

6.0 RESULTS - BIOLOGICAL RESOURCES

6.1 Impact of Dredging Outside the Boundaries of the Licence Area

6.1.2 Abundance and Variety of Benthos

A list of the taxa recorded from the sediments of the North Nab survey area is given in Appendix Table 3. In all, a total of as many as 316 taxa were recorded. Polychaeta and Crustacea dominated the whole assemblage, although hydroids, Mollusca and Bryozoa were also important at some stations.

The species variety and abundance of individuals of macrofauna at each of the sampling stations is summarised in Appendix Table 4. This shows the species identification code from Appendix 3 in parentheses, followed by the number of individuals of each species per 0.2 m² Hamon grab sample. The total number of individuals and the total number of species recorded in the sample is shown in the final columns of Appendix Table 4. Inspection of Appendix Table 4 shows that both the species variety and abundance of individuals varied widely throughout the survey area. A maximum species variety of 71 species was recorded at Station 144 with a minimum of only 1-4 species in sandy deposits at Stations 80-82.

The population density of macrobenthos also showed large variations throughout the survey area. Inspection of Appendix Table 4 shows that a maximum of as many as 1,423 individuals per 0.2m² Hamon grab sample was recorded at Station 144. A minimum value of only 1 individual per 0.2m² was recorded in sandy deposits at Station 82. The average values for the North Nab survey area were: total number of taxa recorded = 316: Number of species (*S*) = 26.8 (s.d. 14.96); Number of individuals (*N*) = 199.5 (s.d. 244.1).

The corresponding values for the biomass of the main faunal components are summarised in Appendix Table 5. This shows the biomass as grams ash-free dry weight (AFDW) estimated for each of the main faunal groups estimated from the blotted wet weight using the following conversion factors (Eleftheriou and Basford, 1989):

Polychaetes x 0.155;
Crustaceans x 0.225;
Molluscs x 0.085;
Echinoderms x 0.08;
Other Groups x 0.155

The total biomass of macrofauna expressed as AFDW in grams is shown for each of the sampling stations in the final column of Appendix Table 5.

The values for the number of species (S), the population density (N), the biomass (B) and the size of individuals (B/N) for each of the stations sampled in the North Nab study site are summarised in Text Table 6.1.2a

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Station #	Volume of sample (litres per 0.2m ²)	No. of Species (S)	No. of Individuals per 0.2m ² (N)	Biomass (AFDW) grams per 0.2m ² (B)	Size (mg) biomass/ individuals (B/N)
1	8	17	233	0.1904	0.817
3	6	40	266	1.4352	5.395
5	1	18	57	0.4358	7.646
6	6	24	71	0.2705	3.81
7	8	20	160	0.3264	2.04
8	4	27	107	0.3661	3.421
9	8	38	251	1.5378	6.127
10	10	22	116	0.7558	6.516
11	9	38	214	1.8789	8.78
12	1	15	34	0.0373	1.103
13	1	17	33	0.2201	6.67
16	8	51	299	1.4146	4.731
17	2	26	123	1.6352	13.294
18	20	33	623	5.5984	8.986
20	20	26	404	1.0606	2.625
21	5	38	210	0.5208	2.48
22	2	16	65	0.0189	0.291
23	10	35	166	0.7884	4.75
24	8	21	59	0.3856	6.536
25	20	9	17	0.0465	2.735
26	0.25	10	12	0.0709	5.908
27	8	6	8	0.0155	1.938
28	20	3	6	0.4464	74.4
32	6	46	116	0.263	2.267
33	0.25	4	5	0.0935	18.7
34	10	47	396	11.727	29.614
35	8	28	149	1.2726	8.541
36	8	15	302	1.9822	6.564
37	20	26	918	21.8398	23.791
38	0.25	30	1223	9.385	7.674
39	12	22	267	2.1763	8.151
40	4	29	274	1.9507	7.119
41	22	26	268	4.051	15.116
42	20	21	72	0.5515	7.66
43	20	4	9	<0.01	<1.11
44	15	3	6	0.2155	35.917
45	20	2	6	0.2604	43.4
46	20	5	16	0.217	13.563
47	20	4	12	0.0744	6.2
49	8	20	425	1.376	3.238
50	2	61	193	1.5327	7.941
51	0.25	17	33	1.0954	33.194
52	0.75	25	83	0.3385	4.078
53	20	24	192	3.7748	19.66
54	8	35	318	3.8566	12.128
55	0.25	8	88	5.0308	57.168
56	15	26	150	0.725	4.833
57	10	44	163	5.0756	31.139
58	5.25	39	142	4.4844	31.58

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59	20	18	33	0.2148	6.509
60	2	17	20	0.376	18.8
61	1	13	15	0.0491	3.273
62	20	20	89	2.4184	27.173
63	20	6	18	0.1364	7.578
64	20	2	4	0.0032	0.8
65	7	19	37	0.1712	4.627
67	3	32	121	0.654	5.405
68	1	61	246	2.135	8.679
69	8	30	134	0.6785	5.063
70	20	19	97	0.168	1.732
71	18	37	518	9.5504	18.437
72	5	30	148	0.6708	4.532
73	15	34	386	2.387	6.184
74	4	23	111	1.4272	12.857
75	25	31	171	1.0322	6.036
76	20	23	175	1.1916	6.809
77	15	20	43	0.0839	1.951
78	7	13	22	0.038	1.727
79	10	9	14	0.0837	5.979
80	20	4	6	0.0093	1.55
81	20	4	12	0.1116	9.3
82	20	1	1	<0.01	<10
84	4	39	151	1.3361	88.483
85	7	42	189	8.3026	43.929
86	8	19	237	0.5613	2.368
87	8	29	163	2.9794	18.279
88	10	28	228	0.8527	3.74
89	15	29	253	0.842	3.328
90	20	29	135	0.1509	1.118
91	15	36	123	0.7176	5.834
92	15	35	136	0.3822	2.81
93	15	21	37	0.3625	9.797
94	10	28	73	0.3657	5.01
95	5	39	245	3.461	14.127
96	15	17	66	0.2189	3.317
97	4	20	33	0.1248	3.782
98	5	14	23	0.2525	10.978
99	20	4	14	0.2046	14.614
104	9	16	62	0.3961	6.389
106	20	24	114	0.914	8.018
108	21	35	289	26.1456	90.469
109	5	34	80	0.8845	11.056
111	0.5	14	31	0.0524	1.69
113	4	42	324	1.5361	4.741
115	10	33	279	0.9242	3.313
116	20	24	231	2.6636	11.531
117	6	29	106	0.4894	4.617
118	17	25	89	0.5939	6.673
119	10	23	83	0.5114	6.161
120	24	25	362	2.0996	5.8
121	5	18	126	0.1958	1.554
122	15	28	98	0.2353	2.401

123	7	30	109	0.3013	2.764
124	20	10	116	0.9642	8.312
125	8	35	125	1.2606	10.085
126	20	11	26	0.0259	0.996
127	15	35	77	0.2314	3.005
128	3	36	152	0.4626	3.043
129	6	24	135	0.6098	4.517
130	4	23	51	0.2556	5.011
131	7	46	296	0.8887	3.002
132	8	33	108	0.5134	4.754
133	8	43	104	0.3329	3.201
134	8	21	169	0.6055	3.583
135	9	36	1337	13.2447	9.906
136	8	33	360	0.1703	0.473
137	6	26	333	2.1058	6.324
138	7	55	677	2.3263	3.436
139	6	21	44	0.0369	0.839
140	8	20	157	0.258	1.643
141	9	22	130	0.1485	1.142
142	7	68	492	5.3613	10.897
143	14	64	848	10.6218	12.526
144	14	71	1423	27.8532	19.574
145	8	48	546	9.0035	16.49
146	14	52	599	7.6634	12.794
147	14	38	330	0.9828	2.978
148	10	52	270	0.4831	1.789
149	12	56	241	0.7837	3.252
150	14	60	679	3.1514	4.641
151	14	12	42	0.2486	5.919
Mean	10.55	26.77	199.52	2.11	10.38
S.D.	6.69	14.96	244.1	4.36	14.77
N	131	131	131	131	131

Text Table 6.1.2a. Values for the volume of sediment sampled, the number of species (S), the population density (N), the biomass (g AFDW per 0.2m²), and the body size (biomass mg AFDW / N) of macrofauna at each of a series of stations sampled with a 0.2m² Hamon grab in March 1999 in the North Nab Study site. Data compiled from Appendix Tables 1, 4 and 5.

This shows several features of interest when compared with the results of surveys that we have carried out as part of baseline studies of unexploited deposits using similar methods in recent years and which are summarised in Text Table 6.1.2b.

Site	Total Taxa	Mean Species per 0.2m ²	Mean Individuals per 0.2m ²	Biomass g AFDW	N	Source
St. Catherine's Isle of Wight	270	37±22	918±1166	5.59±8.97	52	MESL, 1996a
Folkestone, Kent	343	37±25	595±777	4.95±23.6	70	MESL, 1996b
Orford Ness, Suffolk	223	30±20	949±4056	3.18 ±9.7	60	MESL, 1997a
Lowestoft, Norfolk	-	36	1488	5.66	-	Recalculated from Kenny <i>et al.</i> 1998
Lowestoft, Norfolk	112	9±5	134±272	1.49±3.49	60	MESL, 1997b
Tay Estuary	38	6±4	108±243	0.036±0.076	25	MESL, 1998
West Channel	229	20.78±14.79	77.97±89.09	1.47± 2.45	91	MESL, 1999a
West Bassurelle	294	44.04±18.84	186.44± 109.95	2.41± 2.85	100	MESL, 1999b
North Nab	316	26.77±14.96	199.52± 244.08	2.11±4.36	131	This study

Text Table 6.1.2b. Comparison of survey data recorded for the vicinity of a worked site at North Nab Production Licence Area 122/3 with the results of surveys of the macrofauna of unexploited deposits in U.K coastal waters

Inspection of the data summarised in Text Table 6.1.2b shows that the total number of taxa recorded in the North Nab survey area is generally similar to that in unexploited deposits in the central mid-English Channel, as well as in deposits near to the Isle of Wight and in the eastern English Channel. The average species variety (*S*) and population density (*N*) of macrofauna is also within the range of that recorded in unexploited deposits nearby. The values for biomass in the deposits of the worked North Nab Licence Area 122/3 are similar to those recorded elsewhere. In general, values of 1.5 g AFDW to 5.0 g AFDW per 0.2 m² have been recorded from unexploited deposits. The average biomass of benthic macrofauna in the vicinity of the North Nab Licence Area 122/3 was 2.11 g AFDW per 0.2 m².

It is noteworthy that in some instances the biomass values reached 30-90 g AFDW per 0.2 m² particularly in stations outside the boundaries of the dredged site and which correspond with the zone of dispersion of material discharged during normal loading operations. The significance of this is discussed in Section 6.5 of this Report.

6.1.3 Multivariate Analysis of Community Composition

It has been shown above that the macrofauna of the deposits in the survey area in the vicinity of North Nab Production Licence Area 122/3 shows considerable variation in both species variety and population density. Differences and similarities in community composition in the survey area are best analysed by non-parametric multivariate techniques, despite the variability in the samples.

Gray *et al.* (1988) showed that ordinations for macrobenthic community structure at six stations in Frierfjord, Norway, were similar to the results for the entire species complement even when only 20% of the species, selected at random, were used in the analyses. Warwick (1993) subsequently showed that analysis at taxonomic levels higher than that of species shows similar patterns to the full species analysis. The fact that there is a high degree of variability between single samples taken at each of the survey stations is therefore unlikely to affect the interpretation of the results of multivariate analysis of community composition, since each of the single samples taken evidently contains sufficient taxa to define the community from which the sample was taken (see also Clarke and Warwick, 1998).

A group average sorting dendrogram showing the percentage similarity of the macrofauna at each of the stations sampled in the North Nab survey area is shown in Figure 6.1.3a. This shows that there are several clearly defined assemblages or Groups of macrofauna in the survey area. These have been designated Group A (coded red), Group B (coded green), Group C (coded blue) and Group D (coded brown).

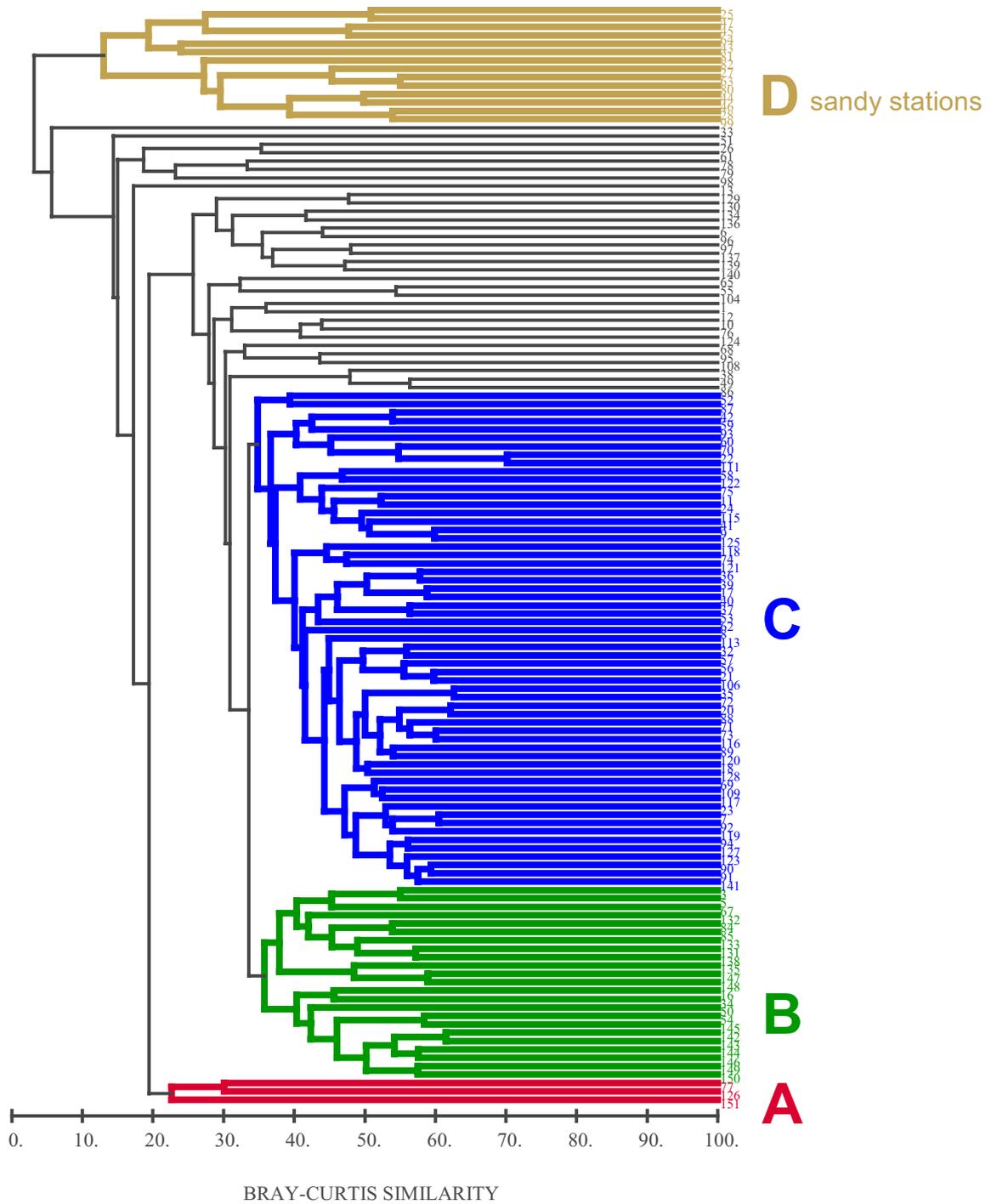


Figure 6.1.3a. Group average sorting dendrogram showing the percentage similarity of the macrofauna at each of the stations sampled in the North Nab survey area.

There are also a number of stations that do not clearly classify into any one group. The level of similarity of the faunal communities at each station within recognisable Groups is also rather low, reflecting the high degree of inter-sample variability in the macrofauna of marine gravels and sands. The Group D community corresponds with sandy deposits, and was so distinct that it was removed from subsequent analyses of the communities of the gravels in and surrounding the Licence Area. A group average sorting dendrogram for the reduced data set from which the fauna of sandy deposits had been excluded is shown in Figure 6.1.3b.

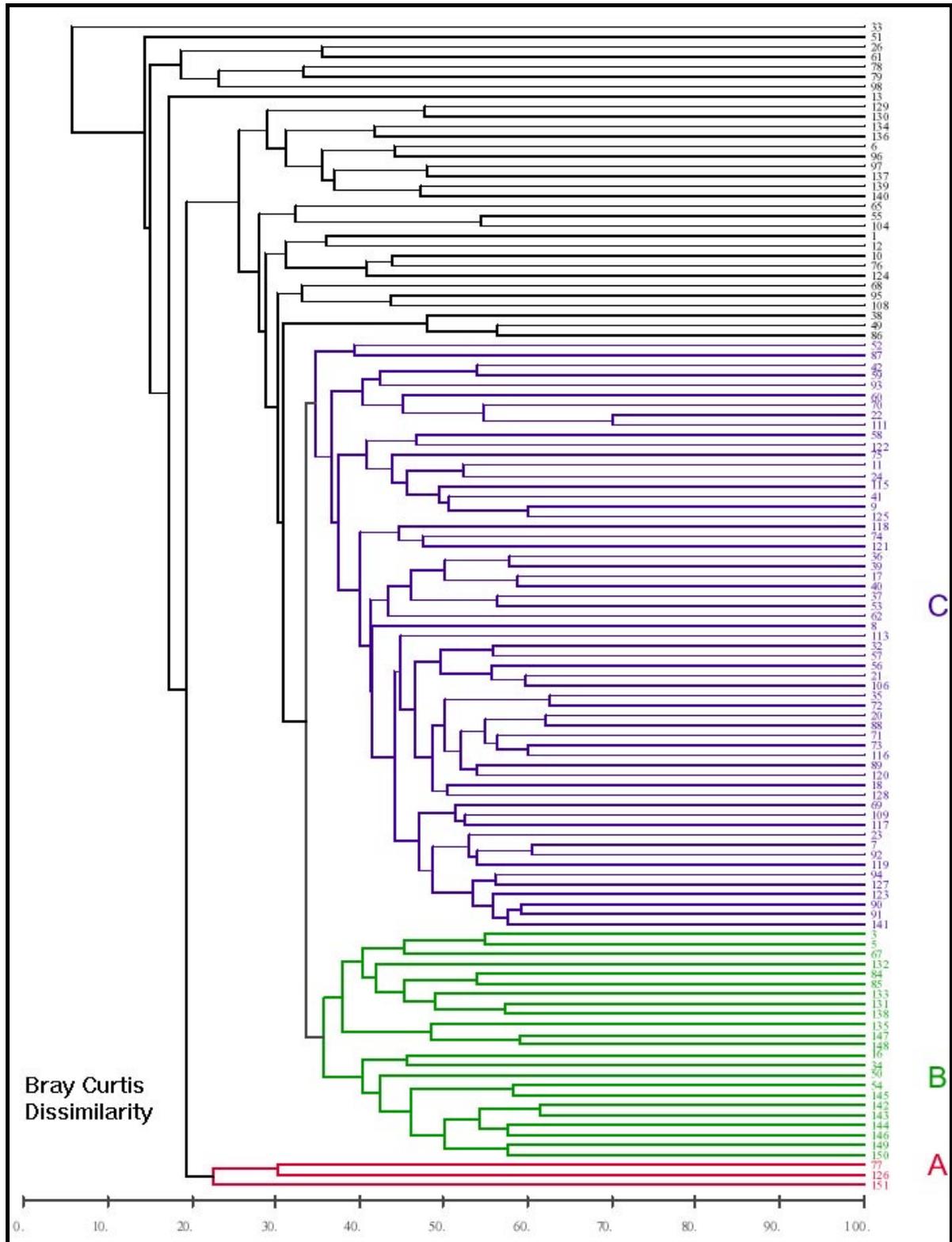


Figure 6.1.3b. Group average sorting dendrogram showing the percentage similarity of the macrofauna at a reduced number of sampling sites where the sandy deposits have been excluded.

The corresponding two-dimensional multidimensional scaling (MDS) ordination is shown in Figure 6.1.3c.

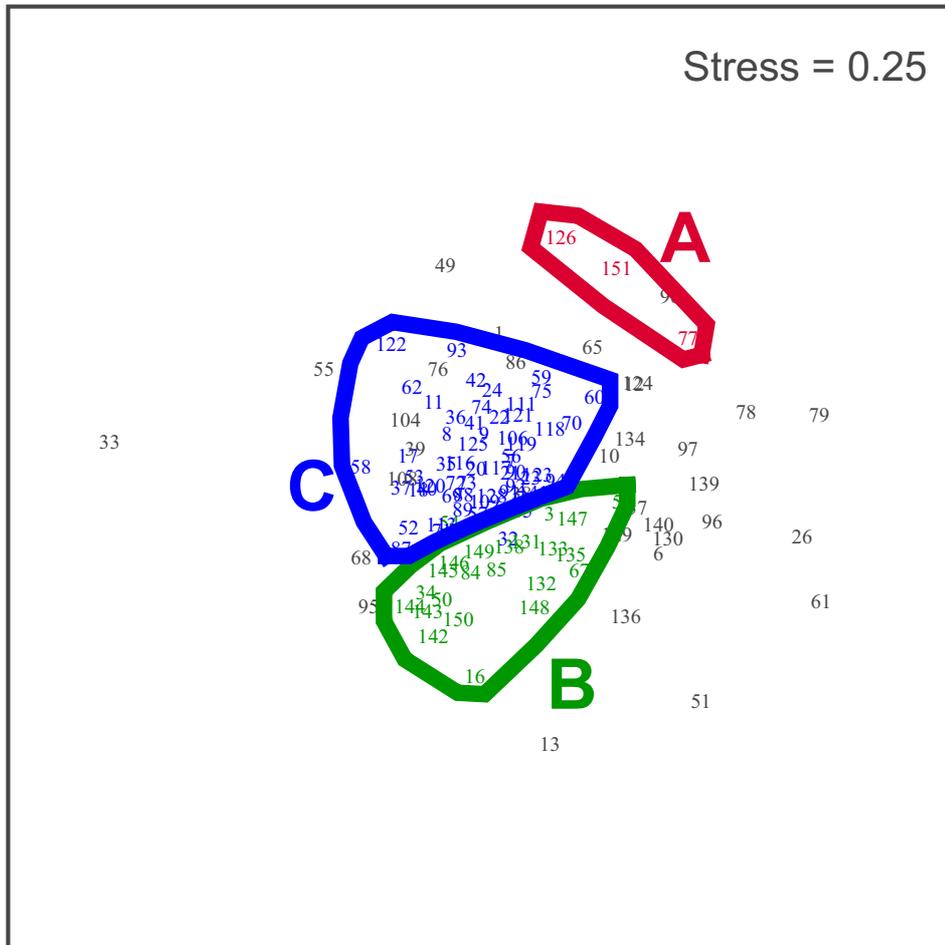


Figure 6.1.3c. Two-dimensional multidimensional scaling (MDS) ordination for the macrofauna of the North Nab survey site from which the sandy deposits have been excluded. Colour codes as in Figure 6.1.3a

These show that the macrofaunal communities fall into at least three distinct Groups or communities. These have been designated Group A (coded red), Group B (coded green) and Group C (coded blue). There is also a relatively large group of stations where the macrofaunal communities have a low level of similarity with one another and with the faunal groups that occur elsewhere in the survey area. This is very unusual, and may reflect disturbance of the macrofaunal communities in the vicinity of the dredged site, as well as other environmental factors. This group of dissimilar stations is also shown in Figure 6.1.3c. The distribution of the main faunal communities identified by multivariate analysis of macrofaunal community composition is shown in a map of the survey area in Figure 6.1.3d.

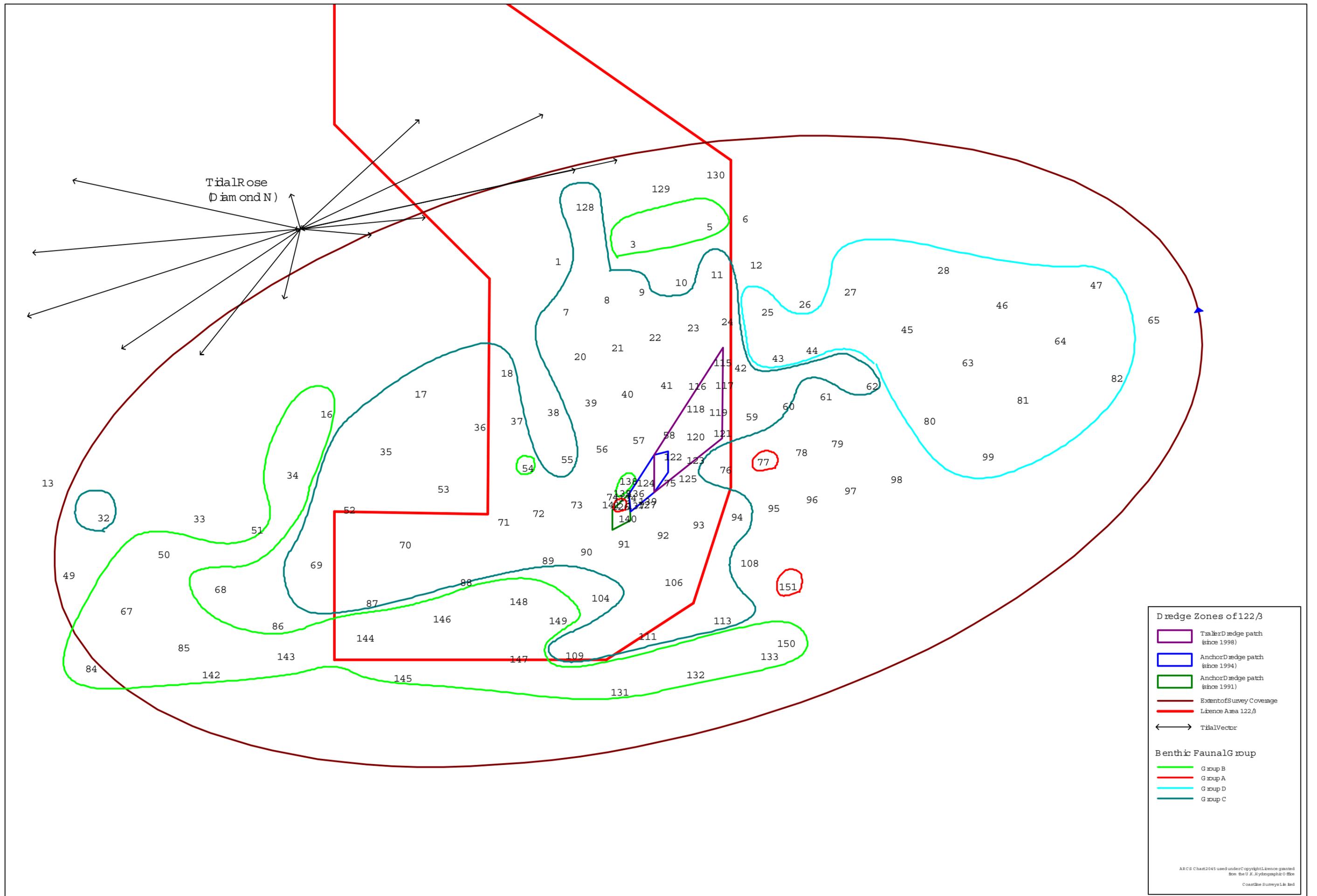


Figure 6.1.3d. Map of the survey area showing the distribution of the faunal groups identified by multivariate techniques in Figures 6.1.3b and 6.1.3c.

Figure 6.1.3d shows that the sandy community identified in Figure 6.1.3b occupies the deposits east of the Nab Tower. The Group B community (coded green in Figures 6.1.3b and 6.1.3c) occurs mainly in mixed muds and gravels to the west and south of the survey area, with a small patch to the north. The Group C community (coded blue in Figures 6.1.3b and 6.1.3c) evidently includes the macrofauna of the mixed sands and gravels of the main central part of the survey area.

Interestingly, the macrofaunal community within the immediate vicinity of the dredged site is quite distinct from that in the surrounding deposits. Similar poorly classified communities occur in mixed sands and reef communities to the south of the Nab Tower and bordering the coastal reefs in shallow waters to the south-east of the Isle of Wight. The location of the distinct group of sites where the macrofauna is dissimilar to that elsewhere is shown in an enlarged map of the dredged area and surrounding deposits in Figure 6.1.3e.

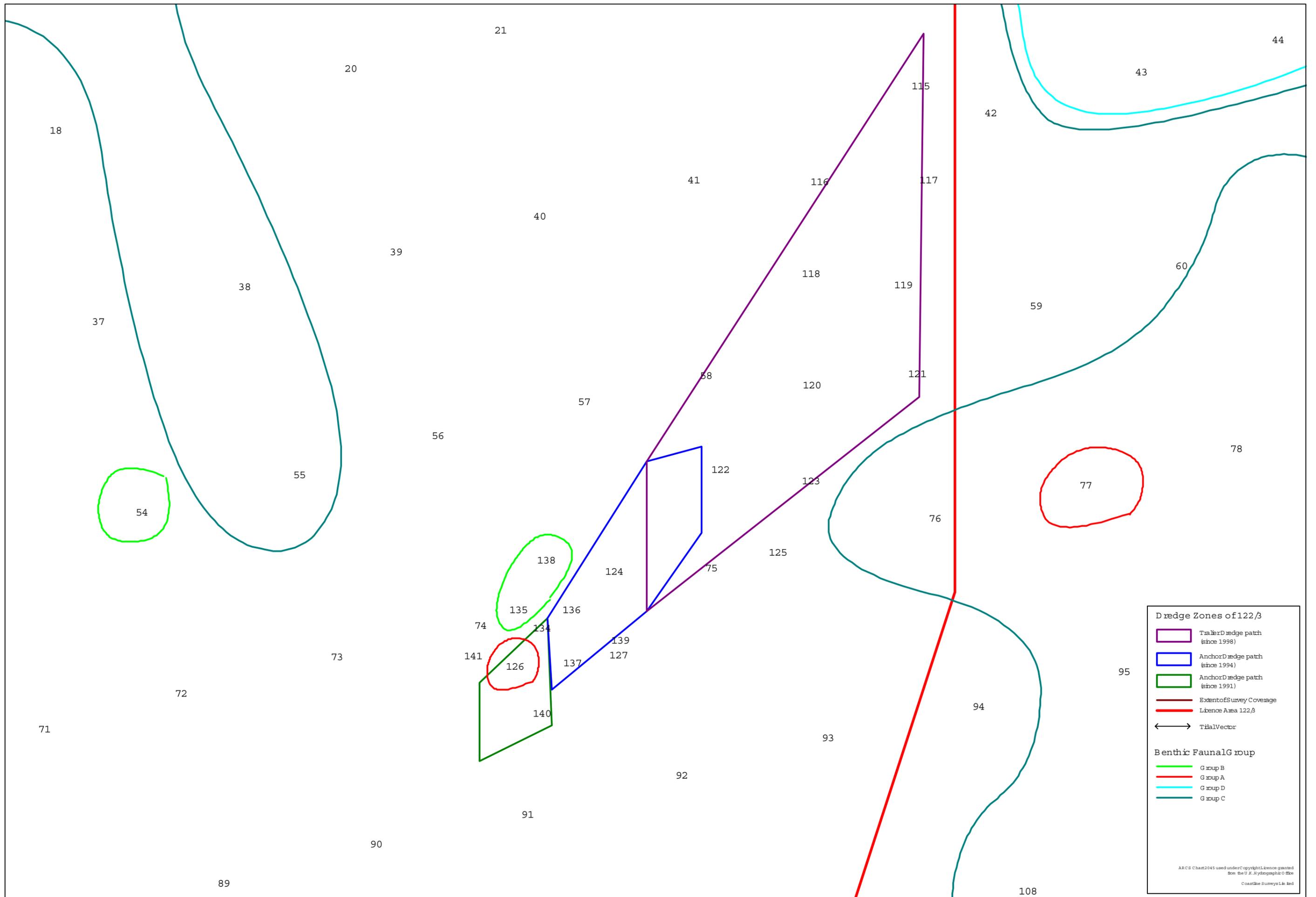


Figure 6.1.3e. Detail of the survey area showing the distribution of the faunal groups identified by multivariate techniques in Figures 6.1.3b and 6.1.3c.

There is clearly a correspondence between the area that is intensively worked by stationary dredgers and a macrofaunal community that is quite distinct from that in the surrounding deposits. A similar disruption of community structure and low similarity levels of the macrofauna following dredging has been recorded for an experimentally dredged site in the southern North Sea off Lowestoft, Norfolk by Kenny and Rees (1994, 1996).

The conclusion from multivariate analysis of biological community composition is that the sands to the east of the survey area support a clearly distinct macrofaunal community. The muddy gravels in the periphery of the survey area support a distinct (Group B) community and the mixed sands and gravels of the central part of the survey area support a third distinct (Group C) community. Superimposed on these spatial variations in community structure is a macrofaunal assemblage that shows a very low level of internal similarity and which is quite distinct in community composition to that in the surrounding deposits. This community coincides with mixed gravels and reefs and also with the zone of gravels exploitation by anchor dredging. The low level of similarity of the macrofauna within this group of stations is typical of disturbed communities or those that are in differing stages of recolonisation and recovery.

It is inferred that anchor dredging at this site has had an impact on community structure of the macrobenthos, much as reported for an intensively dredged experimental site off the Norfolk coast by Kenny and Rees (1994, 1996). Examination of Figure 6.1.3e suggests that this impact on macrofaunal community structure is confined to the dredge sites themselves and that communities in the surrounding deposits immediately outside the boundaries of the dredged area are typical of those elsewhere in the central survey area.

The fact that communities within the trailer-dredge site are similar to those in the surrounding deposits suggests that in contrast to anchor-dredging, trailer-dredging at the current level of exploitation in the Production Licence Area since 1998 has had no detectable impact on community composition of the macrofauna (see Figure 6.1.3e).

6.2 Community Structure in Relation to Aggregate Dredging

Variations in community structure of the macrobenthos in relation to aggregate dredging are generally interpreted in terms of community characteristics including population density expressed as the number of individuals (N), the species diversity (S), the biomass (B) and the size of individuals (B/N).

6.2.1 Population Density of Macrofauna in the Survey Area

A map summarising the numbers of individuals recorded per 0.2 m² Hamon grab at each of the stations sampled in the North Nab survey area is shown in Figure 6.2.1a.

This shows that the sandy deposits to the northeast of the survey area are characterised by a relatively low population density compared with the gravels that characterise the main part of the central survey area, including Production Licence Area 122/3. The muddy sands and gravels to the west of the survey area also support relatively low population densities of macrofauna. The spatial distribution of invertebrate abundance is therefore truncated by the sands to the east of the dredged site, and to some extent in the west of the survey area. The broad similarity of deposits throughout the central part of the survey area allows some inferences to be made on the impact of dredging on invertebrate community structure in gravels.

The distribution of areas of high invertebrate population density within the gravel deposits is of particular interest. Inspection of Figure 6.2.1a shows that there is a zone of high population density of >1000 individuals per 0.2 m² approximately 3 km downstream on the axis of dispersion of material discharged from the anchor-dredged site on the west-going (ebb) current. There are also zones of enhanced population density approximately 1-1.5 km across the axis of dispersion of material from the dredged site.

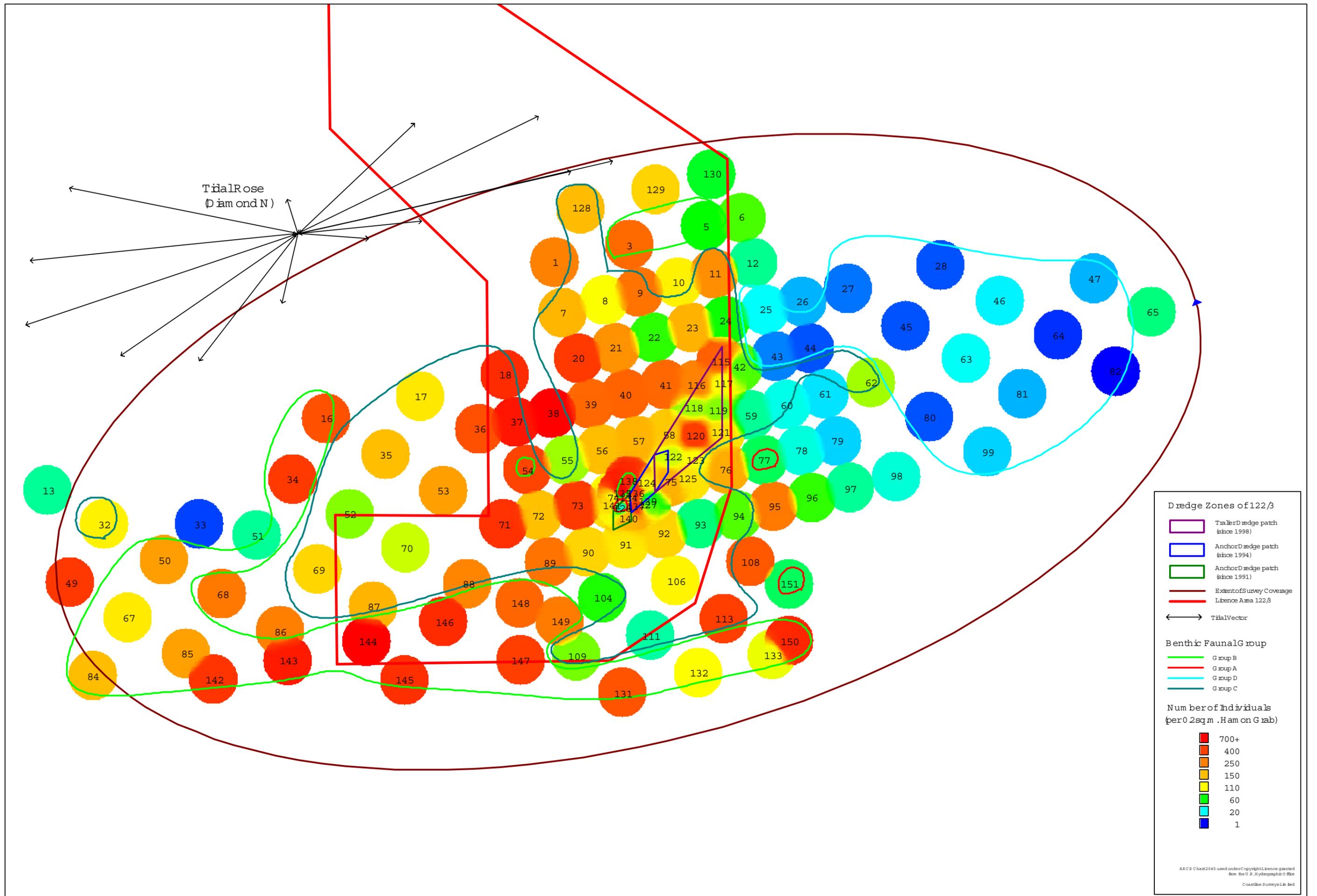


Figure 6.2.1a. Response surface diagram and corresponding spectral plot showing the number of individuals of macrofauna recorded per 0.2 m² Ham on grab sample at each of the stations sampled in the North Nab survey area.

These areas of enhanced invertebrate population density are similar to those reported to occur beyond the boundaries of dredged areas in Moreton Bay, Queensland, by Poiner and Kennedy (1984). They attributed this to the release of organic matter from the sediments during the dredging process; this material then being carried by currents outside the boundaries of the dredged area.

6.2.2 Species Diversity in the Survey Area

A map showing the number of species of macrofauna at each of the stations sampled in the survey area is shown in Figure 6.2.2a.

As in the case of population density, the sands to the northeast of the dredged site are relatively impoverished compared with the gravels that characterise the central part of the survey area.

Gravel deposits to the southwest of the dredged area show a broad zone of enhancement with maximum values of >50 species at stations approximately 3 km to the south west of the intensively dredged site. Other zones of high species variety occur up to 1.5 km to the northwest and southeast of the dredge site. This horseshoe-shaped zone of high species variety is truncated to the east by sandy deposits, and is consistent with a far-field impact enrichment from organic matter in the dispersing outwash from the dredged site.

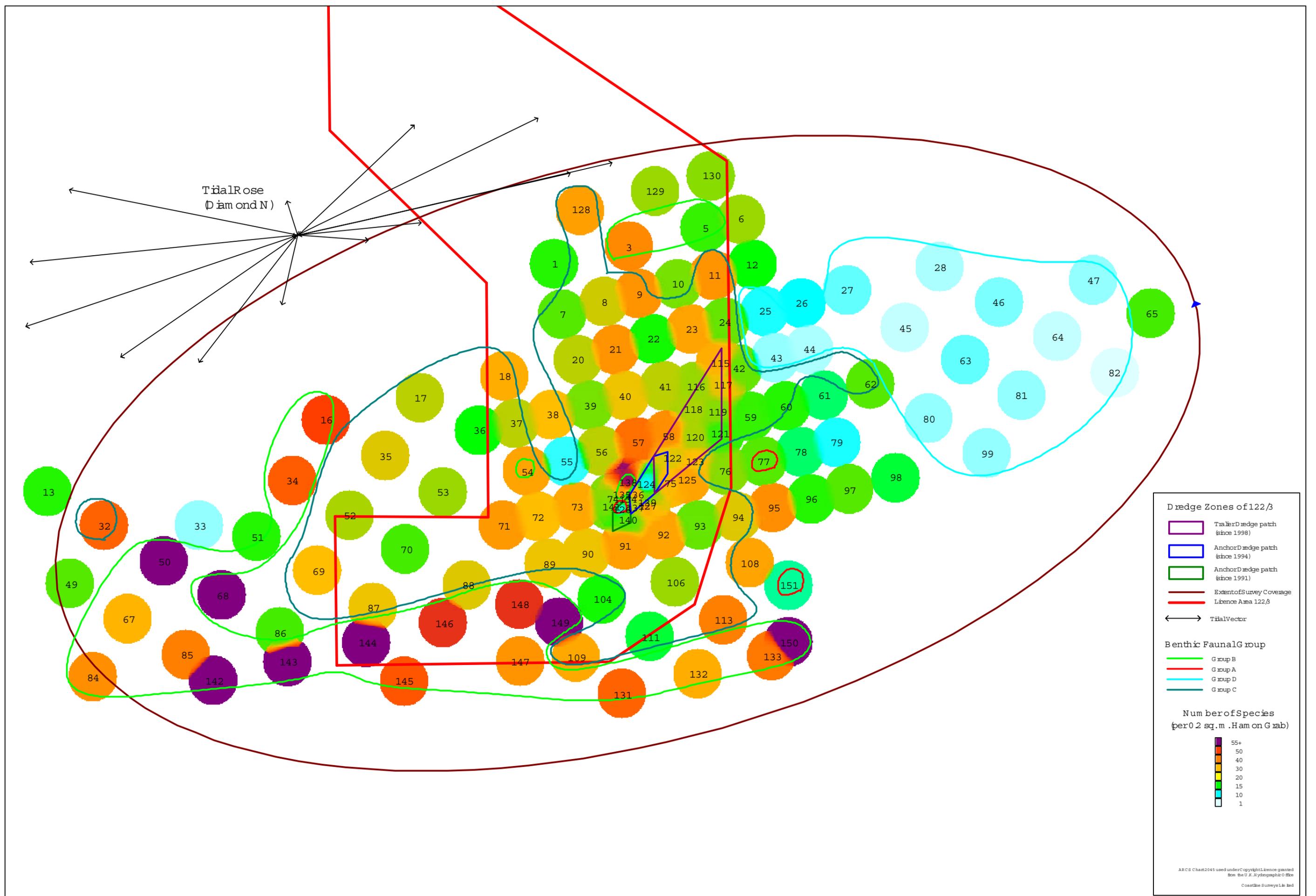


Figure 6.2.2a. Map of the North Nab survey area showing a grid of 151 sampling stations with a color scale for the number of species of macrofauna (<1mm) per 0.2sq.m Ham on Grab

6.2.3 Distribution of Biomass in the Survey Area

A map for the total biomass recorded at each of the sampling stations in the survey area is shown in Figure 6.2.3a.

As in the case of population density and species variety, the distribution is clearly affected by the sand deposits that occur to the east and northeast of the dredge site. Elsewhere, however there is some evidence of a horseshoe-shaped zone of enhanced macrofaunal biomass that extends approximately 3 km to the southwest of the dredge site and approximately 1 km to the northwest and southeast. This distribution is again consistent with an enhancement of biomass associated with deposition of material on the west-going (ebb) current from the dredge site, and with near-site deposition across the axis of the main tidal current.

It is of interest to examine whether the enhanced biomass is attributable to any particular component of the macrofauna. Appendix Table 5 shows the contribution of each of the main faunal components to the total biomass recorded from each site. Values for the biomass of Mollusca are shown in Figure 6.2.3b.

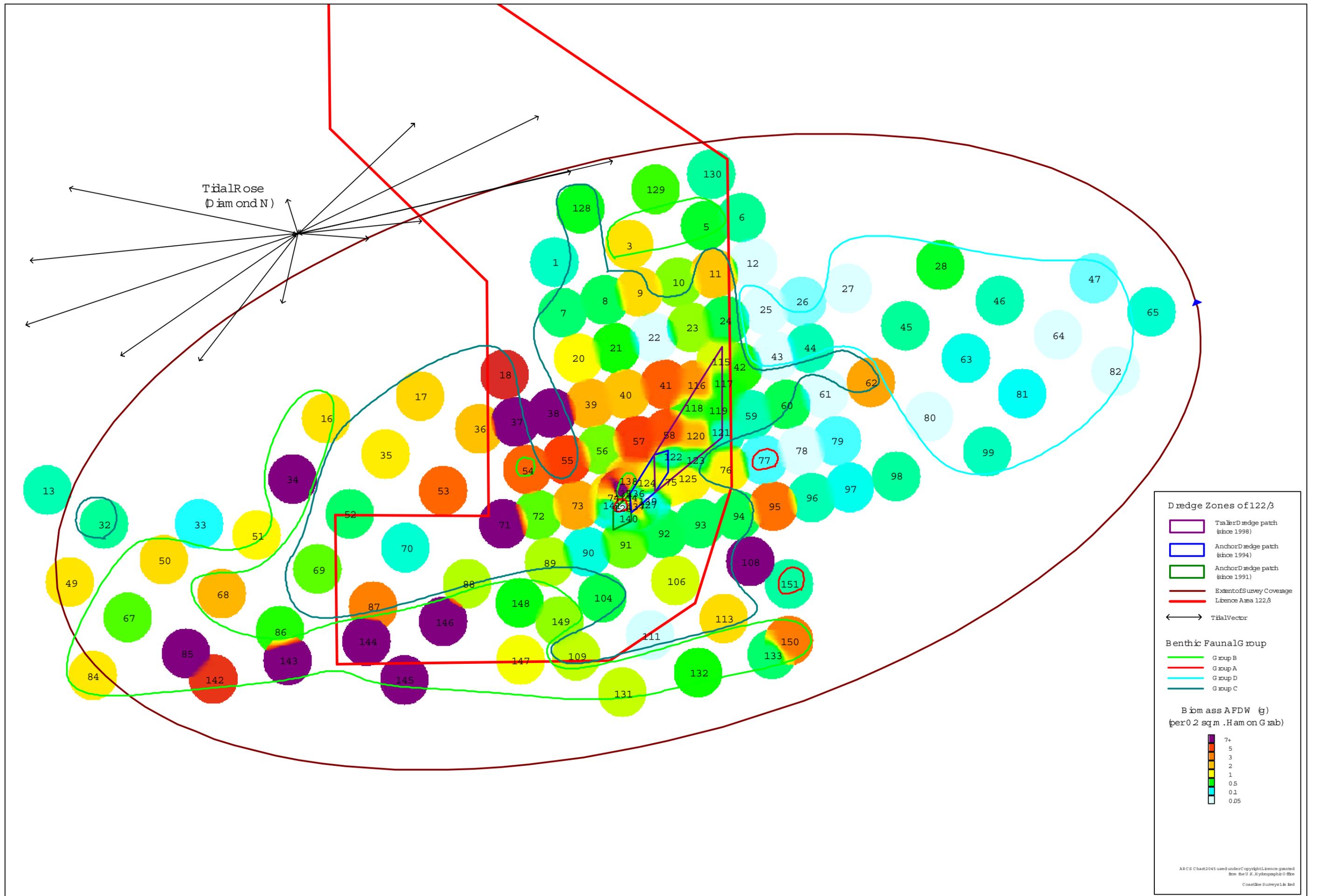


Figure 6.2.3a. Map of the North Nab survey area showing a grid of 150 sampling stations. The map is a map for the biomass (AFDW) of macrofauna (>1mm) per 0.2 sq m. Ham on Grab.

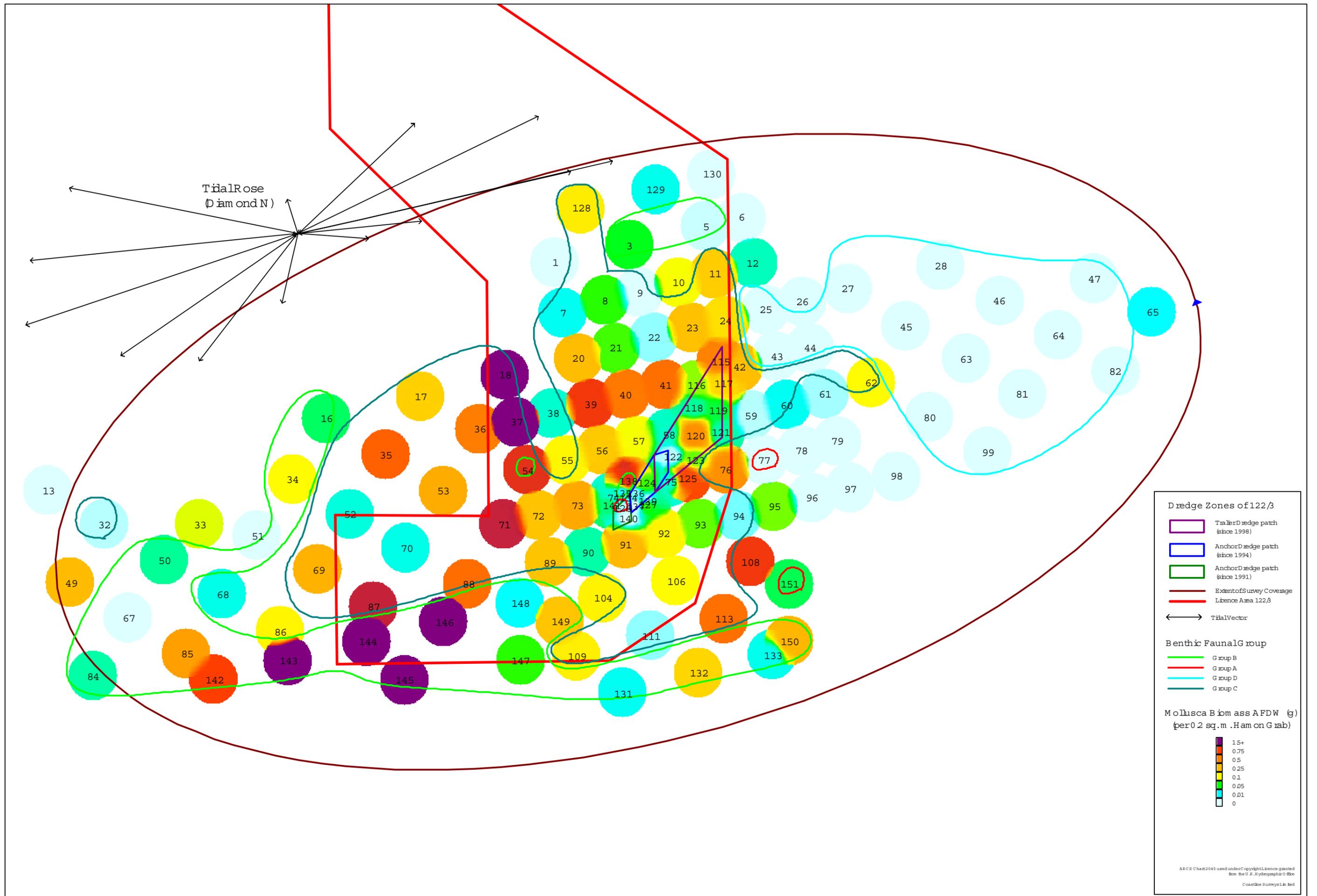


Figure 6.2.3b. Map of the North Nab survey area showing a grid thematic map for the mollusc biomass (AFDW (g) of macrofauna (>1mm) per 0.2 sq.m. Ham on Grab).

The Mollusca were dominated by high population densities of the filter-feeding American slipper-limpet (*Crepidula fornicata*). These reached maximum densities in gravel deposits approximately 2 km to the southwest of the intensively dredged area, and within 1 km to the northwest of the dredged area.

The biomass of the “Miscellaneous” groups of invertebrates shown in Appendix Table 6 comprises mainly filter-feeding particulate feeders including Bryozoa (mainly *Flustra* spp.), hydroids, ascidians and sponges.

Figure 6.2.3c shows that the sands to the east and northeast of the dredge site have a low biomass of these components, but that elsewhere there is a zone of high biomass surrounding the intensively dredged area, and extending as a truncated ‘halo’ approximately 3 km along the axis of the west-going tidal stream from the anchor-dredge area. This is again consistent with an anticipated zone of sedimentation of organic matter based on backscatter profiling data of outwash plume morphology from the Owers Bank to the east (Hitchcock and Drucker, 1996; Hitchcock *et al.*, 1998).

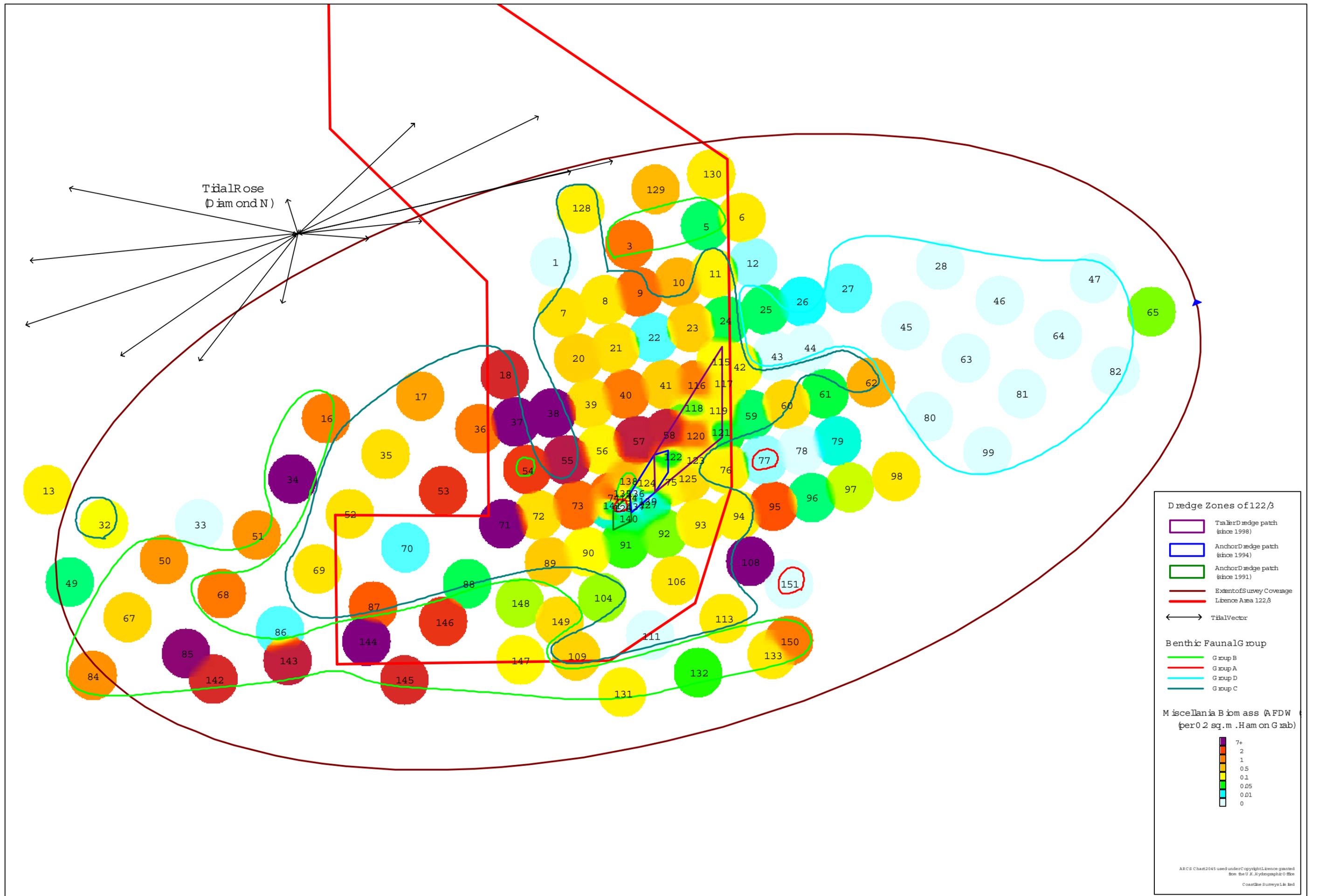


Figure 6.2.3c. Map of the North Nab survey area showing a grid thematic map for the miscellaneous biomass (AFDW/g) of macrofauna (>1mm) per 0.2 sq.m. Ham on Grab.

6.2.4 Body Size of Macrofauna in the Survey Area

A final feature that is often used in analysis of invertebrate population structure is the mean body size based on the biomass (B) and population density (N). The ratio of B/N is expressed as mg AFDW per individual in a response surface diagram and spectral plot in Figure 6.2.4.

This shows that relatively large individuals of macrofauna outside the boundaries of the intensively dredged anchor-dredge site along the axis of the tidal streams to the northeast and southwest. As in the case of the other population determinants, the zone of enhanced body size corresponds with what would be anticipated for far-field settlement of material from a dispersing plume originating at the intensively dredged anchor-dredge site in North Nab Production Licence Area 122/3.

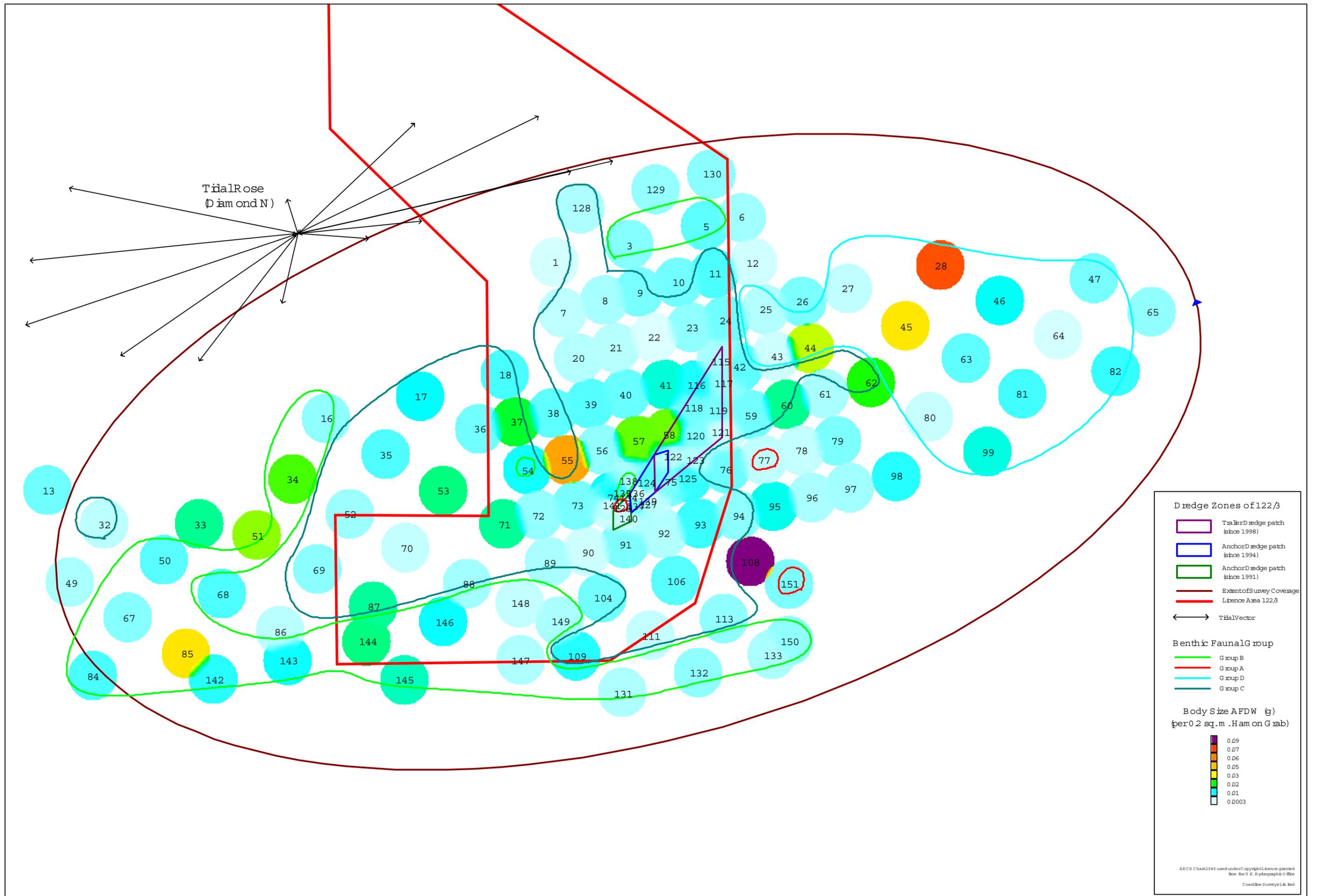


Figure 6.2.4. Map of the North Nab survey area showing a grid of 150 stations for the body size (AFDW (g)) of macrofauna (>1mm) per 0.2 sq.m. Ham on Grab.