6. Macrofaunal Biology

6.1. Introduction

This section describes benthic macrofauna (seabed-dwelling animals retained on a 0.5-mm mesh) collected from 26 stations during the 2010 Chirag Benthic survey. Station co-ordinates are given in section 2, and sediment characteristics in section 3 of this report.

The structure and composition of macrofaunal communities determined from this type of survey can provide useful information on the status of the marine benthic ecosystem which can be used to monitor the extension of pollution affected areas and temporal trends.

As noted in section 2 the 2010 survey design follows the Chirag Benthic survey of 2008. Surveys have taken place around the Chirag platform position in 1998, 2000, 2004, 2006, 2008 and 2010. Table 6.1 lists the sample stations and the years in which macrobenthic analysis was carried out. As no stations sampled for macrofaunal analysis in 1998 have been revisited in 2008, comparison between 1998 and 2010 data will be on a survey area basis only.

Table 6.1 Macrobenthic Analysis Matrix

Station	2000	2004	2006	2008	2010
1	MA	MA	MA	MA	MA
2	MA	MA	MA	MA	MA
7		MA	MA	MA	MA
8		MA	MA	MA	MA
9	MA	MA	MA	MA	MA
15	MA	MA	MA	MA	MA
16	MA			MA	MA
25	MA			MA	MA
33	MA	MA	MA	MA	MA
34		MA	MA	MA	MA
35		MA	MA	MA	MA
36		MA	MA	MA	MA
37		MA	MA	MA	MA
38			MA	MA	MA
39			MA	MA	MA
40					
41					

Station	2000	2004	2006	2008	2010
42					
43					
44					
45					
46		MA	MA	MA	MA
47		MA	MA	MA	MA
48		MA	MA	MA	MA
49		MA	MA	MA	MA
50				MA	MA
51					
52				MA	MA
53				MA	MA
54		MA	MA	MA	MA
55			MA	MA	MA
56			MA	MA	MA
57			MA	MA	MA

MA: Macrobenthic Analysis

6.2. Macrofaunal Abundance and Biomass

In addition to the taxonomic groups for which numerical estimates are reported below, the presence of Bryozoa and Hydrozoa were recorded in samples from 13 and 26 stations respectively. Abundance and biomass data are not reported for these colonial organisms, which are difficult to enumerate and hard to separate from their substrates for biomass determination.

A 'rationalised' data table was prepared which excluded these taxa and also juvenile records. Appendix 6 lists the raw data from macrobenthic analysis, and indicates which taxa were removed prior to numerical analysis. The list of the species abundance, rationalised for

numerical analysis at each station is given in table 6.2. The number of taxa identified in rationalised data set was 55, of these 49 were valid, discrete, macrobenthic taxa and 6 were identified to spp level.

Macrofaunal data can be analysed and interpreted in a number of ways, each of which provides a different type of information. Not all of the analytical methods are appropriate for all circumstances; the most appropriate method will depend on the complexity of the environment and biological communities under investigation. The three general types of analysis and interpretation include:

- Basic descriptive analysis;
- Univariate analysis;
- Multivariate analysis.

6.3. Basic descriptive analysis

In any study, it is sensible to progress from simple to complex modes of analysis. The simplest approach relies on basic features, such as the number and variety of species, and the number of individuals present at each sampling location. The biomass of macrobenthic communities is also a useful indicator of ecosystem health, and can be used to assess the ability of the ecosystem to support communities (such as fish populations) at higher trophic levels.

Table 6.2 Rationalised Species abundance (individuals per 1.0 m^2) at each station, Chirag Benthic Survey 2010

Taxon/Station	1	2	7	8	9	15	16	25	33	34	35	36	37	38	39	46	47	48	49	50	52	53	54	55	56	57
Type Nemathelminthes																										
Class Nematoda																										
Nematodes spp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	7	0	0	0
Type Annelida																										
Class Polychaeta																										
Nereis succinea	0	0	0	0	0	3	0	3	0	10	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nereis diversicolor	0	0	0	0	0	3	0	0	0	3	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0
Ampharetidae spp.	0	0	0	60	3	0	20	40	0	0	0	0	0	0	0	0	17	7	0	0	20	0	43	0	0	0
Hypania invalida	0	3	0	0	0	0	7	0	0	0	0	0	0	0	0	0	10	40	0	0	7	3	107	0	0	0
Hypaniola kowalewskii	7	0	0	63	0	3	347	53	3	0	0	3	0	0	0	3	190	73	0	13	87	7	427	0	0	0
Sabellidae spp.	117	17	37	277	13	217	3	240	337	0	10	143	0	0	3	0	0	0	10	63	17	23	33	193	0	10
Manayunkia caspica	683	53	93	760	30	577	100	707	857	0	190	383	0	0	0	40	513	427	77	197	47	57	77	430	0	13
Fabricia sabella caspica	447	40	70	530	10	443	10	547	513	0	7	260	0	0	0	20	80	133	43	153	30	33	50	233	0	0
Class Oligochaeta																										
Tubificidae spp.	0	0	23	53	43	20	0	30	7	0	0	13	3	0	0	0	0	0	27	27	3	13	23	27	0	7
Isochaetides michaelseni	33	0	27	63	23	23	100	30	7	0	77	20	10	0	0	3	80	100	20	7	7	43	70	13	0	3
Psammoryctides deserticola	50	0	23	97	97	77	280	50	63	0	93	20	17	0	0	43	243	210	70	13	7	43	293	33	0	17
Stylodrilus cernosvitovi	37	0	7	30	47	40	10	17	60	0	3	20	7	0	0	7	0	0	3	7	3	10	73	20	0	0
Type Arthropoda																										
Class Crustasea																										
Order Cirripedia																										
Balanus improvisus	97	7	40	27	0	47	153	60	13	0	140	40	113	17	37	60	67	3	103	103	17	3	0	27	20	0
Order Cumacea																										
Pterocuma rostrata	0	0	0	0	3	3	0	0	0	0	0	3	0	0	3	3	0	3	0	0	3	0	0	0	0	0
Schizorhynchus eudorelloides	0	0	0	3	0	0	0	0	0	217	0	0	0	0	0	10	0	0	0	0	0	3	233	0	3	0
Stenocuma diastyloides	0	0	3	0	17	0	0	0	3	7	0	3	7	7	3	7	10	7	3	7	10	13	0	7	33	7
Pseudocuma cercaroides	0	0	0	37	0	0	20	0	23	0	0	7	0	0	0	0	0	0	0	0	27	0	17	0	0	0
Volgocuma telmatophora	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0
Order Amphipoda																										
Pseudalibrotus platyceras	0	0	0	3	0	0	0	3	0	0	0	3	3	0	3	0	0	0	0	0	0	0	0	3	0	0
Pseudalibrotus caspius	0	3	0	0	0	3	0	0	0	0	3	0	0	0	3	3	0	0	3	3	0	0	0	0	0	0

Table 6.2 (Continued) Rationalised Species abundance (individuals per 1.0 m^2) at each station, Chirag Benthic Survey 2010

Taxon/Station	1	2	7	8	9	15	16	25	33	34	35	36	37	38	39	46	47	48	49	50	52	53	54	55	56	57
Order Amphipoda (Continued)																										
Gammaracanthus loricatus caspius	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	0	0	0
Amathillina creistata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0
Amathillina spinosa	0	0	0	0	0	0	10	0	0	0	3	0	0	0	0	0	3	3	0	0	0	0	0	7	0	0
Amathillina pusilla	3	0	3	0	0	7	30	7	0	0	0	3	7	0	3	0	23	30	3	13	0	0	10	13	0	0
Dikerogammarus oskari	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	7	0	0	0
Dikerogammarus haemobaphes	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	13	0	0	0
Gammaridae spp.	0	7	23	87	3	0	53	27	0	0	3	0	0	7	0	0	37	30	3	33	37	10	197	7	7	0
Gammarus spp	3	3	13	103	3	23	83	47	0	0	0	17	0	0	0	0	63	53	0	33	60	50	287	3	0	0
Gammarus ischnus	0	0	0	110	0	27	153	13	0	0	3	0	3	0	0	0	60	37	0	7	7	13	133	7	0	0
Gammarus pauxillus	17	7	50	540	43	140	793	147	0	0	20	47	7	0	0	13	240	253	0	87	247	240	1783	37	0	0
Niphargoides spp	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Niphargoides caspius	0	0	0	0	0	0	33	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Niphargoides grimmi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0
Niphargoides deminutus	0	0	0	3	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pontoporeia affinis microphthalma	0	3	0	0	53	3	0	0	30	0	3	0	13	20	10	13	7	43	3	3	0	357	287	7	47	390
Caspicola knipovitschi	27	0	3	0	3	7	7	10	0	0	0	7	3	0	0	0	7	0	0	0	10	3	7	0	0	0
Gmelina costata	0	0	0	17	0	13	30	0	0	0	0	0	0	0	0	0	33	30	7	0	0	3	23	0	0	0
Gmelina brachyura	3	0	0	43	0	23	63	0	0	0	0	0	0	0	0	0	47	60	7	0	0	30	43	0	0	0
Gmelinopsis aurita	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	3	0	0	0	0	0	0	0	0
Cardiophilus baeri	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Iphigenella andrussovi	0	0	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0
Corophium spp	73	80	110	120	77	97	90	183	97	0	100	157	70	43	37	97	110	117	167	183	110	80	90	187	87	57
Corophium curvispinum	30	17	20	27	20	20	23	23	20	0	13	27	7	3	13	13	23	10	17	7	10	7	20	33	10	3
Corophium mucronatum	0	0	3	10	3	10	0	10	0	0	13	0	10	3	7	10	13	7	0	3	13	10	7	7	10	7
Corophium chelicorne	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	7	0	0	0	0	0	0	0	0
Corophium nobile	7	10	7	13	7	7	0	7	17	3	7	13	17	3	13	0	10	7	13	10	13	17	20	20	7	7
Corophium volutator	3	3	0	7	0	0	17	0	0	0	3	0	0	0	0	3	0	7	0	0	0	7	3	3	0	0
Order Isopoda																										
Saduria entomon caspia	0	0	0	7	10	7	0	3	0	0	3	0	10	17	10	0	0	0	10	3	0	7	0	3	0	3

Table 6.2 (Continued) Rationalised Species abundance (individuals per 1.0 m^2) at each station, Chirag Benthic Survey 2010

Taxon/Station	1	2	7	8	9	15	16	25	33	34	35	36	37	38	39	46	47	48	49	50	52	53	54	55	56	57
Class Insecta																										
Chironomus albidus	0	0	0	0	0	0	0	0	0	0	0	7	0	0	3	0	0	0	0	0	0	3	7	3	0	0
Type Mollusca																										
Class Gastropoda																										
Turricaspia curta	0	0	0	3	0	0	0	0	0	0	7	0	0	0	3	0	0	0	3	0	0	0	0	0	0	0
Turricaspia cincta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0
Turricaspia marginata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0
Class Bivalvia																										
Mytilaster lineatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27	0	0	0	0	0	0
Dreissena rostriformis grimmi	3	0	0	40	0	83	857	73	0	0	57	0	0	0	0	0	513	3	97	113	23	0	53	0	0	0
Didacna profundicola	0	0	0	7	0	0	30	3	0	0	0	0	0	0	0	0	7	0	0	0	13	0	37	0	0	0

6.3.1. Distribution and Abundance of Taxa

The abundance (N/m^2) and taxonomic richness for each major taxonomic group at each station is given in table 6.2.

Taxonomic richness and abundance was greatest at station 54, with 4,517 per m^2 from 38 taxa. The lowest taxonomic richness was observed at station 34 with 5 taxa with a low abundance of 240 per m^2.

The spatial distribution of total abundance and taxonomic richness is given in figure 6.1. The distribution plots are relatively similar indicating that the stations with higher species richness generally had a higher abundance.

Taxonomic richness was lowest at contiguous stations 34 and 38 directly to the northeast of the platform and also station 56 2000m to the northeast. Abundance was lowest at stations 34, 38, 46 and 39 extending 750m to the northeast and stations 2 and 37 directly to the north and northwest of the platform. A low abundance was also present at station 56 located 2000m to the northeast.

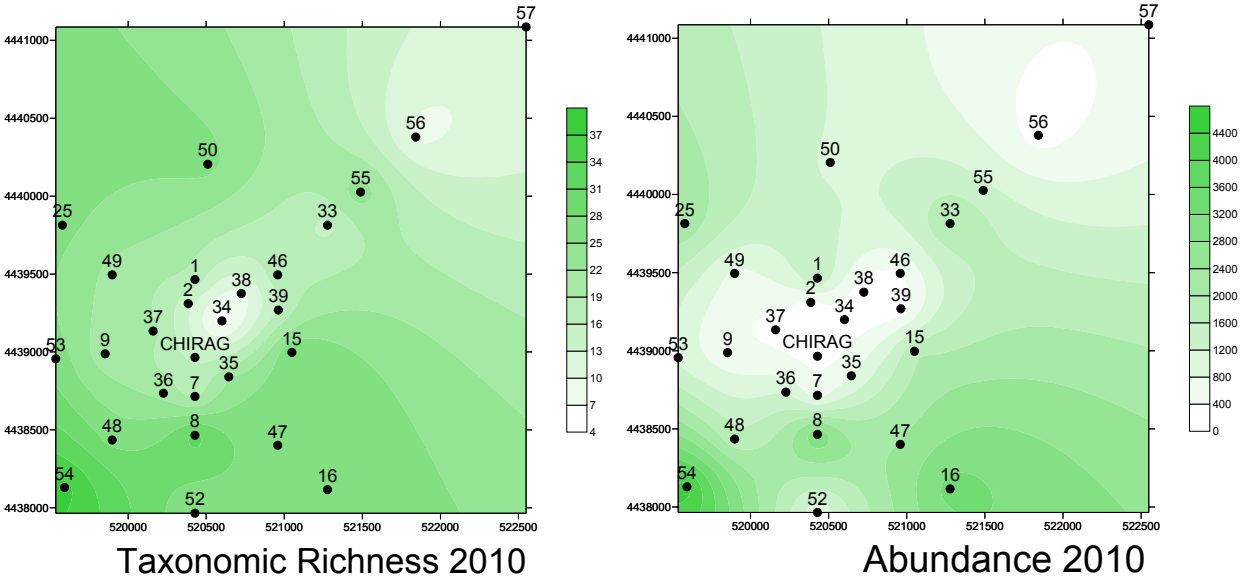

Figure 6.1 Spatial Distribution of Total Abundance and Species Richness; Chirag 2010

Of the eight polychaete species present *Manayunkia caspica* and *Fabricia sabella caspica* had the highest frequency of occurrence and were the most abundant, being present at 21 and 20 stations respectively. Two *Nereis* species (*diversicolor* & *succinea*) were identified. In combination this genus was present at 5 stations; overall abundance was low and where present ranged from 3 to 13 individuals per m^2.

Polychaetes were absent at stations 37, 38, and 56 and present in very low numbers at stations 34, 39 and 57. The highest abundance >1000 per m^2 was present at stations 1, 8, 15, 25 and 33.

Oligochaetes were absent from stations 2, 34, 38, 39 and 56. Abundance was greatest (>300 per m^2) at stations 16, 47, 48 and 54. *Psammoryctides deserticola* and to a lesser extent *Isochaetides michaelseni* were the most abundant of the 4 oligochaete species and were present at 21 of the 26 stations.

Cumacean abundance was highest at stations 34 and 53 with 223 and 253 per m^2. Abundance at all other stations was far lower and where present, ranged from 3 to 40 per m^2. The high

abundance at stations 34 and 53 was the result of a high abundance of *Schizorhynchus* with respective abundances of 217 and 233 per m^2.

Amphipods were the most taxonomically rich group with 29 species being recorded. Amphipods were present at all stations with abundance ranging from 3 per m^2 at station 34 to 2947 per m^2 at station 54. A high abundance >1000 per m^2 was also observed at stations 8 and 16. Abundance was greatest at stations on the periphery of the survey area and tended to decrease towards the platform (Fig 6.2). A similar pattern was observed for amphipod species richness (Fig 6.2).

Two *Gammarus* species were present and along with *Gammarus spp* were the most abundant genus accounting for 49% of the overall amphipod abundance. The genus *Corophium* was represented by 5 species and along with *Corophium spp* accounted for 28% of the overall amphipod abundance.

Pontoporeia affinis microphthalma was present at 18 stations. Abundance was greatest at stations 53, 54 and 57 and ranged from 287 to 390per m^2. These stations are located on the periphery of the survey area to the southwest, west and northeast. The abundance at all other stations was low and where present ranged from 3 to 53 per m^2

Isopods were present at 13 stations. Where present abundance was low and ranged from 3 to 17 per m^2.

Three gastropod species were identified, all of which were of the genus *Turricaspia*. A gastropod presence was only observed at 5 stations with abundance ranging from 3 to 17 per m^2. Bivalves were present at 12 stations, with the highest abundance being observed at stations 16 and 47 with 887 and 520 per m^2.

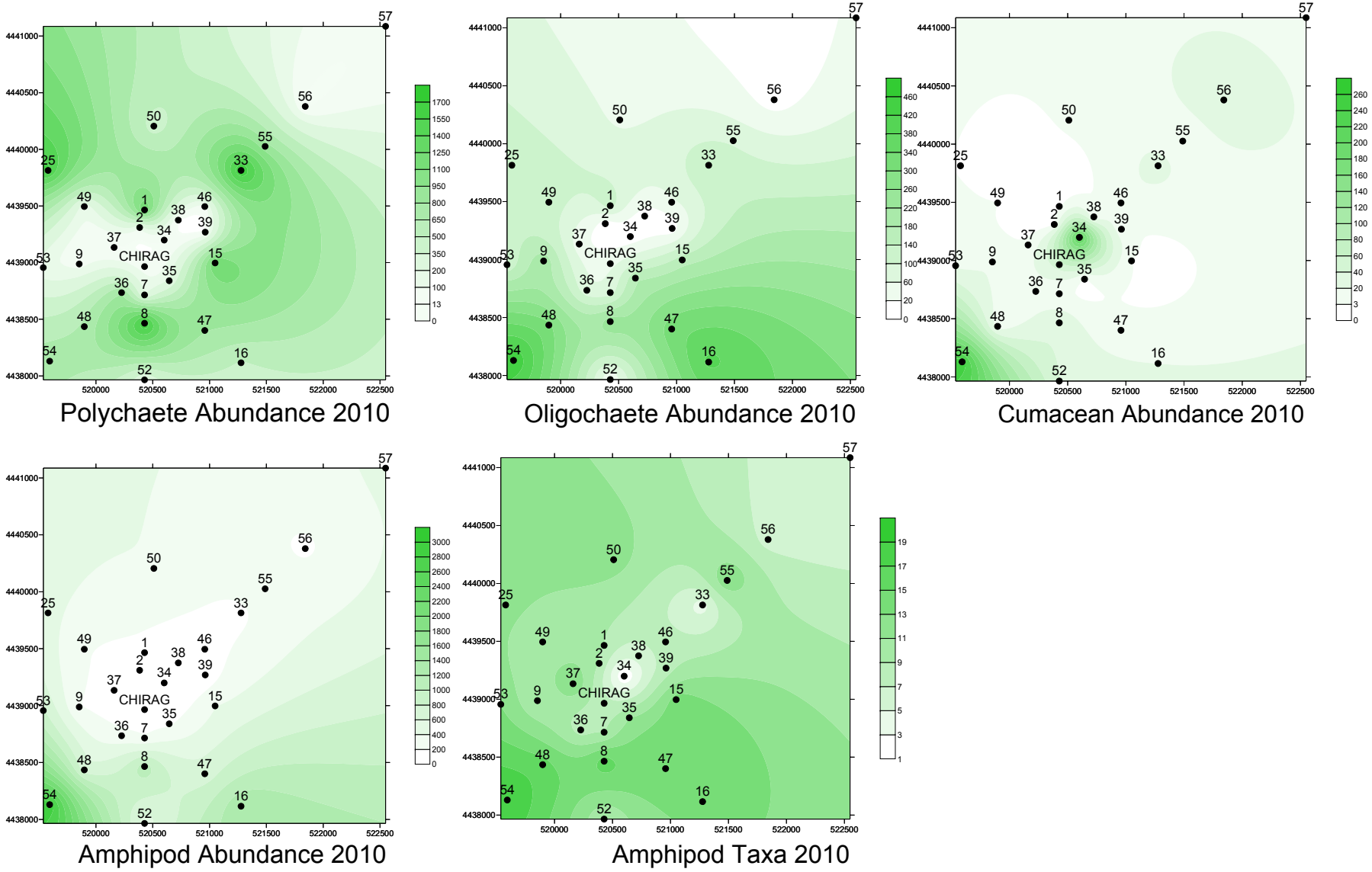

Figure 6.2 Spatial Distribution of Abundance N/m^2 of Major Taxonomic Groups & Amphipod Taxonomic Richness; Chirag 2010

Table 6.3 Abundance N/m^2 & Taxa Per Taxonomic Group, Chirag Survey 2010

Station	Class Polychaeta		Class Oligochaeta		Order Cumacea		Order Amphipoda		Order Isopoda		Class Insecta		Class Gastropoda		Class Bivalvia		Total	
	Taxa	Abund	Taxa	Abund	Taxa	Abund	Taxa	Abund	Taxa	Abund	Taxa	Abund	Taxa	Abund	Taxa	Abund	Taxa	Abund
1	4	1253	3	120	0	0	9	167	0	0	0	0	0	0	1	3	**18**	**1640**
2	4	113	0	0	0	0	9	133	0	0	0	0	0	0	0	0	**14**	**253**
7	3	200	4	80	1	3	9	233	0	0	0	0	0	0	0	0	**18**	**557**
8	5	1690	4	243	2	40	16	1123	1	7	0	0	1	3	2	47	**32**	**3180**
9	4	57	4	210	2	20	9	213	1	10	0	0	0	0	0	0	**20**	**510**
15	6	1247	4	160	1	3	14	393	1	7	0	0	0	0	1	83	**28**	**1940**
16	6	487	3	390	1	20	14	1390	0	0	0	0	0	0	2	887	**27**	**3327**
25	6	1590	4	127	0	0	12	480	1	3	0	0	0	0	2	77	**26**	**2337**
33	4	1710	4	137	2	27	4	163	0	0	0	0	0	0	0	0	**15**	**2050**
34	2	13	0	0	2	223	1	3	0	0	0	0	0	0	0	0	**5**	**240**
35	4	213	3	173	0	0	11	173	1	3	0	0	1	7	1	57	**22**	**767**
36	4	790	4	73	3	13	8	273	0	0	1	7	0	0	0	0	**21**	**1197**
37	0	0	4	37	1	7	13	150	1	10	0	0	0	0	0	0	**20**	**317**
38	0	0	0	0	1	7	6	80	1	17	0	0	0	0	0	0	**9**	**120**
39	2	7	0	0	2	7	8	90	1	10	1	3	1	3	0	0	**16**	**157**
46	3	63	3	53	3	20	8	157	0	0	0	0	0	0	0	0	**18**	**353**
47	5	810	2	323	1	10	15	680	0	0	0	0	0	0	2	520	**26**	**2410**
48	5	680	2	310	2	10	16	697	0	0	0	0	0	0	1	3	**27**	**1703**
49	3	130	4	120	1	3	9	223	1	10	0	0	1	3	1	97	**21**	**690**
50	4	427	4	53	1	7	12	387	1	3	0	0	0	0	2	140	**26**	**1123**
52	6	207	4	20	3	40	9	507	0	0	0	0	0	0	2	37	**25**	**827**
53	5	123	4	110	2	17	13	827	1	7	1	3	0	0	0	0	**27**	**1090**
54	6	737	4	460	3	253	19	2947	0	0	1	7	2	17	2	90	**38**	**4517**
55	3	857	4	93	1	7	13	333	1	3	1	3	0	0	0	0	**24**	**1323**
56	0	0	0	0	2	37	6	167	0	0	0	0	0	0	0	0	**9**	**223**
57	2	23	3	27	1	7	5	463	1	3	0	0	0	0	0	0	**12**	**523**

The composition and structure of the benthic community in 2010 can be usefully summarised by tabulating the dominant taxa at each station (Table 6.4). These are defined here as the six most abundant taxa at each station. The cumulative percentage abundance is included in the table; this indicates the degree of numerical dominance by the most common taxa.

The majority of stations were numerically dominated by the polychaete *Manayunkia* or the amphipod *Corophium*.

Manayunkia was numerically dominant at stations 1, 8, 15, 25, 33, 35, 36, 47, 48, 50 and 55. Abundance was generally high and ranged from 190 to 857 per m^2.

A very low polychaete abundance was observed at stations 2, 7, 37, 38, 39, 46, 49 and 56 where *Corophium* was the numerically dominant taxa, the abundance of which was, in general, relatively low and ranged from 37 to 167 per m^2.

Gammarus pauxillus was the numerically dominant taxa at stations 52 and 54 and the numerically dominant amphipod species at stations 8, 15, 16, 47 and 48. With the exception of station 15 all of these stations are located in the most southerly third of the survey area.

Table 6.4 Numerically Dominant Taxa at Each Station, Chirag Benthic Survey 2010

	TAXON	Taxa Group	N/m^2	Cum %		TAXON	Taxa Group	N/m^2	Cum %
1	*Manayunkia caspica*	*Poly*	683	42	2	*Corophium spp*	*Amp*	80	32
	Fabricia sabella caspica	*Poly*	447	69		*Manayunkia caspica*	*Poly*	53	53
	Sabellidae spp.	*Poly*	117	76		*Fabricia sabella caspica*	*Poly*	40	68
	Balanus improvisus	*Bal*	97	82		*Sabellidae spp.*	*Poly*	17	75
	Corophium spp	*Amp*	73	86		*Corophium curvispinum*	*Amp*	17	82
	Psammoryctides d.	*Olig*	50	89		*Corophium nobile*	*Amp*	10	86
7	*Corophium spp*	*Amp*	110	20	8	*Manayunkia caspica*	*Poly*	760	24
	Manayunkia caspica	*Poly*	93	37		*Gammarus pauxillus*	*Amp*	540	41
	Fabricia sabella caspica	*Poly*	70	49		*Fabricia sabella caspica*	*Poly*	530	58
	Gammarus pauxillus	*Amp*	50	58		*Sabellidae spp.*	*Poly*	277	66
	Balanus improvisus	*Bal*	40	65		*Corophium spp*	*Amp*	120	70
	Sabellidae spp.	*Poly*	37	72		*Gammarus ischnus*	*Amp*	110	73
9	*Psammoryctides d.*	*Olig*	97	19	15	*Manayunkia caspica*	*Poly*	577	30
	Corophium spp	*Amp*	77	34		*Fabricia sabella caspica*	*Poly*	443	53
	Pontoporeia affinis m.	*Amp*	53	44		*Sabellidae spp.*	*Poly*	217	64
	Stylodrilus cernosvitovi	*Olig*	47	54		*Gammarus pauxillus*	*Amp*	140	71
	Tubificidae spp.	*Olig*	43	62		*Corophium spp*	*Amp*	97	76
	Gammarus pauxillus	*Amp*	43	71		*Dreissena rostriformis g.*	*Biv*	83	80
16	*Dreissena rostriformis g.*	*Biv*	857	26	25	*Manayunkia caspica*	*Poly*	707	30
	Gammarus pauxillus	*Amp*	793	50		*Fabricia sabella caspica*	*Poly*	547	54
	Hypaniola kowalewskii	*Poly*	347	60		*Sabellidae spp.*	*Poly*	240	64
	Psammoryctides d.	*Olig*	280	68		*Corophium spp*	*Amp*	183	72
	Balanus improvisus	*Bal*	153	73		*Gammarus pauxillus*	*Amp*	147	78
	Gammarus ischnus	*Amp*	153	78		*Dreissena rostriformis g.*	*Biv*	73	81
33	*Manayunkia caspica*	*Poly*	857	42	34	*Schizorhynchus e.*	*Cum*	217	90
	Fabricia sabella caspica	*Poly*	513	67		*Nereis succinea*	*Poly*	10	94
	Sabellidae spp.	*Poly*	337	83		*Stenocuma diastyloides*	*Cum*	7	97
	Corophium spp	*Amp*	97	88		*Nereis diversicolor*	*Poly*	3	99
	Psammoryctides d.	*Olig*	63	91		*Corophium nobile*	*Amp*	3	100
	Stylodrilus cernosvitovi	*Olig*	60	94					

Table 6.4 (Continued) Numerically Dominant Taxa at Each Station, Chirag Benthic Survey 2010

	TAXON	Taxa Group	N/m^2	Cum %		TAXON	Taxa Group	N/m^2	Cum %
35	*Manayunkia caspica*	*Poly*	190	25	36	*Manayunkia caspica*	*Poly*	383	32
	Balanus improvisus	*Bal*	140	43		*Fabricia sabella caspica*	*Poly*	260	54
	Corophium spp	*Amp*	100	56		*Corophium spp*	*Amp*	157	67
	Psammoryctides d.	*Olig*	93	68		*Sabellidae spp.*	*Poly*	143	79
	Isochaetides michaelseni	*Olig*	77	78		*Gammarus pauxillus*	*Amp*	47	83
	Dreissena rostriformis g.	*Biv*	57	86		*Balanus improvisus*	*Bal*	40	86
37	*Balanus improvisus*	*Bal*	113	36	38	*Corophium spp*	*Amp*	43	36
	Corophium spp	*Amp*	70	58		*Pontoporeia affinis m.*	*Amp*	20	53
	Psammoryctides d.	*Olig*	17	63		*Balanus improvisus*	*Bal*	17	67
	Corophium nobile	*Amp*	17	68		*Saduria entomon caspia*	*Iso*	17	81
	Pontoporeia affinis m.	*Amp*	13	73		*Stenocuma diastyloides*	*Cum*	7	86
	Isochaetides michaelseni	*Olig*	10	76		*Gammaridae spp.*	*Amp*	7	92
39	*Balanus improvisus*	*Bal*	37	23	46	*Corophium spp*	*Amp*	97	27
	Corophium spp	*Amp*	37	47		*Balanus improvisus*	*Bal*	60	44
	Corophium curvispinum	*Amp*	13	55		*Psammoryctides d.*	*Olig*	43	57
	Corophium nobile	*Amp*	13	64		*Manayunkia caspica*	*Poly*	40	68
	Pontoporeia affinis m.	*Amp*	10	70		*Fabricia sabella caspica*	*Poly*	20	74
	Saduria entomon caspia	*Iso*	10	77		*Gammarus pauxillus*	*Amp*	13	77
47	*Manayunkia caspica*	*Poly*	513	21	48	*Manayunkia caspica*	*Poly*	427	25
	Dreissena rostriformis g.	*Biv*	513	43		*Gammarus pauxillus*	*Amp*	253	40
	Psammoryctides d.	*Olig*	243	53		*Psammoryctides d.*	*Olig*	210	52
	Gammarus pauxillus	*Amp*	240	63		*Fabricia sabella caspica*	*Poly*	133	60
	Hypaniola kowalewskii	*Poly*	190	71		*Corophium spp*	*Amp*	117	67
	Corophium spp	*Amp*	110	75		*Isochaetides michaelseni*	*Olig*	100	73
49	*Corophium spp*	*Amp*	167	24	50	*Manayunkia caspica*	*Poly*	197	18
	Balanus improvisus	*Bal*	103	39		*Corophium spp*	*Amp*	183	34
	Dreissena rostriformis g.	*Biv*	97	53		*Fabricia sabella caspica*	*Poly*	153	47
	Manayunkia caspica	*Poly*	77	64		*Dreissena rostriformis g.*	*Biv*	113	58
	Psammoryctides d.	*Olig*	70	74		*Balanus improvisus*	*Bal*	103	67
	Fabricia sabella caspica	*Poly*	43	81		*Gammarus pauxillus*	*Amp*	87	74
52	*Gammarus pauxillus*	*Amp*	247	30	53	*Pontoporeia affinis m.*	*Amp*	357	33
	Corophium spp	*Amp*	110	43		*Gammarus pauxillus*	*Amp*	240	55
	Hypaniola kowalewskii	*Poly*	87	54		*Corophium spp*	*Amp*	80	62
	Gammarus spp	*Amp*	60	61		*Manayunkia caspica*	*Poly*	57	67
	Manayunkia caspica	*Poly*	47	67		*Gammarus spp*	*Amp*	50	72
	Gammaridae spp.	*Amp*	37	71		*Isochaetides michaelseni*	*Olig*	43	76
54	*Gammarus pauxillus*	*Amp*	1783	39	55	*Manayunkia caspica*	*Poly*	430	32
	Hypaniola kowalewskii	*Poly*	427	49		*Fabricia sabella caspica*	*Poly*	233	50
	Psammoryctides d.	*Olig*	293	55		*Sabellidae spp.*	*Poly*	193	65
	Gammarus spp	*Amp*	287	62		*Corophium spp*	*Amp*	187	79
	Pontoporeia affinis m.	*Amp*	287	68		*Gammarus pauxillus*	*Amp*	37	82
	Schizorhynchus e.	*Cum*	233	73		*Psammoryctides d.*	*Olig*	33	84
56	*Corophium spp*	*Amp*	87	39	57	*Pontoporeia affinis m.*	*Amp*	390	75
	Pontoporeia affinis m.	*Amp*	47	60		*Corophium spp*	*Amp*	57	85
	Stenocuma diastyloides	*Cum*	33	75		*Psammoryctides d.*	*Olig*	17	89
	Balanus improvisus	*Bal*	20	84		*Manayunkia caspica*	*Poly*	13	91
	Corophium curvispinum	*Amp*	10	88		*Sabellidae spp.*	*Poly*	10	93
	Corophium mucronatum	*Amp*	10	93		*Tubificidae spp.*	*Olig*	7	94

6.3.2. Biomass

Total Biomass (measured as grams blotted wet weight per square metre is given in table 6.5 below. Biomass was lowest at station 2 with 1.0014g.m^{-2} and highest at station 16 with 42.0299g.m^{-2}. Around 80% of the biomass contribution at station 16 was from the bivalve *Dreissena rostriformus.* This species also contributed to the high biomass at station 47. Bivalves accounted for the highest proportion of total biomass, representing 32% and despite their low abundance, isopod species *Saduria entomon caspia* accounted for 24% of the overall total.

Amphipods and polychaetes were the numerically dominant taxonomic groups and accounted for 16 and 2% of the biomass respectively.

Overall biomass distribution generally follows that of individual abundance for each of the taxonomic groups.

Table 6.5 Biomass (g.m^{-2}) of Major Taxonomic Groups, Chirag Benthic Survey 2010

Station	Nematode	Polychaete	Oligochaete	Balanus	Cumacea	Amphipod	Isopoda	Bivalve	Gastropod	Insect	Total for station
1		0.1144	0.4276	4.5251		0.5326		0.1337			**5.7334**
2		0.0159		0.2446		0.7408					**1.0014**
7		0.0225	0.4243	1.4706	0.0055	0.7588					**2.6817**
8		0.2496	1.3118	0.7055	0.0086	2.1764	3.6265	2.5415	0.1870		**10.8068**
9		0.0119	1.0047		0.0345	1.0942	6.3504				**8.4957**
15		0.3087	0.7101	3.6370	0.0072	1.1361	3.7555	3.4737			**13.0284**
16		0.2169	0.5578	4.1135	0.0069	2.4943		34.6406			**42.0299**
25		0.3858	0.8827	2.6806		1.8531	5.1923	1.9436			**12.9381**
33		0.2372	0.3695	0.3884	0.0170	1.1853					**2.1973**
34		1.5069			0.1031	0.0172					**1.6273**
35		0.3376	0.6861	5.9151		0.8068	2.4600	2.7392	0.2718		**13.2167**
36		0.0744	0.5926	1.9213	0.0059	1.5773				0.0004	**4.1720**
37		0.0168	0.1234	5.0911	0.0040	2.5864	3.9011				**11.7228**
38				0.8732	0.0109	0.4198	11.6846				**12.9885**
39		0.2003		1.2243	0.0410	0.7633	11.9541		0.1382	0.0003	**14.3215**
46		0.0144	0.1211	2.0991	0.0288	0.7801					**3.0435**
47		0.1617	0.6806	4.0745	0.0151	1.5295		22.8199			**29.2813**
48		0.1356	0.6689	0.3953	0.0192	1.8283		0.1444			**3.1918**
49		0.0310	0.7059	5.9525	0.0082	1.1586	6.9804	5.1621	0.1484		**20.1472**
50	0.0004	0.0772	0.1710	4.7691	0.0045	3.4128	1.7410	8.6263			**18.8023**
52		0.1091	0.0752	0.4369	0.0581	0.9017		0.9902			**2.5713**
53		0.1142	0.9132	0.0697	0.0235	2.4871	2.8702			0.0002	**6.4782**
54	0.0087	1.1282	4.6094		0.0982	5.7454		3.4730	0.0981	0.0805	**15.2415**
55		0.1144	0.3604	0.6055	0.0166	2.2695	3.4748			0.0002	**6.8414**
56				0.5459	0.0960	1.2915					**1.9335**
57		0.0013	0.1428		0.0061	2.3339	1.6613				**4.1453**
	0.0091	5.5861	15.5391	51.7387	0.6190	41.8809	65.6522	86.6883	0.8435	0.0816	**268.6385**
% total	0	2	6	19	0	16	24	32	0	0	

6.4. Univariate analysis

The next level of analysis is based on the calculation of single (univariate) numerical statistics for each sampling location. These are based on information theory (diversity, dominance, and evenness) or upon basic population statistics (numbers of individuals and taxa per station). The calculation of univariate parameters is based upon the number and abundance of taxa at each location, but takes no account of the identity of those taxa.

Table 6.6 lists the univariate statistics calculated for each station (explanation for the terms is provided at the beginning of this report).

The lowest evenness and diversity indices were observed at station 34 where abundance and taxonomic richness were lowest. The particularly low evenness value of 0.28 is the result of the high abundance of *Schizorhynchus*, with the 4 other species present having an abundance of ≤10 per m^2.

Low indices were also observed at station 57, where the majority of taxa were present in very low numbers with one species, *Pontoporeia affins microphthalma* being relatively abundant.

Lower diversity indices were also observed at stations 38, 1, 56 and 33. With the exception of station 1 which lies 500m to the north, all are located on the NE transect.

The diversity indices at the remaining stations are very similar, ranging from 0.80 to 0.90 for Simpson's and 2.04 to 2.53 for Shannon Weiner.

Table 6.6 Macrofaunal Community Statistics for all Stations, Chirag Benthic Survey 2010

Station	Taxa	Abundance (N/m2)	Pielou evenness (J)	Shannon-Weiner diversity	Simpson's diversity
1	18	1640	0.62	1.78	0.74
2	14	253	0.77	2.04	0.82
7	18	557	0.85	2.45	0.89
8	32	3180	0.72	2.50	0.87
9	20	510	0.84	2.52	0.90
15	28	1940	0.68	2.27	0.83
16	27	3327	0.71	2.35	0.85
25	26	2337	0.68	2.23	0.83
33	15	2050	0.61	1.65	0.73
34	5	240	0.28	0.44	0.18
35	22	767	0.73	2.25	0.86
36	21	1197	0.68	2.08	0.81
37	20	317	0.74	2.21	0.81
38	9	120	0.83	1.83	0.80
39	16	157	0.84	2.32	0.87
46	18	353	0.80	2.31	0.86
47	26	2410	0.76	2.46	0.88
48	27	1703	0.76	2.50	0.88
49	21	690	0.77	2.34	0.87
50	26	1123	0.78	2.53	0.89
52	25	827	0.78	2.52	0.87

Table 6.6 (Continued) Macrofaunal Community Statistics for all Stations, Chirag Benthic Survey 2010

Station	Taxa	Abundance (N/m2)	Pielou evenness (J)	Shannon-Weiner diversity	Simpson's diversity
53	27	1090	0.70	2.32	0.83
54	38	4517	0.66	2.40	0.82
55	24	1323	0.67	2.13	0.82
56	9	223	0.79	1.75	0.77
57	12	523	0.43	1.06	0.43
Min	5	120	0.28	0.44	0.18
Max	38	4517	0.85	2.53	0.90
Median	21	958	0.73	2.29	0.83
Mean	21	1284	0.71	2.12	0.80
St Dev	8	1135	0.13	0.48	0.15
%CV	36	88	18	23	19

6.5. Multivariate analysis

The purpose of multivariate analysis is to reduce a large number of variables (in this case the different taxa, their abundance, and stations at which they are present) into a smaller number of variables which are representative of the characteristics of each station and of any systematic species associations. Unlike univariate statistics, multivariate methods take into account the joint presence and absence of species, not just the number of species and individuals. Additionally, they simplify the analysis of communities as a whole, providing a more comprehensive and statistically resistant alternative to analysis of the variation of individual species' distributions.

The power advantage of multivariate analysis is greatest when data sets are large and complex (i.e. a large number of stations and species) and when there is a substantial amount of structure in the biology of the survey area (*ie* when there are distinct and consistent associations of species).

In all ecological studies, it should be remembered that any statistical analysis may produce misleading results, and any conclusions drawn should be carefully checked with the original species-abundance data.

A variety of methods is available, falling into two major categories; ordination and classification, either or both of which may be useful in analysing a data set. One classification and one ordination method have been used to analyse the 2010 Chirag data.

Classification

- Hierarchical Agglomerative Clustering, based on station-station similarities

Ordination

- Non-metric Multi Dimensional Scaling (NMDS, based on similarities)
- Detrended Correspondence Analysis

6.5.1. Cluster Analysis

A matrix of similarities between each pair of stations was calculated using log transformed taxon-abundance data. This matrix was subjected to hierarchical agglomerative clustering using group average linking (also known as flexible sorting).

The results of this analysis are presented as a dendrogram indicating which samples (in this case, stations) cluster together, and the similarity between stations and groups.

The dendogram is given in figure 6.3 below. Overall the analysis has failed to indicate any structure in the data which has not been identified by examination of the species abundance data.

Station 34 has been isolated with the % similarity of all other stations being 40%. Stations 37, 46, 57, 39, 38 and 56 (Group 1) have been grouped together at 50% similarity. As indicated above, the community at these stations is characterised by a low abundance and/or species richness.

Station 2 where a lower abundance and species richness was also observed was separated from the remaining Group 2 stations.

Group 2 stations have been separated into subgroups A & B. Subgroup A has a similarity of 60% and contains stations 54, 16, 47 and 48. Abundance and species richness were high at these stations, all of which are located in the southern third of the survey area. Subgroup 2B stations have a 65% similarity and accounts for the remaining sample stations.

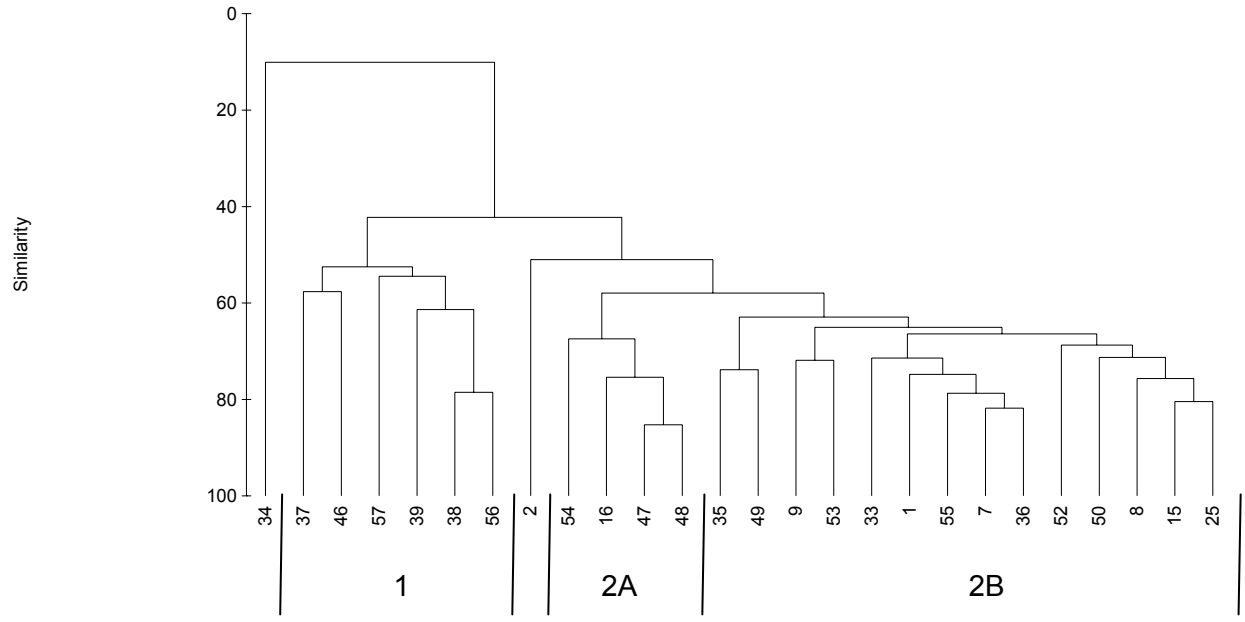

Figure 6.3 Cluster Analysis Dendogram

6.5.2. Non-metric Multi Dimensional Scaling (NMDS)

As with cluster analysis NMDS analysis is carried out on the log transformed matrix of similarities. To ease visual interpretation station 34 was omitted. The resulting ordination of stations is given in figure 6.4 below. The stress value was 0.09.

Group 1 stations where abundance and/or species richness was poorest are positioned to the right of the ordination with a relatively wide scatter. In general the remaining stations are spread throughout the ordination, indicating the absence of any clear divisions between groups of stations. Overall the resulting ordination has not identified any further information than previously obtained from the cluster analysis or examination of the basic species abundance data.

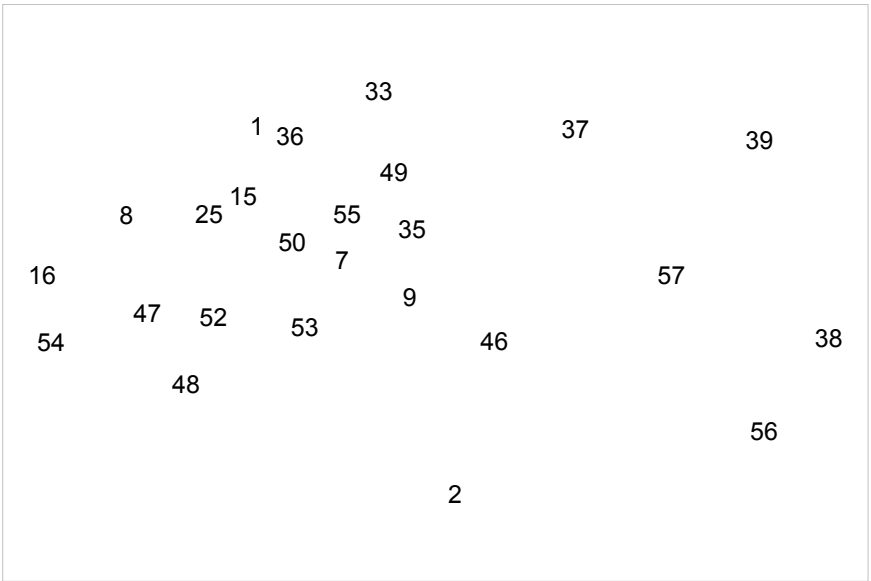

Figure 6.4 NMDS Ordination

6.5.3. Detrended Correspondence Analysis DCA

DCA considers species variation at each sample station, the eigenvalues of DCA lie between 0-1 with values over 0.5 indicating good separation of species along the axis.

DCA ordination was carried out macrofaunal abundance data. The eigenvalues of the 1st and 2nd ordination axes are 0.49 and 0.27, indicating that the ordination represents a low amount of variation in the data set. The ordination is given in figure 6.5 below and the case scores for the 1st and 2nd axes are given in appendix 9.

As with the cluster and MDS analysis no further structure was revealed within the data set.

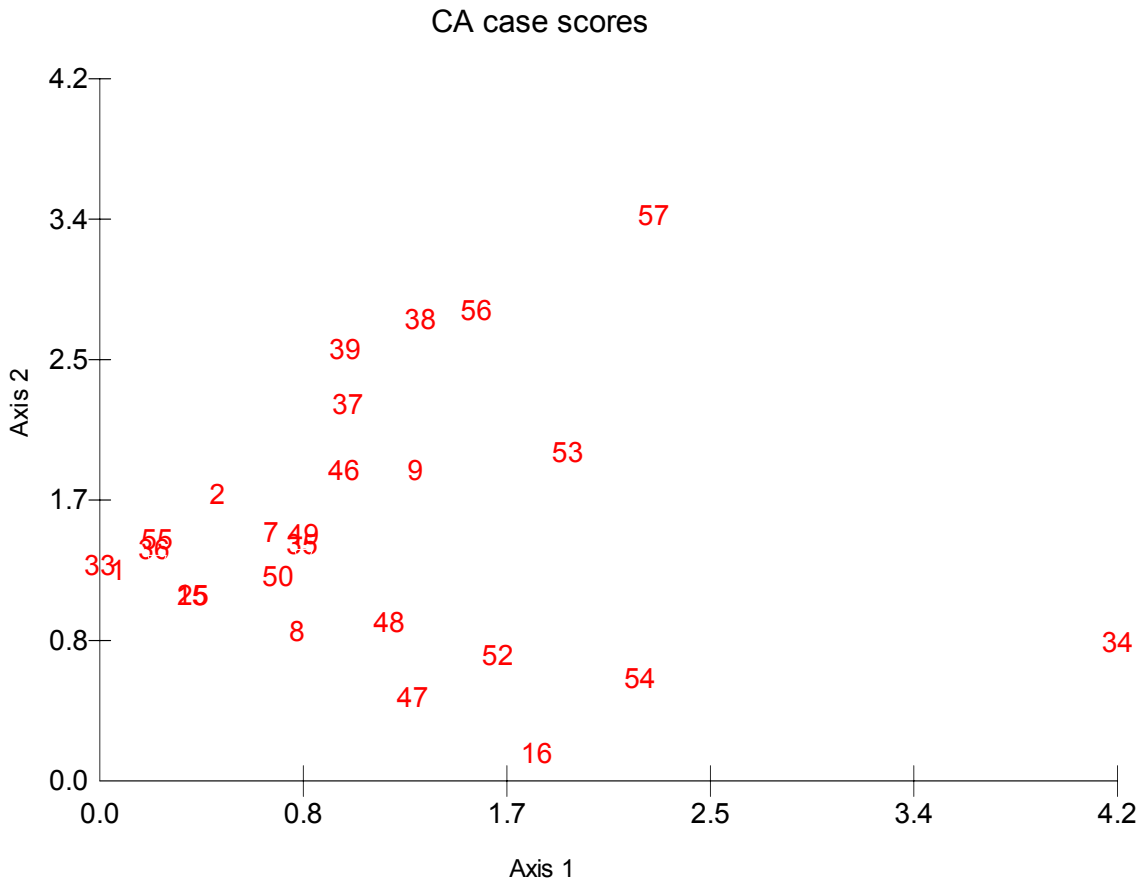

Figure 6.5 DCA Ordination

6.6. Comparison to Previous Survey Data

To assess temporal change in the macrobenthic community, the 2008 results will be compared to the data from the 2006, 2004, 2000 and 1998 Chirag surveys. The rationalised combined species abundance data for all years is given in appendix 7.

Table 6.7 gives the total species and average abundance for each main taxonomic group for each survey. The average abundance values have been given as each year's data has been generated from a different number of stations; 2010 and 2008 data is from 26 stations, 2006 from 21 stations, 2004 from 16 stations, 2000 from 15 stations and 1998 from 16 stations. The individual species abundance and frequency of occurrence data is given in Table 6.8. A zero in this table indicates that the species was absent.

After an increase between 1998 and 2000, the average annelid abundance reduced on all consecutive surveys to 2008, which then increased in 2010.

Other than the large difference in species richness in 2000 with 10 taxa being present, oligochaete species richness has remained relatively stable. The variation in taxa between 2004 and 2008 was due to the presence and absence of *Tubificardium spp* and *Tubificidae spp,* with the most abundant species *Stylodrilus, Isochaetides* and *Psammoryctide*s being present in all surveys. The high oligochaete species richness in 2000 was due to the presence of the relatively abundant *Potamothrix* species. Other than a very small presence in 1998 this was the only year this genus was present in the Chirag community.

Polychaete average abundance increased from 84 to 516 per m^2 between 2008 and 2010. This was due to increases in *Hypaniola kowalewskii*, *Sabellidae, Manayunkia* and *Fabricia. Sabellidae* average abundance increased from 40 to 1763 per m^2 and frequency of occurrence from 5 to 14 stations, this species was absent in the Chirag community prior to 2008.

After an increase in 2006 from its first presence in 2004, the abundance and frequency of occurrence of *Nereis* reduced in 2008 and has remained low in 2010.

Amphipod species richness has fluctuated between surveys. Twenty four taxa were present in the 1998 survey, which then reduced to 11-15 taxa between 2000 and 2008. A substantial increase was observed in 2010 with 28 taxa being present.

Average amphipod abundance was highest in 2000 with 1359 per m^2. This reduced on each consecutive survey, with the lowest average abundance being observed in 2008 with 94 per m^2. An increase has been observed in 2010 with 479 per m^2, which was due to higher numbers of *Gammarus*, *Pontoporeia* and a large increase in *Corophium*.

When the species data in table 6.9 is examined the high species richness in 1998 and 2010 were influenced by the presence of species from the genus *Amathillina,* and *Dikerogammarus* which were either absent or represented by fewer species in the intervening surveys.

Pandorites was present and relatively abundant in 1998 and 2000 and although abundance was lower *Gmelinopis* was also present on these years. With the exception of 7 individuals of *Gmelinopis* in 2010, these species have been absent from the Chirag community from 2004.

Niphargoides abundance has reduced from 1998, whereas the abundance of *Corophium* has increased, it should also be noted that *Pontoporeia was* present in 2008 and 2010 after being absent in the previous two surveys and only being represented by 3 individuals in 2000. The frequency of occurrence has increased from 5 in 2008 to 16 stations in 2010.

Cumacean average abundance and total species richness increased between 1998 and 2000. Abundance then reduced in 2004, and then again in 2008. Despite an increase in 2010, the average abundance remains below that observed in 1998 to 2006.

Gastropod species richness was relatively high between 1998 and 2004 with 7 or 8 species present. This reduced in 2006 when gastropods were virtually absent from the Chirag community. Although abundance is low, gastropods were present in 2008 with a total of 4 species being identified. The majority of abundance in 2008 was represented by the genus *Caspiohydrobia*. Species richness and average abundance are lower in 2010, with *Caspiohydrobia* absent and Turricaspia being the only genus present.

Bivalve species richness and average abundance have fluctuated between years with the highest average abundance and species richness being recorded in 2004.

Table 6.8 Species Richness & Average Abundance for each main taxonomic group

		1998	2000	2004	2006	2008	2010
Polychaeta	Taxa	3	5	8	5	8	8
	Abundance	229	672	245	123	84	516
Oligochaeta	Taxa	5	10	5	3	4	4
	Abundance	701	2068	728	281	86	128
Cumacea	Taxa	3	5	5	3	5	5
	Abundance	104	213	74	76	7	30
Amphipoda	Taxa	24	13	11	13	15	28
	Abundance	485	1359	421	272	94	479
Isopod	Abundance	743	960	125	300	30	93
Insecta	Abundance	106	789	2366	410	23	23

Table 6.8 (Continued) Species Richness & Average Abundance for each main taxonomic group

		1998	2000	2004	2006	2008	2010
Gastropoda	Taxa	7	7	8	1	4	3
	Abundance	22	30	129	0	4	1
Bivalve	Taxa	3	4	5	5	2	3
	Abundance	306	342	1022	220	18	78

Table 6.9 Species Total Abundance & Frequency of Occurrence Chirag; 1998, 2000, 2004, 2006 & 2008

	Average Abundance N/m^2						Frequency of Occurrence					
	1998	2000	2004	2006	2008	2010	1998	2000	2004	2006	2008	2010
Class Nematoda												
Nematoda spp	0	0	46	13	10	10	0	0	7	3	1	2
Class Oligochaeta												
Stylodrilus spp.	0	7570	0	0	0	0	0	12	0	0	0	0
Stylodrilus cernosvitovi	0	0	5854	1230	70	400	0	0	16	15	5	14
Isochaetides michaelseni	20	3907	462	2837	1020	760	2	14	8	21	15	17
Marionina sp 1	0	7	0	0	0	0	0	2	0	0	0	0
Tubifex acapillatus	63	102	0	0	0	0	2	7	0	0	0	0
Tubificidae spp.	0	92	3389	0	23	320	0	4	14	0	5	12
Psammoryctides deserticola	10431	6062	1914	1843	1117	1840	14	13	16	20	16	17
Aktedrilus svetlovi	693	0	0	0	0	0	4	0	0	0	0	0
Tubificidarum sp	0	333	26	0	0	0	0	5	2	0	0	0
Potamothrix cekanovsckaje	7	673	0	0	0	0	1	6	0	0	0	0
Potamothrix cf cekanovskajae	0	422	0	0	0	0	0	2	0	0	0	0
Potamothrix spp.	0	640	0	0	0	0	0	8	0	0	0	0
Class Polychaeta												
Ampharetidae spp.	0	251	33	0	43	210	0	8	1	0	4	6
Nereis succinea	0	0	0	0	27	23	0	0	0	0	3	4
Nereis diversicolor	0	0	366	827	20	10	0	0	12	18	3	3
Hypania invalida	3650	3617	1125	1060	63	177	15	13	12	12	4	6
Hypania invalida damaged	0	0	3	0	0	0	0	0	1	0	0	0
Parhypania brevispinis	0	33	0	0	0	0	0	2	0	0	0	0
Hypaniola kowalewskii	10	993	1614	140	170	1280	1	5	12	5	8	12
Hypaniola kowalewskii damaged	0	0	350	0	0	0	0	0	4	0	0	0
Sabellidae spp.	0	0	0	0	40	1763	0	0	0	0	5	14
Manayunkia caspica	0	1531	175	480	1050	6310	0	10	6	10	13	16
Fabricia sabella caspica	0	0	261	67	770	3653	0	0	10	3	12	15
Ostracoda												
OSTRACODA sp 1	0	10	9323	50	0	0	0	2	16	3	0	0
Cirripedia												
Balanus improvisus	0	0	0	0	910	1193	0	0	0	0	16	18
Amphipoda												
Gammaridae spp.	0	0	0	0	377	570	0	0	0	0	11	13
Pseudalibrotus platyceras	26	0	30	23	13	20	1	0	7	6	2	5

Table 6.9 (Continued) Species Total Abundance & Frequency of Occurrence Chirag; 1998, 2000, 2004, 2006 & 2008

	Average Abundance N/m^2						Frequency of Occurrence					
	1998	2000	2004	2006	2008	2010	1998	2000	2004	2006	2008	2010
Pseudalibrotus caspius	26	10	3	420	17	23	2	2	1	7	5	6
Pontoporeia affinis microphthalma	36	3	0	0	390	1293	4	1	0	0	5	16
Gammarus spp. indet.	2366	10758	6353	743	227	847	12	13	12	14	10	11
Gammarus ischnus	0	0	0	833	80	573	0	0	0	7	5	12
Gammarus pauxillus	0	0	0	3060	467	4710	0	0	0	18	12	14
Amathillina spinosa	7	10	0	0	0	27	2	3	0	0	0	5
Amathillina cristata	36	0	0	3	0	3	4	0	0	1	0	1
Amathillina pusilla	43	0	0	0	0	157	2	0	0	0	0	12
Amathillina affinis	17	17	0	0	0	0	3	4	0	0	0	0
Dikerogammarus aralensis	59	0	0	0	0	0	4	0	0	0	0	0
Dikerogammarus haemobaphes	330	7	0	3	0	20	10	2	0	1	0	2
Dikerogammarus oscari	132	13	0	0	0	10	9	4	0	0	0	2
Akerogammarus knipowitschi	13	0	0	0	0	0	1	0	0	0	0	0
Gmelinopis aurita	861	482	0	0	0	7	12	8	0	0	0	2
Cardiophilus baeri	0	0	0	0	0	20	0	0	0	0	0	0
Iphigenella andrussovi	0	0	0	0	0	27	0	0	0	0	0	1
Gammaracanthus loricatus caspius	142	0	10	3	0	7	11	0	2	1	0	2
Niphargoides spp	4	0	102	3	10	3	1	0	3	1	2	1
Niphargoides caspius	3	119	20	0	0	37	1	1	1	0	0	2
Niphargoides grimmi	23	10	0	0	0	3	2	1	0	0	0	1
Niphargoides paradoxus	165	0	0	0	0	0	3	0	0	0	0	0
Niphargoides deminutus	3	0	0	0	0	17	1	0	0	0	0	1
Niphargoides quadrimanus	3	0	0	0	0	0	1	0	0	0	0	0
Niphargoides compressus	0	0	162	0	0	0	0	0	1	0	0	0
Niphargoides deminutus	0	0	33	0	0	0	0	0	1	0	0	0
Niphargoides derzhavini	0	0	0	0	10	0	0	0	0	0	2	0
Gmelina costata	0	0	0	0	10	157	0	0	0	0	1	7
Gmelina brachyura	0	0	0	0	0	320	0	0	0	0	0	7
Pandorites podoceroides	3452	1168	0	13	0	0	11	11	0	1	0	0
Pandorites platycheir	7	0	0	0	0	0	1	0	0	0	0	0
Caspicola knipovitschi	0	0	0	0	13	93	0	0	0	0	2	9
Corophium spp	0	0	0	567	527	2617	0	0	0	19	16	20
Corophium robustum	3	7	0	0	0	0	1	2	0	0	0	0
Corophium curvispinum	0	0	3	0	193	417	0	0	1	0	15	20
Corophium mucronatum	0	0	3	0	0	157	0	0	1	0	0	16
Corophium chelicorne	0	0	0	0	0	10	0	0	0	0	0	2
Corophium nobile	7	17	13	23	87	253	1	2	4	3	13	19
Corophium monodon	0	0	0	20	0	0	0	0	0	5	0	0
Corophium volutator	0	0	0	0	13	57	0	0	0	0	3	7
Isopoda												
Jaera sars caspica	0	0	59	10	0	0	0	0	1	1	0	0
Saduria entomon caspia	743	218	66	290	30	93	15	13	11	17	7	11
Cumacea												
Pterocuma rostrata	40	0	389	333	50	23	4	0	14	17	6	6
Pterocuma pectinata	17	0	0	7	0	0	1	0	0	1	0	0

Table 6.9 (Continued) Species Total Abundance & Frequency of Occurrence Chirag; 1998, 2000, 2004, 2006 & 2008

	Average Abundance N/m^2						Frequency of Occurrence					
	1998	2000	2004	2006	2008	2010	1998	2000	2004	2006	2008	2010
Schizochynchus eudorelloides	964	1383	485	967	90	470	11	11	14	11	4	5
Pseudocuma cercaroides	0	56	0	0	0	130	0	2	0	0	0	5
Stenocuma diastyloides	644	99	211	213	43	153	9	3	11	13	5	16
Stenocuma gracilis	0	0	3	0	0	0	0	0	1	0	0	0
Stenocuma graciloides	0	0	102	70	0	0	0	0	8	3	0	0
Volgocuma telmatophora	0	0	0	0	0	3	0	0	0	0	0	1
Decapod												
Rhitropanopeus harrisii tridentatus	7	3	3	0	0	0	1	1	1	0	0	0
Insecta												
Chironomus albidus	106	683	2366	410	23	23	8	11	13	11	4	5
Gastropoda												
GASTROPODA SPP.	0	0	3	0	0	0	0	0	1	0	0	0
Anisus eichwaldi	0	3	0	0	0	0	0	1	0	0	0	0
Anisus kolesnikovi	0	0	63	0	0	0	0	0	2	0	0	0
Turricaspia curta	0	0	0	0	0	17	0	0	0	0	0	3
Turricaspia marginata	0	0	0	0	0	10	0	0	0	0	0	1
Turricaspia trivialis	0	7	0	0	0	0	0	2	0	0	0	0
Turricaspia similis	0	13	0	0	0	0	0	1	0	0	0	0
Turricaspia caspia	0	0	46	0	0	0	0	0	4	0	0	0
Turricaspia cincta	0	0	0	0	10	7	0	0	0	0	2	1
Caspiohydrobia convexa	3	0	0	0	0	0	1	0	0	0	0	0
Caspiohydrobia conica	0	0	0	0	13	0	0	0	0	0	2	0
Caspiohydrobia curta	271	20	663	3	40	0	6	2	14	1	2	0
Caspiohydrobia gemmata	10	10	680	0	30	0	2	2	13	0	2	0
Pyrgula caspia	3	0	0	0	0	0	1	0	0	0	0	0
Pyrgula ulskii	23	0	0	0	0	0	3	0	0	0	0	0
Caspia pallasii	0	7	0	0	0	0	0	1	0	0	0	0
Caspia baerii (=Pyrgula baeri)	0	0	432	0	0	0	0	0	7	0	0	0
Caspia knipowitchi	0	0	36	0	0	0	0	0	2	0	0	0
Abeskunus brusinianus	3	43	142	0	0	0	1	4	4	0	0	0
Caspiohoration (Horatia) marina	36	0	0	0	0	0	5	0	0	0	0	0
Bivalve												
Dreissena rostriformis pontocaspica	0	0	0	500	0	0	0	0	0	4	0	0
Dreissena rostriformis distincta	0	3	0	1437	0	0	0	1	0	7	0	0
Dreissena rostriformis grimmi	0	191	15560	2477	447	1917	0	5	14	9	10	10
Dreissena spp. indet.	0	36	3	0	0	0	0	1	1	0	0	0
Dreissena rostriformis compressa	0	0	3	0	0	0	0	0	1	0	0	0
Mytilaster lineatus	4887	10	30	17	0	27	12	3	5	1	0	1
Cerastoderma lamarcki	3	0	0	0	0	0	1	0	0	0	0	0
Didacna profundicola	3	0	749	200	23	97	1	0	10	5	4	5

To assess the variation in community between years, an NMDS analysis was carried out on the log transformed matrix of similarities for the combined macrobenthic data from 1998 to 2010. The resulting ordination of stations is given in figure 6.6 below. The stress value was 0.13.

Distinct and separate groups have been created for 1998, 2000, 2004 and 2006, whereas the 2008 and 2010 stations are intermingled, indicating a greater similarity in the communities present on these two years.

The wider scatter present for 2008 compared to 2010 stations indicates a greater similarity between stations in 2010.

Station 34 has been isolated on all surveys from 2004 and grouped together on the ordination, indicating that the community at this position differs to the other sample stations and has observed relatively changed little between years.

Table 6.10 outlines the species and total abundance for each main taxonomic group at each station, for the surveys carried out between 2004 and 2010.

In general, total abundance and taxonomic richness reduced on each consecutive survey from 2004 to 2008 and then increased in 2010, with annelid and amphipod abundance and taxonomic richness increasing at the majority of stations.

A number of stations were identified in 2008 as having particularly sparse communities. Although abundance and taxonomic richness remain relatively low at some, all of have observed increases in abundance and taxonomic richness in 2010. This includes stations 34, 38 and 39, where the least taxonomically rich and/or abundant communities were present in 2010. It should be noted however that amphipod presence at station 34 has never exceeded 10 individuals per m^2.

The greatest change was observed at stations 8, 15, 16 and 47, were taxonomic richness has increased from 0-5 to 25-31 and abundance has increased from 0-20 to 1893-3173 per m^2.

6.7. Summary of Chirag Benthic Survey 2010 Macrobenthic Communities

The 2010 macrobenthic community was numerically dominated by polychaetes and amphipods. Abundance and species richness were highest at stations on the periphery of the survey area and decreased towards the platform. Taxonomic richness was lowest at contiguous stations 34 and 38 directly to the northeast of the platform and abundance was lowest at stations 34, 38, 46 and 39 extending 750m to the northeast and stations 2 and 37 directly to the north and northwest of the platform.

A general reduction in abundance and taxonomic richness has been observed in the Chirag macrobenthic data set from 2000 to 2008. This trend has reversed in 2010, with a survey wide increase in annelid abundance and amphipod abundance and taxonomic richness being observed. Despite this general increase amphipods remain almost absent at station 34.

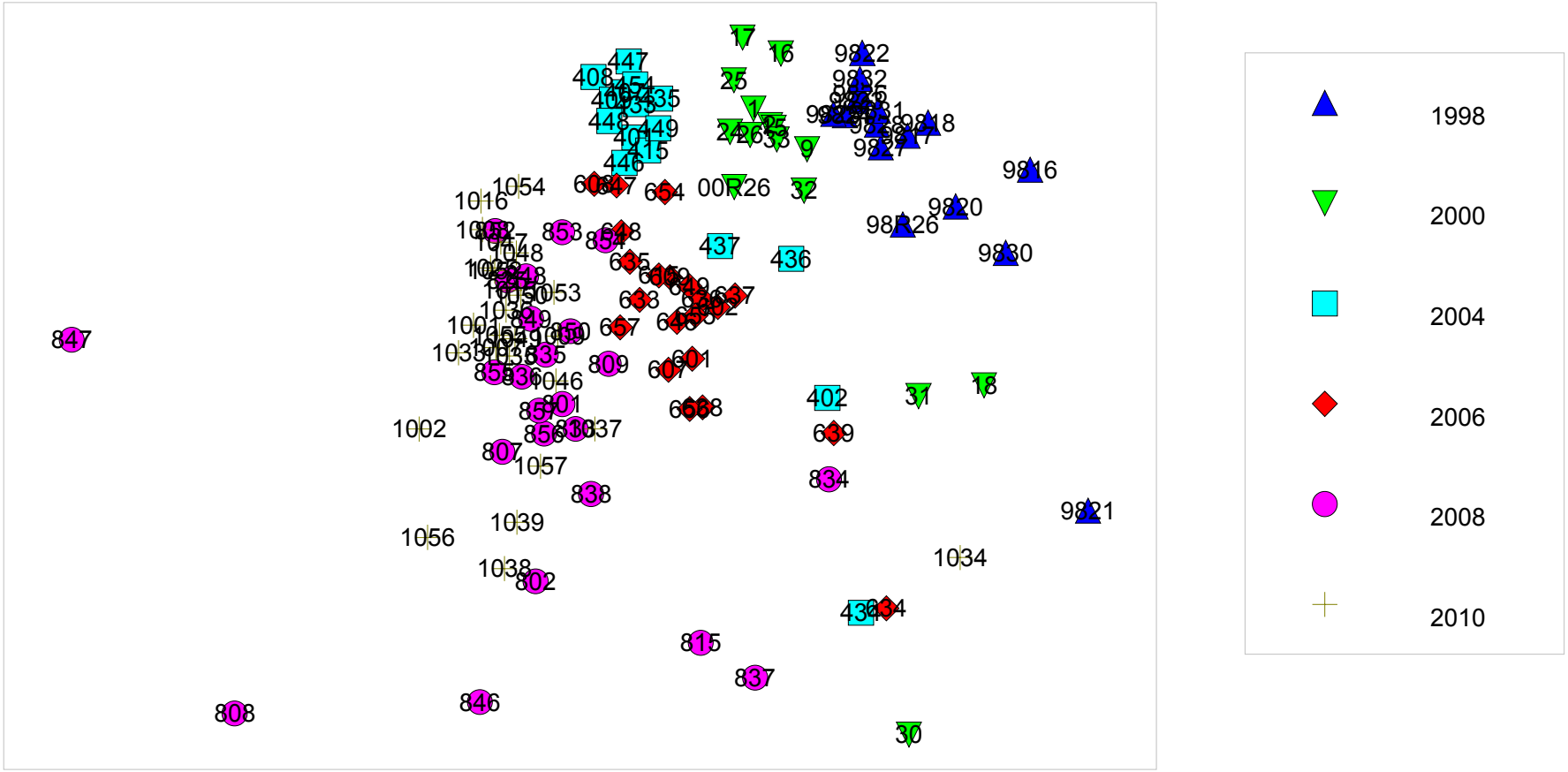

Figure 6.6 NMDS Ordination Combined Macrobenthic Data 1998-2010

Table 6.10 Species Richness & Abundance for each Taxonomic Group at each Station 2004-2010

		1				2				7				8				9			
		2004	2006	2008	2010	2004	2006	2008	2010	2004	2006	2008	2010	2004	2006	2008	2010	2004	2006	2008	2010
	Taxa	0	0	0	0	1	0	0	0	0	0	0	0	1	1	1	0	1	0	1	0
Class Nematoda	Abund	0	0	0	0	3	0	0	0	0	0	0	0	20	7	3	0	3	0	3	0
	Taxa	5	3	3	4	2	2	2	4	4	3	2	3	8	3	0	5	4	2	0	4
Class Polychaeta	Abund	347	87	257	1253	56	147	13	113	165	30	13	200	1046	240	0	1690	26	40	0	57
	Taxa	4	2	3	3	3	3	1	0	3	3	2	4	3	3	0	4	3	3	3	4
Class Oligochaeta	Abund	1247	273	40	120	79	137	3	0	274	170	7	80	389	503	0	243	383	293	107	210
	Taxa	1	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0
Order Ostracoda	Abund	1284	0	0	0	307	0	0	0	122	0	0	0	1686	0	0	0	541	0	0	0
	Taxa	3	3	1	0	3	3	0	0	4	2	0	1	3	3	0	2	3	3	1	2
Order Cumacea	Abund	66	17	3	0	23	497	0	0	53	10	0	3	191	80	0	40	73	137	20	20
	Taxa	2	4	5	9	0	4	4	9	2	3	5	9	3	6	2	16	0	3	7	9
Order Amphipoda	Abund	10	40	47	167	0	57	47	133	69	83	37	233	911	857	13	1123	0	53	60	213
	Taxa	1	1	1	0	1	1	0	0	0	1	0	0	0	0	0	1	1	1	0	1
Order Isopoda	Abund	7	3	3	0	3	17	0	0	0	43	0	0	0	0	0	7	3	7	0	10
	Taxa	1	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	1	1	1	0
Class Insecta	Abund	122	0	0	0	0	0	0	0	221	0	0	0	300	80	0	0	46	3	3	0
	Taxa	2	1	0	1	0	0	0	0	2	0	1	0	2	3	0	2	3	2	1	0
Class Bivalvia	Abund	1162	97	0	3	0	0	0	0	413	0	7	0	851	773	0	47	155	40	3	0
	Taxa	3	0	0	0	0	0	0	0	3	0	0	0	4	1	0	1	3	0	0	0
Class Gastropoda	Abund	244	0	0	0	0	0	0	0	119	0	0	0	116	3	0	3	20	0	0	0
	Taxa	**22**	**14**	**13**	**17**	**11**	**13**	**7**	**13**	**20**	**12**	**10**	**17**	**26**	**21**	**3**	**31**	**20**	**15**	**14**	**20**
Total	**Abund**	**4488**	**517**	**350**	**1543**	**472**	**853**	**63**	**247**	**1436**	**337**	**63**	**517**	**5511**	**2543**	**17**	**3153**	**1251**	**573**	**197**	**510**

Table 6.10 Cont Species Richness & Abundance for each Taxonomic Group at each Station 2004-2010

		15				16		25		33				34				35			
		2004	2006	2008	2010	2008	2010	2008	2010	2004	2006	2008	2010	2004	2006	2008	2010	2004	2006	2008	2010
	Taxa	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0
Class Nematoda	Abund	7	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	7	0	0	0
	Taxa	4	2	2	6	0	6	3	6	4	4	2	4	1	1	3	2	5	3	4	4
Class Polychaeta	Abund	152	123	7	1247	0	487	727	1590	185	77	27	1710	50	67	30	13	201	107	87	213
	Taxa	4	3	2	4	0	3	2	4	3	3	2	4	2	2	2	0	3	3	2	3
Class Oligochaeta	Abund	957	250	7	160	0	390	417	127	861	360	77	137	23	7	13	0	650	433	187	173
	Taxa	1	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	1	0	0	0
Order Ostracoda	Abund	551	0	0	0	0	0	0	0	881	27	0	0	277	0	0	0	238	0	0	0
	Taxa	3	2	0	1	0	1	0	0	2	0	1	2	0	0	1	2	5	1	0	0
Order Cumacea	Abund	69	17	0	3	0	20	0	0	33	0	3	27	0	0	50	223	40	13	0	0
	Taxa	3	5	1	14	0	14	10	12	2	6	5	4	1	0	2	1	1	5	5	11
Order Amphipoda	Abund	102	163	7	393	0	1390	150	480	76	97	33	163	3	0	10	3	79	133	57	173
	Taxa	1	1	0	1	0	0	0	1	0	1	1	0	0	0	1	0	1	1	0	1
Order Isopoda	Abund	10	13	0	7	0	0	0	3	0	50	3	0	0	0	3	0	7	23	0	3
	Taxa	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1	0	0
Class Insecta	Abund	271	0	0	0	0	0	0	0	264	3	0	0	0	0	0	0	323	10	0	0
	Taxa	2	1	0	1	0	2	1	2	2	0	0	0	1	0	0	0	3	2	1	1
Class Bivalvia	Abund	1746	197	0	83	0	887	50	77	759	0	0	0	3	0	0	0	2637	250	113	57
	Taxa	2	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	4	0	0	1
Class Gastropoda	Abund	165	0	0	0	0	0	0	0	89	0	0	0	0	0	0	0	116	0	0	7
	Taxa	**22**	**14**	**5**	**27**	**0**	**26**	**16**	**25**	**17**	**16**	**11**	**14**	**7**	**3**	**9**	**5**	**25**	**16**	**12**	**21**
Total	**Abund**	**4029**	**763**	**20**	**1893**	**0**	**3173**	**1343**	**2277**	**3148**	**613**	**143**	**2037**	**360**	**73**	**107**	**240**	**4297**	**970**	**443**	**627**

Table 6.10 Cont Species Richness & Abundance for each Taxonomic Group at each Station 2004-2010

		36				37				38			39			46			
		2004	2006	2008	2010	2004	2006	2008	2010	2006	2008	2010	2006	2008	2010	2004	2006	2008	2010
	Taxa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Class Nematoda	Abund	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0
	Taxa	2	2	3	4	1	3	0	0	2	1	0	1	0	2	2	2	1	3
Class Polychaeta	Abund	40	97	67	790	33	63	0	0	113	3	0	110	0	7	46	313	3	63
	Taxa	3	3	1	4	4	3	1	4	2	2	0	2	0	0	4	3	1	3
Class Oligochaeta	Abund	135	77	103	73	205	177	3	37	10	20	0	43	0	0	340	47	3	53
	Taxa	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0
Order Ostracoda	Abund	297	0	0	0	135	0	0	0	0	0	0	0	0	0	571	0	0	0
	Taxa	3	3	2	3	4	3	0	1	3	1	1	1	0	2	2	3	0	3
Order Cumacea	Abund	20	60	7	13	73	30	0	7	53	3	7	23	0	7	10	37	0	20
	Taxa	1	4	9	8	1	3	1	13	4	7	6	1	0	8	4	3	3	8
Order Amphipoda	Abund	10	43	87	273	7	10	3	150	23	47	80	3	0	90	17	20	10	157
	Taxa	1	0	1	0	1	1	1	1	1	1	1	1	0	1	0	1	0	0
Order Isopoda	Abund	10	0	7	0	10	3	3	10	20	3	17	7	0	10	0	27	0	0
	Taxa	0	1	0	1	1	1	0	0	0	0	0	0	0	1	1	1	0	0
Class Insecta	Abund	0	13	0	7	10	3	0	0	0	0	0	0	0	3	40	7	0	0
	Taxa	2	0	1	0	1	0	0	0	1	0	0	2	0	0	1	1	0	0
Class Bivalvia	Abund	538	0	13	0	135	0	0	0	7	0	0	30	0	0	1132	20	0	0
	Taxa	4	0	0	0	2	0	0	0	0	0	0	0	0	1	3	0	0	0
Class Gastropoda	Abund	59	0	0	0	13	0	0	0	0	0	0	0	0	3	20	0	0	0
	Taxa	**17**	**13**	**17**	**20**	**16**	**14**	**3**	**19**	**13**	**12**	**8**	**8**	**0**	**15**	**19**	**14**	**5**	**17**
Total	**Abund**	**1109**	**290**	**283**	**1157**	**620**	**287**	**10**	**203**	**227**	**77**	**103**	**217**	**0**	**120**	**2178**	**470**	**17**	**293**

Table 6.10 Cont Species Richness & Abundance for each Taxonomic Group at each Station 2004-2010

		47				48				49				50		52		53	
		2004	2006	2008	2010	2004	2006	2008	2010	2004	2006	2008	2010	2008	2010	2008	2010	2008	2010
	Taxa	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
Class Nematoda	Abund	0	3	0	0	0	0	0	0	0	0	3	0	0	3	0	0	0	0
	Taxa	5	1	0	5	4	3	5	5	3	3	3	3	5	4	4	6	6	5
Class Polychaeta	Abund	785	150	0	810	205	160	77	680	248	53	390	130	43	427	30	207	90	123
	Taxa	4	3	0	2	4	3	2	2	4	3	4	4	2	4	2	4	4	4
Class Oligochaeta	Abund	746	347	0	323	3663	280	320	310	855	733	210	120	33	53	17	20	100	110
	Taxa	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
Order Ostracoda	Abund	2049	0	0	0	139	0	0	0	145	0	0	0	0	0	0	0	0	0
	Taxa	3	2	0	1	4	3	1	2	3	2	1	1	0	1	1	3	3	2
Order Cumacea	Abund	162	47	0	10	221	167	13	10	26	57	3	3	0	7	7	40	30	17
	Taxa	5	5	1	15	4	7	8	16	1	4	6	9	6	12	8	9	6	13
Order Amphipoda	Abund	2412	837	3	680	604	1157	240	697	125	87	47	223	30	387	167	507	237	827
	Taxa	1	1	0	0	2	1	0	0	1	1	0	1	0	1	0	0	0	1
Order Isopoda	Abund	3	10	0	0	63	20	0	0	7	27	0	10	0	3	0	0	0	7
	Taxa	1	1	0	0	1	1	0	0	1	1	1	0	1	0	0	0	1	1
Class Insecta	Abund	281	50	0	0	195	50	0	0	241	13	3	0	3	0	0	0	7	3
	Taxa	3	3	1	2	3	3	2	1	2	1	1	1	1	2	2	2	2	0
Class Bivalvia	Abund	3703	2120	7	520	1284	307	20	3	927	70	73	97	20	140	50	37	63	0
	Taxa	4	0	0	0	6	0	0	0	4	0	0	1	0	0	4	0	4	0
Class Gastropoda	Abund	165	0	0	0	320	0	0	0	479	0	0	3	0	0	30	0	63	0
	Taxa	**27**	**17**	**2**	**25**	**29**	**21**	**18**	**26**	**20**	**15**	**17**	**20**	**15**	**25**	**21**	**24**	**26**	**26**
Total	**Abund**	**10306**	**3563**	**10**	**2343**	**6692**	**2140**	**670**	**1700**	**3053**	**1040**	**730**	**587**	**130**	**1020**	**300**	**810**	**590**	**1087**

Table 6.10 Cont Species Richness & Abundance for each Taxonomic Group at each Station 2004-2010

		54				55			56			57		
		2004	2006	2008	2010	2006	2008	2010	2006	2008	2010	2006	2008	2010
	Taxa	0	1	0	1	0	0	0	0	0	0	0	0	0
Class Nematoda	Abund	0	3	0	7	0	0	0	0	0	0	0	0	0
	Taxa	4	1	2	6	3	3	3	3	3	0	1	2	2
Class Polychaeta	Abund	343	430	50	737	33	213	857	100	37	0	33	20	23
	Taxa	5	3	4	4	2	3	4	1	2	0	3	3	3
Class Oligochaeta	Abund	838	1033	177	460	210	293	93	237	33	0	290	60	27
	Taxa	1	1	0	0	0	0	0	0	0	0	1	0	0
Order Ostracoda	Abund	99	13	0	0	0	0	0	0	0	0	10	0	0
	Taxa	3	3	2	3	2	0	1	1	1	2	2	1	1
Order Cumacea	Abund	132	303	30	253	13	0	7	17	7	37	13	7	7
	Taxa	4	6	8	19	3	6	13	3	6	6	5	6	5
Order Amphipoda	Abund	2307	1497	467	2947	63	113	333	83	103	167	410	420	463
	Taxa	1	2	1	0	1	0	1	1	1	0	0	0	1
Order Isopoda	Abund	3	20	3	0	7	0	3	3	3	0	0	0	3
	Taxa	1	1	1	1	0	0	1	0	0	0	0	0	0
Class Insecta	Abund	53	177	7	7	0	0	3	0	0	0	0	0	0
	Taxa	2	3	2	2	2	0	0	1	0	0	0	0	0
Class Bivalvia	Abund	901	667	50	90	50	0	0	3	0	0	0	0	0
	Taxa	3	0	0	2	0	0	0	0	0	0	0	0	0
Class Gastropoda	Abund	142	0	0	17	0	0	0	0	0	0	0	0	0
	Taxa	**24**	**21**	**20**	**38**	**13**	**12**	**23**	**10**	**13**	**8**	**12**	**12**	**12**
Total	**Abund**	**4818**	**4143**	**783**	**4517**	**377**	**620**	**1297**	**443**	**183**	**203**	**757**	**507**	**523**