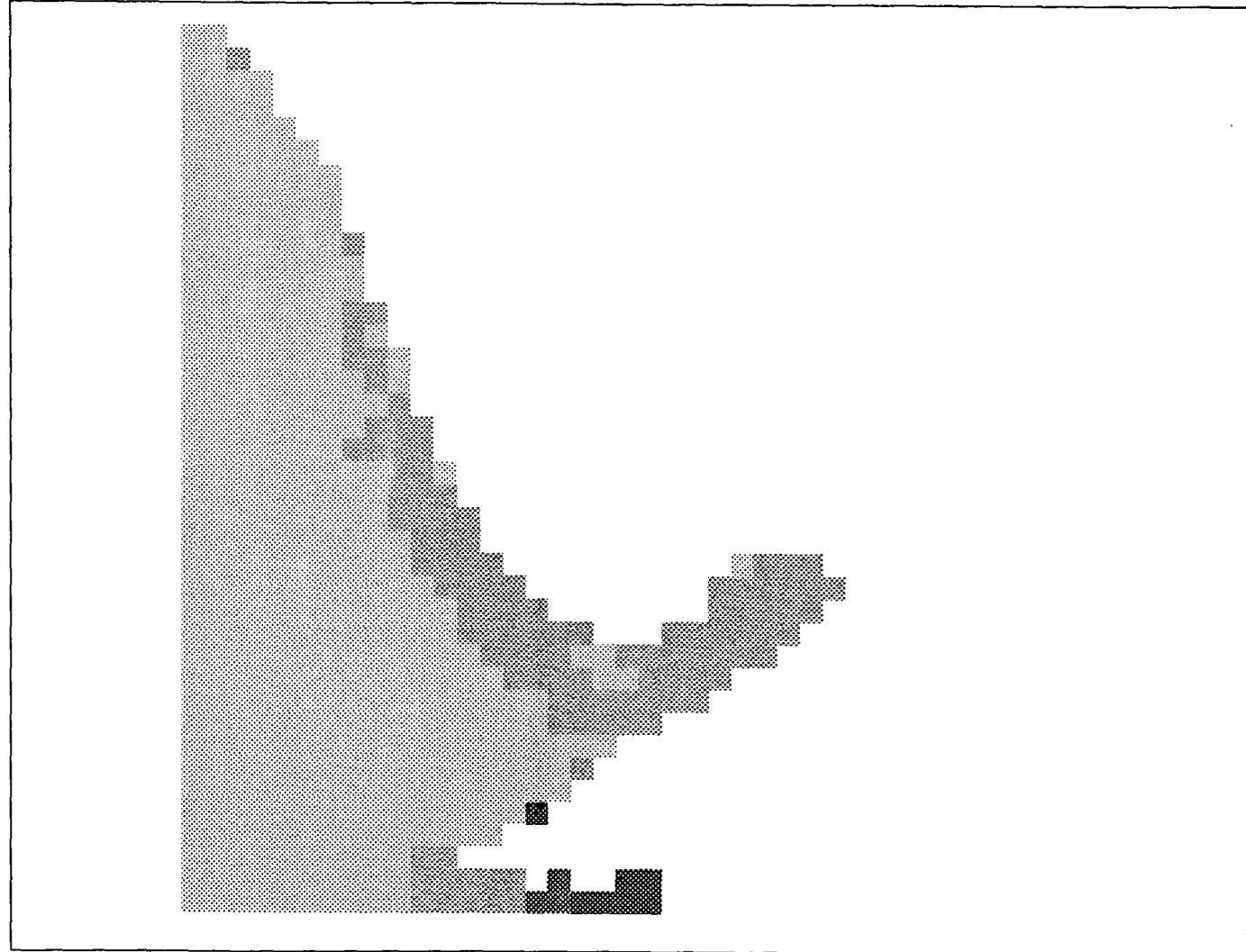
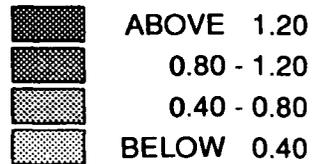


Figure 6.121. MORECAMBE BAY MODEL Difference 5,000 Minus

8,000 Years B.P. Palaeogeography
Maximum Tidal Heights (m.)

122

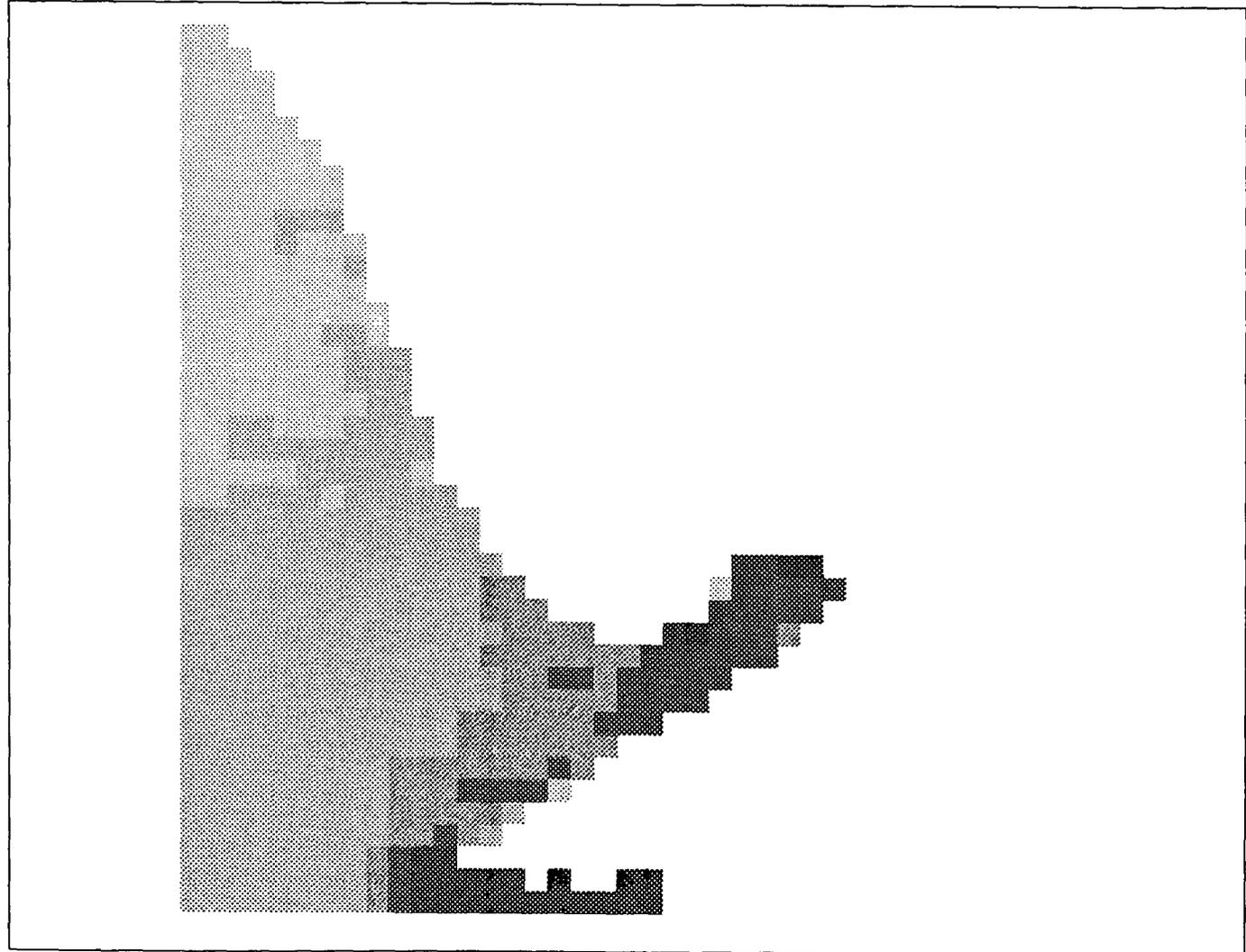
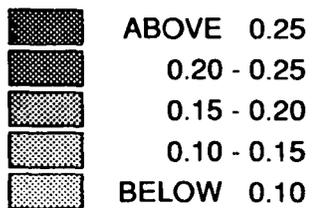
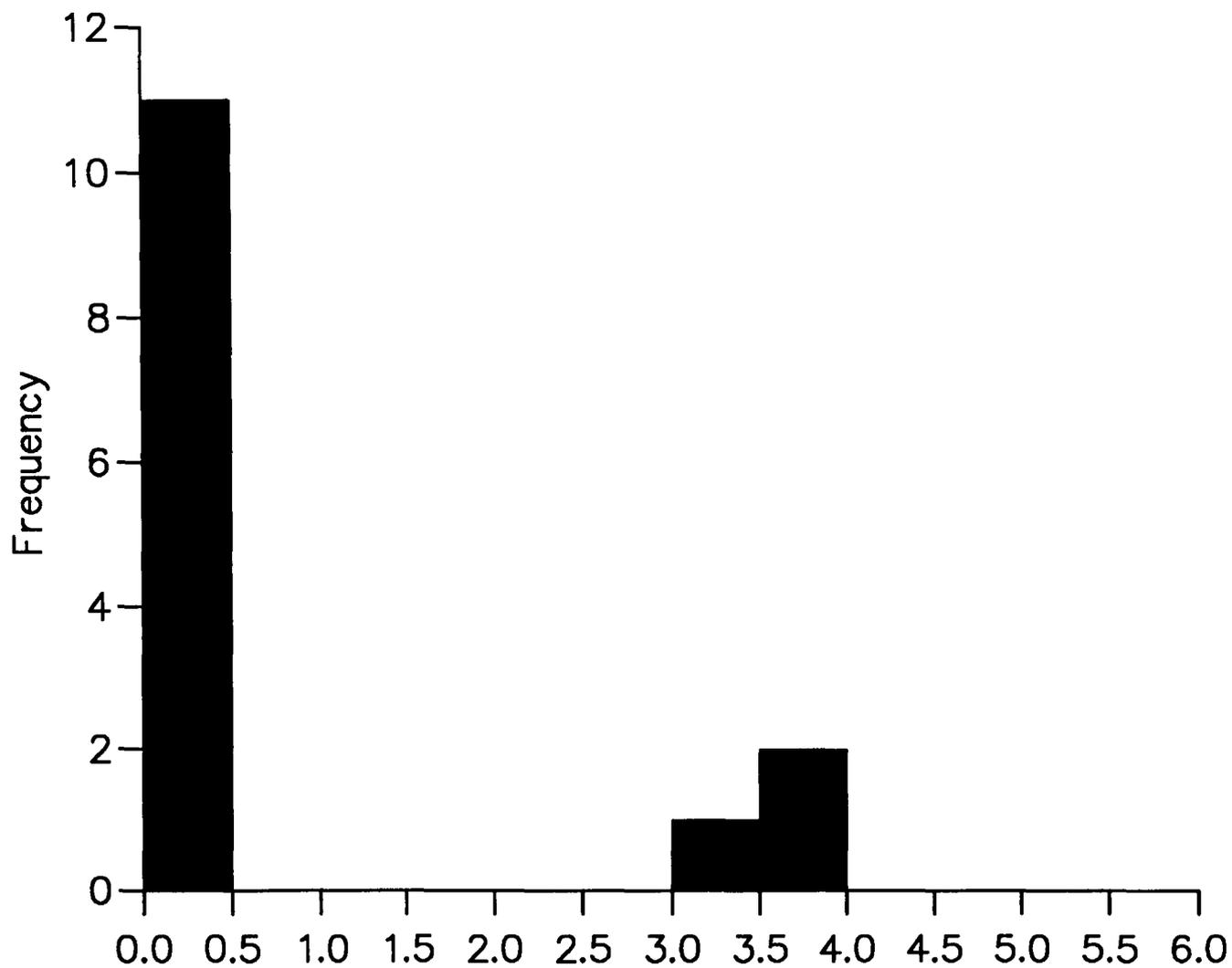


Figure 6.122. MBM Model Histogram: 8,000 Years B.P. Palaeogeography - Higher Sea-Level
with data from Table 6.11.



8,000 Years B.P. Palaeogeography - Higher Sea-Level (metres above mean sea-level)

Figure 6.123.

LIVERPOOL BAY MODEL 8,000 Years B.P. Palaeogeography

Lower Sea-Level

Maximum Tidal Heights (m.)

124

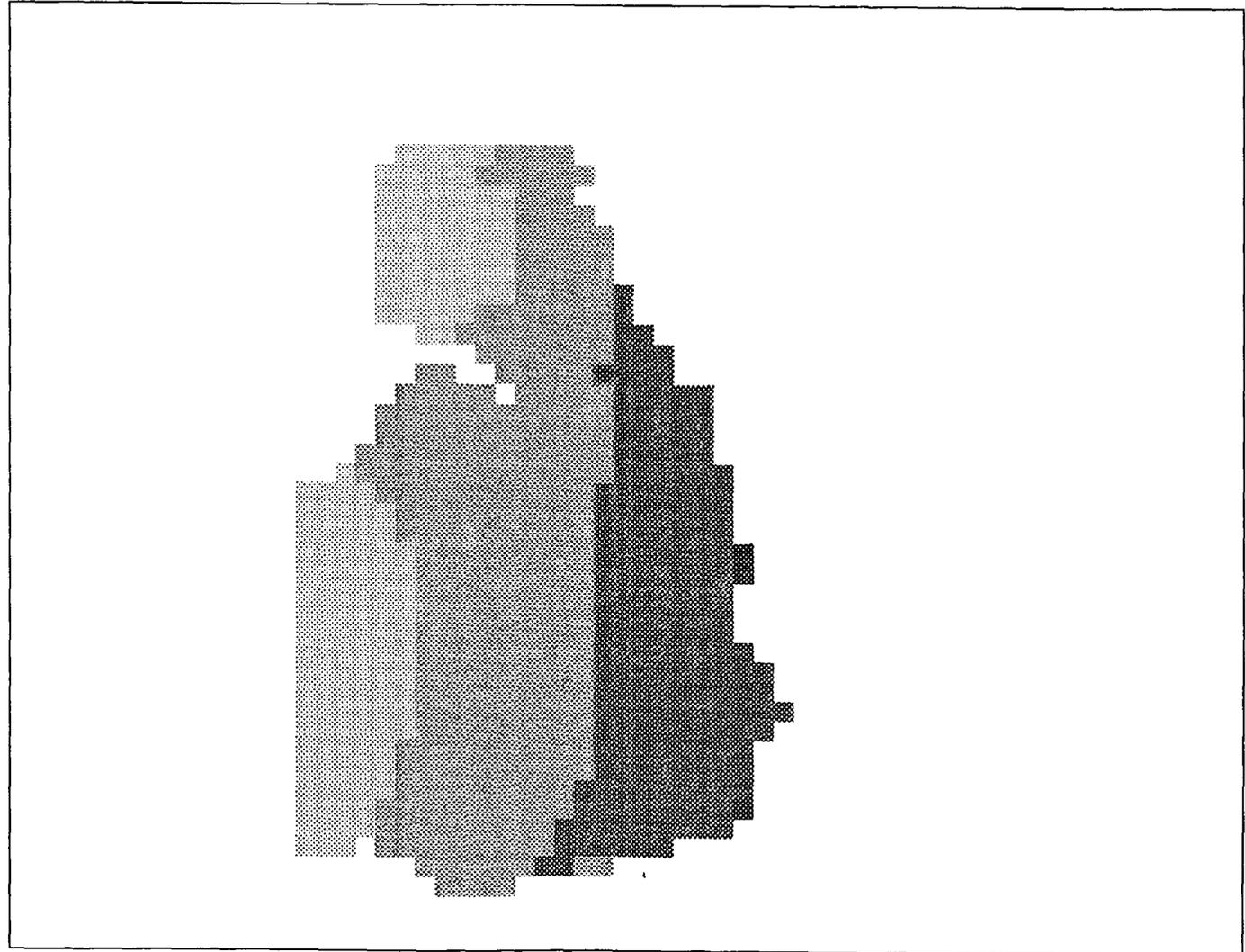
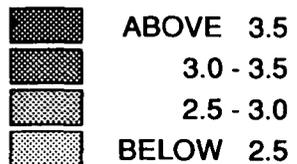


Figure 6.124.

LIVERPOOL BAY MODEL Present Sea-Level Minus

8,000 Years B.P. Palaeogeography Lower Sea-Level

Maximum Tidal Heights (m.)

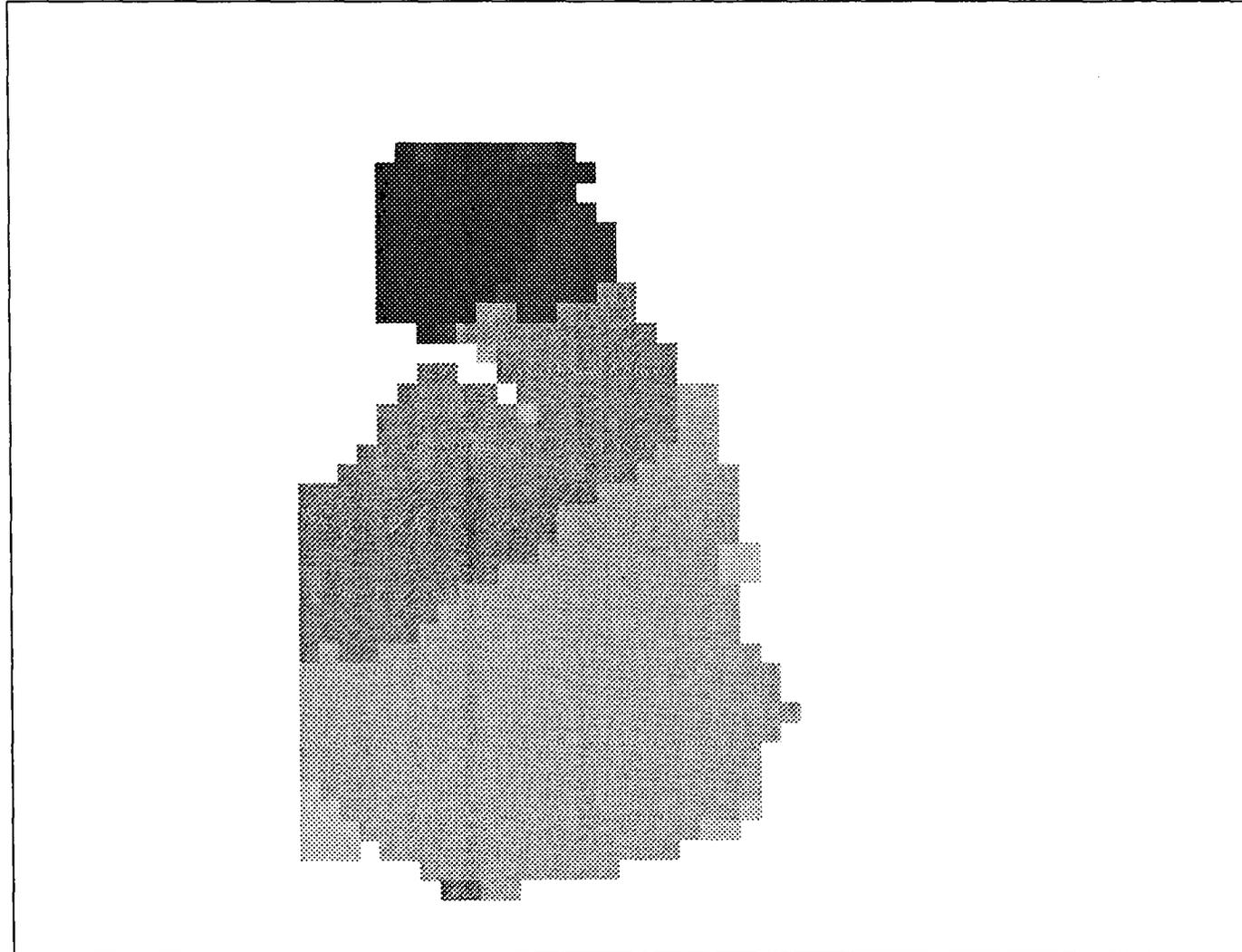
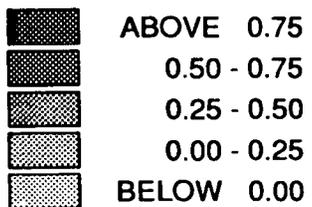


Figure 6.125.

LIVERPOOL BAY MODEL 5,000 Years B.P. Palaeogeography

Minus 8,000 Years B.P. Palaeogeography Lower Sea-Level Maximum Tidal Heights (m.)

126

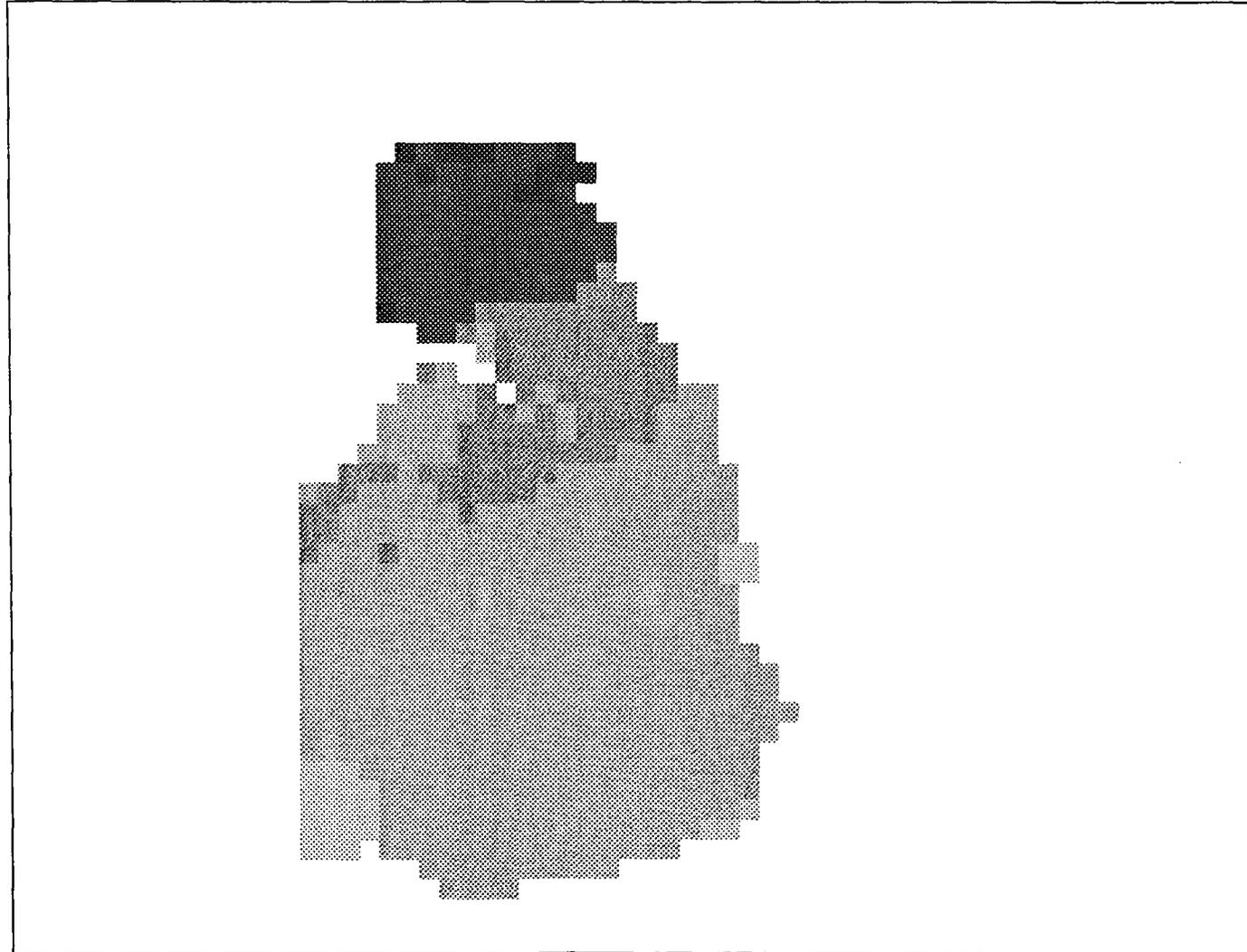
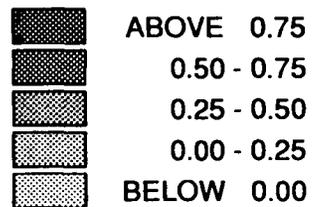


Figure 6.126.

LIVERPOOL BAY MODEL 8,000 Years B.P. Palaeogeography

Higher Sea-Level Minus Lower Sea-Level Simulations
Maximum Tidal Heights (m.)

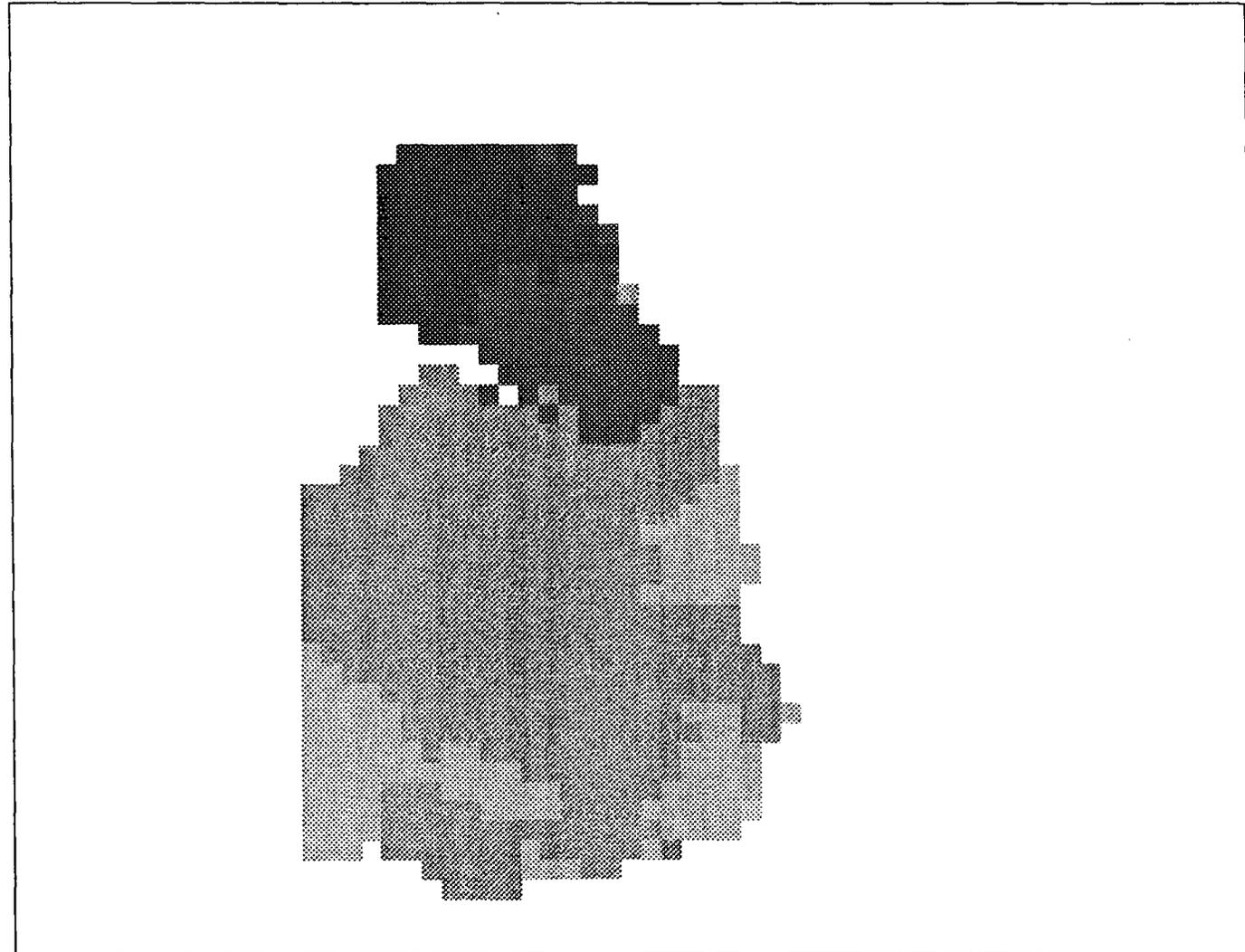
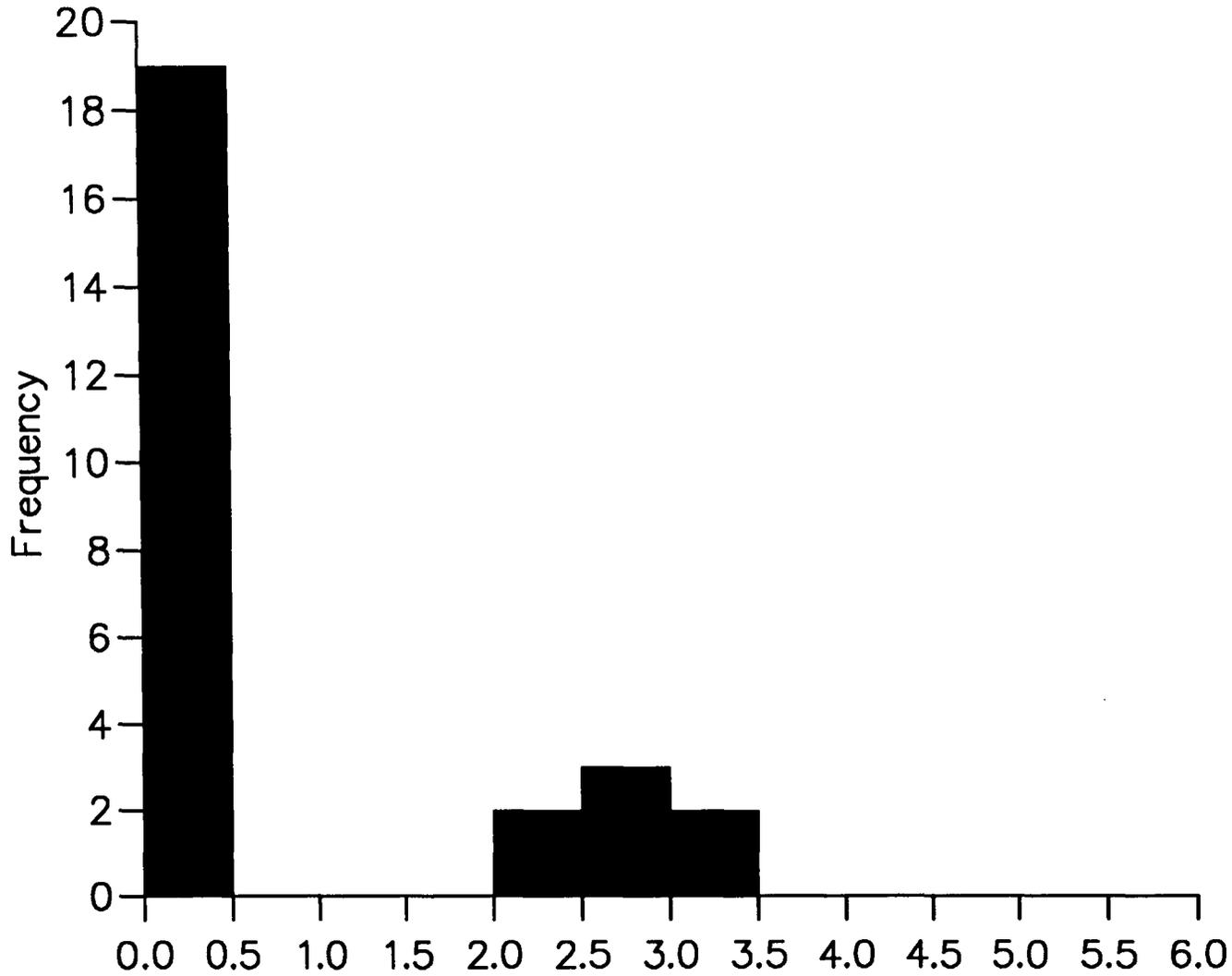


Figure 6.127. LBM Model Histogram: 8,000 Years B.P. Palaeogeography - Lower Sea-Level with data from Table 6.9.



8,000 Years B.P. Palaeogeography - Lower Sea-Level (metres above mean sea-level)