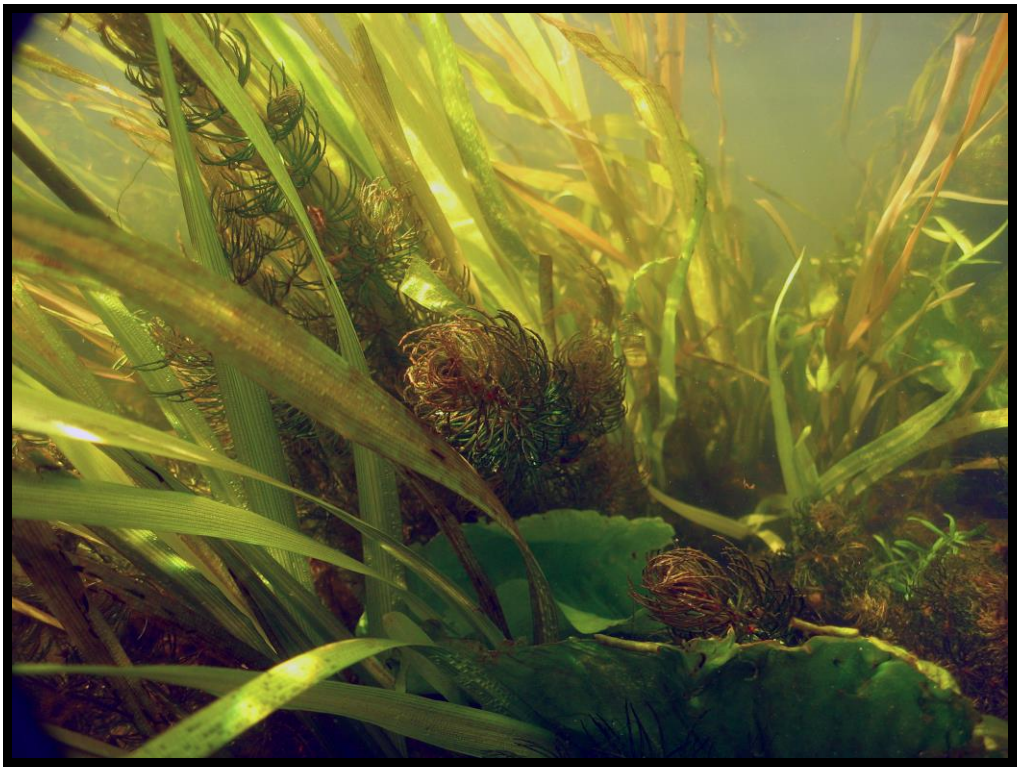
Broads Annual Water Plant Monitoring Report 2012



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Cover Photograph. Aquatic plant community from Waveney Valley.

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1 EXECUTIVE SUMMARY

This report presents and discusses the findings from the annual water plant surveys carried out during 2012, which covered 28 waterbodies. The methodology, data gathering and analysis employed in the annual water plant surveys undertaken by the Broads Authority is detailed in "Broads Annual Water Plant Monitoring Methods."

Key results from the 2012 survey can be summarised as: -

- Hickling and Horsey Mere continue to have a very low number of species present and low abundance. However, there are early signs that species richness in Hickling is slowly increasing and that abundance is gradually increasing in both broads since the low in 2008, although 2012 was a particularly poor year for plants in Heigham Sound.
- Plant communities in the Martham Broads appear to stable, continuing to support diverse, species rich plant communities generally dominated by variety of stonewort species
- Those broads on the Bure with good connectivity to the river continued to show poor species richness and abundance, particularly Wroxham, Ranworth, Hoveton Great and Salhouse Great broads. Interestingly Bridge broad, with high connectivity to the river continued to show much greater abundance levels than the larger broads.
- At the Trinity Broads, the 2012 surveys revealed a surprising change in recent trends. Filby Broad, historically the poorest of the 5 broads in the system in terms of aquatic macrophytes had the highest species richness of all of the Trinity Broads in 2012, and the highest abundance of aquatic macrophytes. Conversely, Ormesby Broad, which in recent times has had the highest species diversity and a good abundance of aquatic plants, in 2012 had one of the lowest species counts, and the lowest abundance of plants in all of the Trinity broads. The water plant report generated for the Trinity Broads Partnership is included in Appendix 4.
- Barnby Broad, mudpumed in 2007 continued on a trend of increasing plant abundance and species diversity with nearly equal proportions of stoneworts and vascular macrophytes. Upton Little broad, mudpumped in 2011 had been rapidly colonised throughout by a stonewort, but did not yet exhibit the species diversity hoped.
- For those broads surveyed in 2011 and 2012, nearly all showed a decrease in the relative levels of plant abundance. It is suspected that the highly unusual weather patterns experienced across the UK in 2012, particularly the drought conditions experienced in the first half of the year followed by record rainfall events, will have directly and indirectly impacted on water quality and plant growth.

As a classification and assessment tool the water plant surveys inform ways in which lake restoration works can be targeted and allow the success of any management to be assessed. The water plant monitoring also provides an early means to identify possible sites of deterioration. The results of the water plant surveys contribute to the classification and monitoring of SSSI waterbodies in partnership with Natural England. The detection of invasive, non-native plant species within the Broads is also important function of the annual survey if the risks posed by these plants are to be effectively managed.

Steady progress is clearly being made through the Lake Restoration Strategy, however much work remains to be done across the Broads to bring degraded broads back to health, in line with national and EU drivers and to increase and subsequently maintain the diversity of those broads lacking in species richness. The annual water plant survey therefore continues to be a valuable part of targeting and measuring the success of restoration efforts.

2 AIMS AND OBJECTIVES

The aim of the Broads annual survey is to monitor water plants within specified broads, along previously defined transects between late July and early September, using the methodology outlined by Kennison *et al* (1998). Where broads have historically been sampled around a particular date, it is aimed that the survey takes place as near as possible to that date.

The main objectives in the annual programme are to monitor key broads with long-term datasets, those that have had restoration measures put in place or those that are known to be experiencing a change in their macrophyte community. Broads that have not received restoration efforts or are stable and/or are generally without plants, are monitored on a less frequent basis. When resources allow, a rolling program of monitoring sites not previously surveyed is also an ongoing aim.

This report will collate the data collected since the last survey report in 2010 and will refer to the long-term data from 1983 to 2012 (Table 1).

Table 1. Sites surveyed for water plants from 1983 to 2012.

	# of years	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12
Alderfen	30	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Bargate	3																						■		■						■
Barnby	6																						■	■	■	■		■			■
Barton	30	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Belaugh	20							■	■	■	■	■	■	■	■	■	■	■	■	■	■		■	■	■	■			■	■	
Blackfleet	3	■		■																					■						
Bridge	12														■	■	■	■	■	■	■		■	■	■	■					■
Buckenham	7																						■	■	■	■		■	■	■	
Burntfen	5																■					■			■				■	■	
Calthorpe	3																												■	■	■
Catfield	2																						■					■			
Cockshoot	30	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Cockshoot Dyke	27	■	■	■	■	■	■	■	■	■	■	■	■	■			■		■	■	■	■	■	■	■	■	■	■	■	■	■
Cromes South	29	■	■	■	■	■	■	■	■	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Cromes North	27	■	■	■	■	■	■	■	■	■	■	■		■		■	■	■	■	■		■	■	■	■	■	■	■	■	■	■
Decoy	8				■												■						■	■	■	■	■	■			
Flixton Decoy	3																								■	■			■		
Hassingham	8																						■	■	■	■	■	■	■	■	
Heigham Sound	22	■	■	■	■	■	■	■	■	■	■	■	■		■	■								■	■	■	■	■	■	■	■
Hickling	30	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Horsey Mere	26	■	■	■	■	■		■	■	■	■			■	■	■	■	■	■		■	■	■	■	■	■	■	■	■	■	■
Hoveton Great	30	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Hoveton Little	12							■						■	■	■	■	■	■	■			■	■	■	■					
Hudson's Bay	8	■	■	■		■		■							■											■					■
Irstead	2																						■					■			

	# of years	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12
Little	4																														
Malthouse	7																														
Martham North	29																														
Martham South	28																														
Mautby Decoy	4																														
Norton	4																														
Pound End	13																														
Ranworth	28																														
Reedham Water	2																														
Rockland	23																														
Round water	2																														
Salhouse Great	13																														
Salhouse Little	7																														
Spratts Water	3																														
Strumpshaw	8																														
Upton Great	30																														
Upton Little	6																														
Wheatfen	5																														
Whitlingham Great	9																														
Whitlingham Little	8																														
Woolners Carr	1																														
Wroxham	30																														
# per year		21	20	21	21	22	13	22	20	21	21	15	12	24	26	24	28	20	24	17	21	19	35	33	38	40	30	31	30	27	27

Table 2 Sampling dates and transect lengths (metres) (2008-2012).

Broad	Survey Date				Transect Length			
	2009	2010	2011	2012	2009	2010	2011	2012
Alderfen	19-Aug	03-Aug	09-Aug	14-Aug	850	758	761	866
Bargate	-	-	-	31-Aug	-	-	-	942
Barnby	14-Aug	-	-	19-Jul	360	-	-	384
Barton	12-Aug	21-Jul	04-Aug	06-Aug	4942	4782	4039	4903
Belaugh	-	05-Aug	11-Aug	-	-	254	264	-
Bridge Broad	-	-		03-Aug	-	-	-	403
Buckenham Broad	28-Aug	30-Jul	20-Jul	-	270	333	299	-
Burntfen	-	12-Aug	01-Sep	-	-	431	403	-
Calthorpe	-	03-Sep	17-Aug	11-Sep	-	155	160	143
Cockshoot Broad	03-Sep	01-Sep	18-Aug	29-Aug	938	817	1066	1063
Catfield	03-Sep	-	-	-	345	-	-	-
Crome's	19-Aug	03-Aug	08-Aug	14-Aug	964	1087	1137	956
Decoy Broad	05-Aug	-	-	-	1567	-	-	-
Flixton Decoy	-	06-Aug	-	-	-	781	-	-
Hassingham Broad	28-Jul	30-Jul	20-Jul	-	254	327	220	-
Heigham Sound	07-Aug	23-Aug	29-Jul	26-Jul	2180	1670	2385	2334
Hickling	13-Aug	23-Jul	05-Aug	25-Jul	8423	8751	9455	8799
Horsey Mere	07-Aug	28-Jul	29-Jul	31-Jul	3520	3426	3309	3418
Hoveton Great	06-Aug	05-Aug	03-Aug	06-Sep	3039	3158	3042	3310
Hoveton Little	-	-	-	-	-	-	-	-
Hudsons Bay	-	-	-	06-Sep	-	-	-	376
Irstead	04-Aug	-	-	-	165	-	-	-
Malthouse	-	17-Aug	-	-	-	1118	-	-
Martham Broad North	30-Jul	29-Jul	25-Jul	24-Jul	814	760	743	744
Martham Broad South	30-Jul	29-Jul	26-Jul	24-Jul	772	758	714	551
Mautby Decoy	09-Sep	02-Sep	-	-	498	389	-	-
Mill Water	-	-	-	-	-	-	-	-
Nortons	29-Jul	05-Aug	11-Aug	-	242	192	92	-
Pound End	-	-	-	-	-	-	-	-
Ranworth	21-Aug	31-Aug	16-Aug	02-Aug	4399	4600	4426	4590
Rockland	-	30-Aug	25-Aug	30-Aug	-	1359	1551	1559
Reedham	04-Aug	-	-	-	421	-	-	-
Round Water	-	-	23-Aug	-	-	-	26	-
Salhouse Great	-	-	-	08-Aug	-	-	-	770
Salhouse Little	-	-	-	08-Aug	-	-	-	0
Spratt's Water	-	-	23-Aug	-	-	-	67	-
Strumpshaw	-	30-Jul	20-Jul	27-Jul	-	299	441	392
Upton Great	18-Aug	13-Aug	10-Aug	22-Aug	986	1006	1071	943
Upton Little	18-Aug	13-Aug	-	22-Aug	173	223	-	229
Wheatfen	-	-	-	30-Aug	-	-	-	677
Whitlingham Great	28-Aug	-	19-Jul	18-Jul	2990	-	2936	2736
Whitlingham Little	28-Aug	30-Aug	19-Jul	18-Jul	672	712	614	660
Woolners Carr	-	-	23-Aug	-	-	-	26	-
Wroxham	04-Aug	04-Aug	21-Jul	03-Aug	1933	1757	1433	1667

3 BROADS MACROPHYTE RESULTS.

Each broad that was surveyed in 2012 is reviewed in terms of species richness and abundance. Species recorded in 2008 to 2010 are starred to illustrate recent trends. For 2011 and 2012 the macrophyte index is also listed to show recent species abundances. The abundance figures, here expressed as the semi-quantitative "Macrophyte Index" (MI), indicate the relative amount of each plant species recorded based on an estimate of the relative volume of each species on the rake. Please see "Broads Annual Water Plants. Monitoring Methods." for further explanation of the macrophyte index. Where data or key events are relevant to the current status of the broad they will be highlighted. The broads are grouped by the river catchment in which they are situated.

Appendix 1 classifies the plants into groups of similar form/structure and these groupings are used to generate the graphs in Appendix 2. Appendix 3 lists the common and Latin names for all plants found to date during broads surveys. The Annual Macrophyte Survey report for the Trinity Broads is attached in Appendix 4.

3.1 Thurne Valley

These broads contain one of the richest population of stoneworts in the UK. Several of which are on the list of high conservation importance plants and have Biodiversity Action Plans attached to them. Stoneworts are recorded in some broads outside of the Thurne catchment but in lower abundances. Species present in the Thurne broads that are included in the Joint Nature Conservation Committee (JNCC) Red Data Book included, three 'Vulnerable' species: Baltic stonewort, Convergent stonewort, Starry stonewort, one 'Rare': Intermediate stonewort (Stewart and Church, 1992). The Thurne broads also provide a stronghold for the rare BAP species holly-leaved naiad, as well as more common vascular plants such as spiked water milfoil and mare's tail.

3.11 Hickling

	2008	2009	2010	2011 MI	2012MI
Spiked water milfoil	*	*	*	0.344	0.339
Fennel-leaved pondweed	*	*	*	0.042	0.058
Curled pondweed			*	0.035	0.020
Stonewort (*Chara*) species *				0.004	0.013
Holly-leaved naiad	*	*	*	0.010	0.004
Rigid hornwort		*	*	0.004	0.002
Intermediate stonewort				0.002	0.001
Delicate stonewort			*		0.001
Mare's tail		*			0.001
Common reed				0.001	
Fragile stonewort				0.001	
Starwort sp.				0.0004	
Stonewort (*Nitella)* species				0.0004	
Filamentous algae			*		
Fragile/convergent stonewort			*		
Canadian waterweed			*		
Total number of species	3	5	9	11	9

Macrophyte diversity in Hickling Broad has been declining since the early 2000s and over a 3 year period the species richness dropped dramatically from 11 in 2005 to 3 in 2008. The last few years have started to see a gradual recovery with 9 species (including the non-specific *Chara* sp figure) recorded in 2012. The relative abundance of macrophytes is still low compared to pre 2006 levels where the abundance of stoneworts generally comprised over half the volume of plants recorded; since 2006 the mass of plants recorded has been dominated by the presence of vascular macrophytes (see Macrophyte abundance trends in Appendix 2).

* Some fragments of *Chara* sp were identified as opposite stonewort *Chara contraria.* This identification has not been verified by an expert and therefore has not been formally recorded. Further survey in 2013 will be needed to clarify the presence of this species.

3.12 Horsey Mere

	2008	2009	2010	2011 MI	2012 MI
Spiked water milfoil	*	*	*	0.146	0.091
Mares tail	*	*	*	0.102	0.157
Filamentous algae			*	0.003	
Fennel-leaved pondweed		*	*	0.002	
Total number of species	2	3	4	4	2

Following a similar trend to Hickling, the species richness and abundance of macrophytes in Horsey Mere has been declining since 2002 and stonewort species were last recorded in 2005. Spiked water milfoil and mare's tail (absent in 1997) have been present in all the 26 years surveyed since 1983 but generally species richness and abundance remains low and 2012 was no exception.

Martham North and South

For many years, the Martham Broads have been characterised by sustained clear water conditions, resulting from the plentiful supply of good quality freshwater draining from the northeast of the broads. These conditions generally continue and are reflected in the high diversity of the plant communities found in the most recent surveys, but there has been a gradual decline in water clarity over the last 5 years.

3.13 Martham North

	2008	2009	2010	2011 MI	2012MI
Holly-leaved naiad	*	*	*	0.561	0.280
Intermediate stonewort		*	*	0.048	0.254
Bristly stonewort	*	*	*	0.033	0.253
Baltic stonewort	*	*	*	0.013	0.245
Mare's tail	*	*	*	0.039	0.069
Starry stonewort	*	*	*	0.129	0.062
Fennel-leaved pondweed			*	0.212	0.044
Opposite stonewort			*	0.010	0.017
Horned pondweed	*	*	*	0.035	0.012
Stonewort (*Nitella*) species				0.017	0.005
Spiked Water Milfoil	*	*			0.005
Fragile/Convergent Stonewort					0.005

	2008	2009	2010	2011 MI	2012MI
Common stonewort		*		0.020	0.004
Stonewort (*Chara*) species				0.024	
Starwort sp.		*		0.004	
Whorled Water Milfoil				0.003	
Filamentous algae		*	*		
Perfoliate pondweed	*		*		
Enteromorpha sp.			*		
Convergent stonewort	*				
Lesser pondweed	*				
Nuttall's waterweed		*			
Pointed stonewort	*	*			
Yellow water lily	*				
Total number of species	12	13	12	14	13

Between 1997 and 2010 surveys recorded a dominance of stonewort species compared to vascular plants comprised primarily of Bristly stonewort and Starry stonewort, the latter species classified as a vulnerable Red Data Book species. In 2011 the data suggested an unusual reduction in the dominance of stoneworts with a shift towards the dominance of vascular macrophytes. However 2012 data indicates that the abundance of stoneworts was at its highest level since 2009.

Species diversity remains very high. There continues to be plant volume (or biomass) variations that are poorly detected by the rake trawl method, especially in broads with generally high macrophyte abundance.

3.14 Martham South

	2008	2009	2010	2011 MI	2012MI
Bristly stonewort	*	*	*	0.466	0.381
Intermediate stonewort	*	*	*	0.101	0.336
Holly-leaved naiad	*	*	*	0.112	0.193
Mare's tail	*	*	*	0.062	0.160
Starry stonewort	*	*	*	0.182	0.101
Baltic stonewort	*	*	*	0.037	0.056
Horned pondweed	*	*	*		0.027
Starwort sp.	*	*	*	0.029	0.015
Spiked water milfoil	*	*	*	0.025	0.015
Willow-leaved Pondweed	*			0.003	0.015
Yellow water lily		*			0.015
Fennel-leaved Pondweed	*	*	*	0.005	0.009
Canadian waterweed	*	*	*	0.017	0.003
Crowfoot sp.		*	*		0.003
Ivy-leaved Duckweed					0.003
Fan-leaved water crowfoot	*	*		0.017	
Filamentous algae	*	*	*	0.015	
Rigid hornwort	*	*	*	0.014	
Opposite stonewort			*	0.007	
Convergent stonewort	*		*	0.007	

	2008	2009	2010	2011 MI	2012MI
Stringy moss			*	0.007	
Hedgehog Stonewort	*	*	*	0.005	
Lesser pondweed	*			0.003	
Curled Pondweed				0.003	
Rough stonewort	*	*	*	0.002	
Enteromorpha sp.	*	*	*		
Perfoliate pondweed	*	*	*		
Arrowhead			*		
Common water moss	*				
Perfoliate pondweed	*	*			
Whorled water milfoil	*				
Total number of species	23	20	23	21	15

As in recent years, records indicate that bristly stonewort, holly-leaved naiad and mare's tail remain abundant across the broad with abundance figures for all but bristly stonewort increasing in 2012. However the abundance of the rare intermediate stonewort had increased since 2011 from 0.101 to 0.336, the highest recorded abundance for this species in Martham South since 1997.

Notably the species richness of the broad in 2012 was significantly lower than in 2011 having dropped from 21 to 15, although the numbers indicate that there has been a gradual decline in species richness over the last 5 years.

It is possible that the very unusual wet weather conditions in the spring and summer may have contributed to this decline. The turbidity of the water observed at the time of survey, if sustained, would undoubtedly have impacted plant growth. However it must also be noted that the trawl survey method is not suited to the high plant abundance conditions of these broads and some species may have been missed as a result. Transect E was not surveyed due to shallow water conditions and the presence of breeding terns on the raft nearby.

3.15 Heigham Sound

	2008	2009	2010	2011 MI	2012MI
Spiked water milfoil	*	*	*	0.441	0.414
Curled pondweed	*	*	*	0.094	0.033
Rigid hornwort	*	*	*	0.024	0.031
Mare's tail	*	*	*		0.015
Stonewort (*Chara*) species *					0.005
Stonewort (*Nitella*) species					0.005
Fan-leaved water crowfoot				0.005	
Fennel leaved pondweed			*	0.003	
Starry stonewort				0.003	
Filamentous algae			*		
Nuttall's waterweed			*		
Canadian waterweed			*		
Holly-leaved naiad	*				
Whorled water milfoil		*			
Total number of species	5	5	8	6	6

The gradual decrease in species numbers from 10 in 2005 to a low of 5 in 2009 appeared to have been temporarily halted with 8 species sampled in 2010 but numbers declined to 6 in 2011 & 2012. Notably, stonewort species have started to reappear in the last 2 years, albeit in very low abundance, since last being recorded in 2006. Fragments of *Chara* species were recorded for the first time in 2012 since 1997, whilst a fragment of *Nitella* sp was recorded in 2011 & 2012 for the first time since 2005.

* Some fragments of *Chara* sp were identified as opposite stonewort *Chara contraria.* This identification has not been verified by an expert and therefore has not been formally recorded. Further survey in 2013 will be needed to clarify the presence of this species.

3.16 Calthorpe

	2010 MI	2011 MI	2012MI
Broad-leaved pondweed	0.003	0.074	0.452
Bristly stonewort	0.331	0.562	0.387
Yellow water lily	0.273	0.030	0.082
Stonewort (*Nitella*) species			0.049
White water lily			0.024
Filamentous algae			0.022
Horned pondweed			0.009
Fragile stonewort		0.220	
Smooth stonewort		0.100	
Fragile/Convergent stonewort	0.013	0.069	
Blunt-leaved pondweed		0.037	
Baltic stonewort	0.062		
Total number of species	5	7	7

Prior to suction dredging in the summer of 2009 Calthorpe broad was very shallow and dominated by water lilies. As it can be seen the seed bank was adequately exposed by the restoration works and resulted in the germination of a number of stonewort species and pondweeds.

Due to delays in getting permission to access the broad, Calthorpe was not surveyed until 11th September nearly a month later than in previous years. At the time of survey most of the stonewort species had started to decay making identification very difficult. The survey conditions may have impacted on the species recorded. The east end still remains very shallow and very bare.

3.2 Ant Valley

In the Ant Valley, Alderfen, Crome's and Barton broad have been regularly surveyed. These water bodies have been subject to extensive restoration effort over the last 25 years and all have improved water quality and macrophyte populations as a result. Alderfen and Crome's have good populations of rigid hornwort. Aquatic plants are numerous within the clear water areas of Barton Broad, which have been restored through the removal of zooplanktivorous fish from exclusion areas. Following the success of plant growth in the restoration areas, plant populations have started to spread out into the main broad itself.

3.21 Barton

	2008	2009	2010	2011 MI	2012 MI
Fennel-leaved pondweed	*	*	*	0.101	0.091
Rigid hornwort	*	*	*	0.006	0.020
Nuttall's waterweed	*	*	*	0.026	0.017
Curled pondweed	*		*		0.007
Water soldier		*			0.005
Yellow water lily	*	*		0.043	0.002
Filamentous algae	*	*		0.004	
Starry stonewort				0.001	
Enteromorpha sp.				0.001	
Arrowhead	*				
Bulrush	*				
Common duckweed	*				
Greater duckweed	*				
Unbranched bur-reed	*				
White water lily		*			
Total number of species	11	7	4	7	6

Barton Broad historically had a very low abundance and occasional complete absence of recorded aquatic macrophytes. Between 2003 and 2008 more than 10 macrophyte species have been recorded each summer, with steadily increasing abundance and richness. However, since 2009 abundance levels have dropped and species richness has declined with fewer than 7 species recorded in 2012.

3.22 Alderfen

	2008	2009	2010	2011 MI	2012 MI
Rigid hornwort	*	*	*	0.823	0.122
Filamentous algae	*	*	*	0.120	0.073
Holly-leaved naiad	*	*	*		0.013
Ivy-leaved duckweed			*	0.003	0.010
Stonewort (*Chara*) species *					0.007
Fragile/convergent stonewort					0.007
Enteromorpha		*	*		

	2008	2009	2010	2011 MI	2012 MI
Common duckweed			*		
Total number of species	3	4	6	3	6

The abundance of macrophytes in Alderfen appears to be cyclical with years of near absence of plants followed by several years where rigid hornwort, macro-algae and sometimes duckweeds occur, such as was found in 2010. Although rigid hornwort remained the dominant species in 2012, the abundance has dramatically decreased since 2011. Holly-leaved naiad first recorded 2006 and has remained present albeit in relatively small patches with low abundance. Notably in 2012, two stonewort species were identified for the first time since 2005 although abundance levels are very low.

* Some fragments of *Chara* sp were identified as opposite stonewort *Chara contraria.* This identification has not been verified by an expert and therefore has not been formally recorded. Further survey in 2013 will be needed to clarify the presence of this species.

3.23 Crome's

	2008	2009	2010	2011 MI	2012 MI
Bladderwort			*	0.148	0.312
Rigid hornwort	*	*	*	0.534	0.194
Filamentous algae	*	*	*	0.449	0.145
Nuttall's waterweed	*	*	*	0.008	0.095
Ivy-leaved duckweed		*	*	0.038	0.077
Common duckweed		*	*	0.011	0.028
Lesser pondweed			*		0.021
Enteromorpha		*	*	0.033	0.016
Frogbit			*	0.068	0.011
Lesser reedmace					0.004
Canadian waterweed	*	*	*	0.411	
Fragile/Convergent stonewort	*	*	*		
White water lily	*	*	*		
Delicate stonewort	*	*	*		
Yellow water lily				0.013	
Fennel-leaved pondweed			*		
Total number of species	7	10	14	10	10

Crome's Broad is divided into north and south basins by a reed strip on top of an old peat baulk. Both the basins have been dredged/mud pumped in the past and historically the south broad has had a greater diversity of plants than the north broad. However in the last few years, the positive effects of increased water depth as a result of the mud pumping have been reflected by increasing species richness in the north basin also. Bladderwort has been present in one or other of the basins for the last 3 years, a species generally indicative of good water quality.

3.3 Bure Valley

The hydrological connection to the River and the position of the Bure Valley broads within the catchment affects both ecological condition and restoration potential of these waterbodies. In recent years Upton and Cockshoot Broads, both isolated from the river, have had the highest populations of aquatic plants present in the Bure Broads. Upton Great Broad is a stronghold for the rare holly-leaved naiad. Upton Little Broad was surveyed for the first time following mudpumping in 2011. Those broads directly connected to the river, such as Ranworth, tend to have minimal plant diversity.

3.31 Bridge

	2008	2009	2010	2011	2012 MI
Filamentous algae	*				0.267
Nuttall's waterweed	*				0.050
Yellow water lily	*				0.042
Unbranched bur-reed	*				0.040
Enteromorpha					0.007
Canadian waterweed					0.004
Branched bur-reed	*				
Starwort sp.	*				
Total number of species	6				6

Following the last survey in 2008, it appears as though the conditions in Bridge Broad have remained relatively stable with a dominance of filamentous algae and similar figures for species richness and abundance. At the time of survey, clear water conditions were present in the broad and in the river allowing views of the bed however, due to its connectivity to the river it is likely that Bridge Broad suffers from fluctuations in water quality which may be a limiting factor for plant growth.

3.32 Cockshoot

	2008	2009	2010	2011 MI	2012 MI
Holly-leaved naiad	*	*	*	0.766	0.731
Filamentous algae	*	*	*	0.209	0.206
Rigid hornwort	*	*	*	0.010	0.026
White water lily		*		0.029	0.012
Enteromorpha	*	*		0.006	0.012
Yellow water lily			*		0.012
Canadian waterweed	*	*	*	0.006	0.002
Common duckweed				0.006	
Horned pondweed		*		0.004	
Lesser pondweed		*		0.002	
Common stonewort		*			
Water net	*				
Total number of species	6	9	5	9	7

Holly-leaved naiad remains the dominant species in Cockshoot, with very high abundance covering virtually the entire waterbody in 2011 and 2012. Cockshoot dyke was mudpumped in the winter 2011/2012 and there appeared to be a slight reduction in the abundance of filamentous algae in 2012 compared to 2011. It should be noted that due to electric outboard engine failure on a first visit, the survey was completed 2 weeks later than initially intended, although this appears to have had little impact on the survey results.

3.33 Hoveton Great

	2008	2009	2010	2011 MI	2012 MI
Rigid hornwort	*	*	*	0.038	0.091
Filamentous algae	*	*	*	0.089	0.052
Yellow water lily	*	*	*		0.025
Fennel-leaved pondweed	*	*	*	0.019	0.016
Curled pondweed	*				0.012
Nuttall's waterweed					0.004
Canadian waterweed			*	0.005	
Horned pondweed			*		
White water lily		*	*		
Holy leaved naiad		*			
Starwort	*				
Total number of species	6	6	7	4	6

Hoveton Great Broad generally has low macrophyte abundance with remnant patches of water lilies in sheltered bays. The species richness of this broad continues to be stable, at a low level, with only slight changes in species composition over the years. Disused fish barriers provide increased shelter from the strong wind-induced waves that can disturb the bottom sediments in this broad. No holly leaved naiad has been found since 2009 but this could be as a result of the sampling method rather than the loss of the species from the broad. Curled pondweed was recorded for the first time since 2008.

3.34 Hudsons Bay

	2008	2009	2010	2011	2012 MI
Filamentous algae					0.145
White water lily					0.061
Yellow water lily					0.057
Rigid hornwort					0.038
Common reed					0.017
Total number of species					5

Hudsons bay was characterised by areas of bare sediment with scattered dense blooms of filamentous algae and yellow and white water lily beds. There were a few scattered areas where rigid hornwort was present, but generally the abundance of aquatic macrophytes was very low. Water clarity was generally poor and there were extensive areas of very shallow water with deep sediment deposits.

3.35 Ranworth

	2008	2009	2010	2011 MI	2012 MI
Fennel-leaved pondweed	*	*	*	0.011	0.011
Rigid hornwort	*	*	*	0.059	0.009
Curled pondweed		*	*	0.002	0.008
Nuttall's waterweed	*			0.013	
Holly-leaved naiad				0.005	
Filamentous algae		*			
Total number of species	3	4	3	5	3

The plants in Ranworth Broad have nearly always been limited to a few sickly-looking individuals on some of the transects. Rigid hornwort, fennel-leaved pondweed and curled pondweed have been recorded every year since 2009 albeit with low levels of abundance. Following an unusual increase in species richness in 2011 with the notable presence of holly leaved naiad, only 3 species were present in 2012. There generally appears to be little change with the broad's plant community being very stable.

3.36 Salhouse Great

	2008	2009	2010	2011	2012 MI
Rigid hornwort					0.011
Filamentous algae					0.013
Total number of species					2

Rigid hornwort and filamentous algae were the only species recorded in 2012. However, no plants were recorded on the last 3 survey occasions. The species richness and abundance of Salhouse Great broad has always been very low. The maximum number of species ever recorded was 4 in 1998 which was also the year when the highest ever total abundance levels were recorded. The broad is closely linked to the river and is also subject to high levels of boat activity particularly in the summer which undoubtedly causes high levels of disturbance to the sediment, increasing turbidity, releasing nutrients into the water column and making it difficult for plants to take root.

3.37 Salhouse Little

In 2012 Salhouse Little broad was dominated by yellow water lily covering an estimated 75% of the broad surface. White water lily was also present but at lower abundance levels. It was not possible to use the rake trawling method as the outboard motor got repeatedly caught up on the density of lily stalks.

3.38 Upton Great

	2008	2009	2010	2011 MI	2012 MI
Holly-leaved naiad	*	*	*	0.752	0.774
Opposite stonewort	*	*	*	0.271	0.206
Common Stonewort					0.048
Water net			*		
Convergent stonewort	*	*			
Filamentous algae	*				
Yellow water lily		*			
Total number of species	4	4	3	2	3

Upton Broad is a stable stronghold for holly-leaved naiad, where in 2012 it continued to occupy much of the water column and area of the lake. The stonewort population fluctuates throughout the survey period, but is generally restricted to the shallower, marginal areas rather than the deeper, central basin where holly-leaved naiad dominates. Common stonewort was recorded in 2012 for the first time since 2003, whilst opposite stonewort remained the second most dominant species having first been recorded in 2004.

3.39 Upton Little

	2008	2009	2010	2011	2012 MI
Opposite stonewort			*		1
Filamentous algae		*	*		
Najas marina		*	*		
Common stonewort		*			
Total number of species		3	3		1

Following the completion of mudpumping in autumn 2011, opposite stonewort has rapidly colonised the bare sediment being the only species recorded from transects in 2012. The abundance was greatest in the deeper central basin, with coverage reducing at the much shallower margins. A small colony of holly leaved naiad was identified in the shallowing eastern arm of the broad using the bathyscope however, this species was not recorded on either of the 2 transects illustrating how species can be missed when using the trawl method.

The broad was first surveyed in 2005 when 4 species were recorded, this continues to be the maximum figure for species richness. Historically the broad has been dominated by holly-leaved naiad and the aim of the pumping project was to enhance species diversity. The early and rapid colonisation of the bare sediment by a stonewort is not surprising. Further survey will be required to see if additional species can establish or if the dominance of opposite stonewort is lasting.

3.40 Wroxham

	2008	2009	2010	2011	2011 MI	2012 MI
Fennel-leaved pondweed	*	*	*	*	0.024	0.087
Rigid hornwort	*		*	*	0.030	0.059
Nuttall's waterweed	*	*		*	0.018	
Horned pondweed			*	*	0.003	
Smooth stonewort			*			
Canadian waterweed			*			
Filamentous algae	*	*	*			
Pointed stonewort	*					
Yellow water lily	*	*				
Total number of species	6	4	6	4		2

Despite improvement in water quality (both lower nutrient and improved water clarity) since the early nineties there has been no development of the aquatic plant community. Wroxham Broad showed no indication of reaching a stable state and following the surprising increase in species numbers found in the 2008 and 2010, species richness had dropped to 2 in 2012. Species abundance remains very low.

3.4 Yare Valley

Waterbodies surveyed in the Yare Valley are generally of good condition in terms of their submerged macrophyte populations; submerged plants are frequent in Rockland and Wheatfen Broads. Whitlingham Great and Little Broads originated from gravel extraction and despite their 'youth' have abundant submerged plant growth and a diverse species assemblage.

3.41 Bargate

	2008	2009	2010	2011 MI	2012 MI
Rigid hornwort					0.220
Branched bur-reed					0.216
Yellow water lily					0.066
Spiked water milfoil					0.016
Whorled water milfoil					0.015
Starwort sp					0.014
Stonewort (*Nitella*) species					0.007
Total number of species					7

Bargate broad is closely connected to the River Yare and historically has recorded low species richness (3 species in 2004 & 2006) and abundance. The presence of 7 species in 2012 is encouraging, particularly the presence of whorled water milfoil which is listed as vulnerable on The Vascular Plant Red Data List for Great Britain (2006 Cheffings, C. and Farrell, L.). Total abundance levels were also the highest recorded, although Bargate broad has only been surveyed 3 times since 1983.

3.42 Rockland

	2007	2008	2010	2011 MI	2012 MI
Yellow water lily	*	*	*	0.316	0.297
Rigid hornwort	*	*	*	0.280	0.116
Un-branched bur-reed		*	*	0.057	0.037
Spiked water milfoil				0.003	0.029
Crowfoot species					0.014
Filamentous algae					0.006
Starwort sp.				0.017	0.004
Fan-leaved water crowfoot	*			0.070	0.003
Horned pondweed				0.016	
Nuttall's waterweed				0.008	
Lesser pondweed				0.003	
Filamentous algae	*	*	*	0.002	
Blunt-leaved pondweed				0.002	
Fennel-leaved pondweed		*	*		
Common water moss			*		
Bulrush	*				
Total number of species	5	5	6	11	8

Having remained relatively stable with low species richness and abundance, 2011 saw a significant increase in the number of species recorded. Spiked water milfoil was recorded in 2011 and 2012 having never been recorded previously.

3.43 Strumpshaw

	2007	2008	2010	2011 MI	2012 MI
Filamentous algae	*	*	*	0.960	0.985
Ivy-leaved duckweed	*		*	0.025	0.038
Rigid hornwort	*	*	*	0.040	0.029
Common reed					0.015
Enteromorpha			*		0.003
Least duckweed					0.003
Lesser pondweed	*	*			
Holly-leaved naiad	*	*	*	0.034	
Common duckweed				0.005	
Frogbit	*			0.005	
Stonewort (*Chara*) species				0.005	
Opposite stonewort				0.003	
Bladderwort	*	*			
Common stonewort	*				
Convergent stonewort		*			
Fragile/Convergent stonewort	*	*			
Unbranched bur-reed	*				
Total number of species	10	7	5	8	6

Saline incursions are considered to be the reason behind the significant loss of species and the very high amounts of filamentous algae found in 2010. Filamentous algae has remained dominant in the years since.

3.44 Wheatfen

	2012 MI
Branched bur-reed	0.269
Yellow water lily	0.170
Starwort sp.	0.055
Filamentous algae	0.034
Rigid hornwort	0.026
Nuttall's waterweed	0.018
Fan-leaved water crowfoot	0.010
Frogbit	0.005
Canadian waterweed	0.003
Common reed	0.003
Lesser pondweed	0.001
Total number of species	11

Wheatfen has been surveyed on 5 occasions since 1998. Records suggest that species richness has been gradually increasing since 6 species were identified in 1998 with 2012 recording a peak of 11 species. But conversely relative levels of abundance appear to have declined significantly since 1998, with 2012 recording the lowest ever total abundance levels.

3.45 Whitlingham Great

	2007	2008	2009	2011 MI	2012 MI
Nuttall's waterweed	*	*	*	0.525	0.347
Rigid hornwort				0.031	0.054
Common stonewort	*	*	*	0.008	0.052
Lesser pondweed		*		0.009	0.034
Canadian waterweed		*	*		0.029
Fan-leaved water crowfoot		*		0.003	0.027
Filamentous algae				0.014	0.012
Opposite stonewort				0.001	0.008
Hair like pondweed				0.014	0.007
Curled pondweed				0.002	0.001
Ivy-leaved duckweed	*		*	0.009	0.0004
Delicate stonewort				0.001	
Amphibious bistort	*	*	*	0.008	
Water net			*	0.005	
Crowfoot sp.				0.005	
Fragile / Convergent stonewort				0.002	
Enteromorpha			*	0.001	
Filamentous algae	*	*	*		
Fragile stonewort	*	*			
Pointed stonewort		*	*		
Smooth stonewort	*	*			
Total number of species	7	10	9	16	11

Since the first survey in 2003, the abundance of plants in Whitlingham Great broad has remained relatively high, however, as the graphs in Appendix 3 illustrate, the abundance of plants in 2012 is much reduced since 2011 and 2010. Species richness peaked in 2011 with 16 species present, but in 2012 this lowered slightly to 11. There appears to have been a reduction in the diversity of stoneworts recorded, particularly the *Nitella* sp, although abundance levels were higher in 2012 compared to 2011. It is also notable that rigid hornwort has been the 2nd most dominant species in the last 2 years having not been recorded since 2004.

3.46 Whitlingham Little

	2008	2009	2010	2011 MI	2012 MI
Rigid hornwort	*	*	*	0.151	0.188
Filamentous algae	*	*	*	0.124	0.044
Nuttall's waterweed	*		*	0.360	0.038
Ivy-leaved duckweed	*	*	*	0.056	0.012
Fragile/Convergent stonewort	*	*	*	0.113	
Canadian waterweed			*	0.007	
Water net				0.001	
Delicate stonewort			*		
Fennel leaved pondweed		*	*		
Common stonewort		*	*		
Amphibious bistort			*		
Enteromorpha		*			
Fan-leaved water crowfoot	*				
Total number of species	6	7	10	7	4

2012 saw a continuation of a decline in species richness since 2010, with only 4 species recorded, the lowest number of species recorded since surveys started in 2005. In addition, there was a notable decline in the abundance of plants throughout the broad recorded in 2012 where historically total abundance levels have been relatively high, particularly in comparison to the Great broad. White water lily and amphibious bistort were present within the broad but not recorded on transects.

It is worth mentioning that Whitlingham Little broad was subject to large bloom of blue-green algae in the weeks prior to the survey, and during the survey large clumps of the algae were still visible in the water column. The presence of blue-green algae is likely to have impacted plant growth, for example by limiting light availability, and could be the explanation for the marked reduction in species richness and abundance observed in 2012.

3.5 Waveney Valley

There are six broads along the Waveney valley that lay within the Broads Authority executive area. These are Barnby, Spratt's Water, Woolner's Carr, Round Water, Flixton Decoy and Oulton Broad. Surveying and monitoring of these broads has been limited in the past, however restoration programmes are now being developed at some of these sites.

3.51 Barnby Broad

	2009	2012
Rigid hornwort	0.442	0.386
Bristly stonewort	0.078	0.364
Filamentous algae	0.122	0.250
Opposite stonewort	0.087	0.095
Fragile stonewort	0.219	0.095
White water lily	0.018	0.068
Horned pondweed		0.050
Hair like pondweed		0.036
Convergent stonewort		0.017
Fragile / convergent stonewort	0.058	
Delicate stonewort	0.051	
Total number of species	8	9

Barnby broad was first surveyed in 2004 where rigid hornwort was the dominant throughout the waterbody accompanied only by filamentous algae. In an attempt to enhance the diversity of aquatic plants at Barnby, it was mudpumped in 2007. The following survey in 2009 recorded 8 species of which 5 were stoneworts. Species richness increased slightly in 2012 to 9 with the addition of a fine-leaved pondweed. Since mudpumping there has also been a steady increase in the abundance levels, although visual observations during the survey showed that the shallow margins of the broad are still bare, with plant growth focussed in the deeper central basin.

4 ACKNOWLEDGEMENTS

The Broads Authority wishes to thank all those individuals and organisations who assisted during the 2012 survey season by providing their time, boats, identification or permissions.

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6 APPENDICIES.

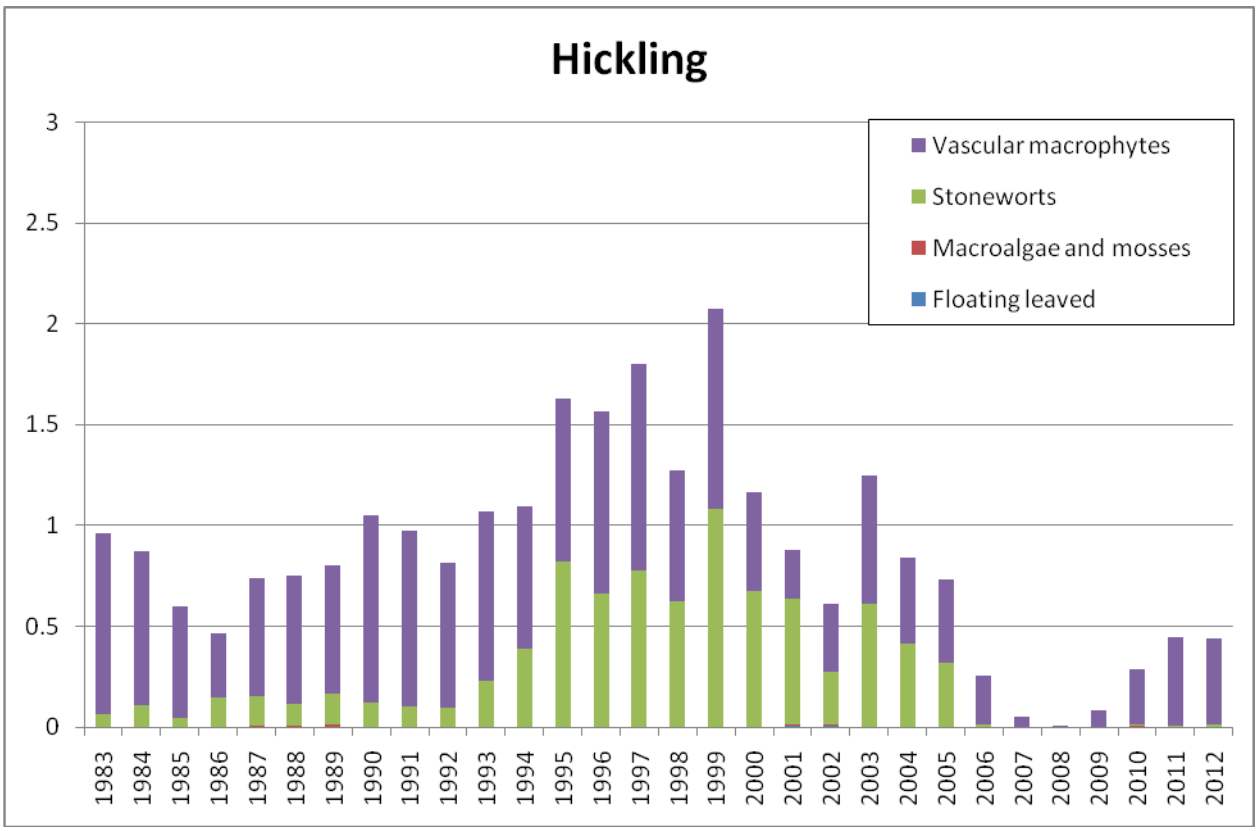
Appendix 1. Macrophyte groupings based on physical form.
Appendix 2. Long term macrophyte abundance trends (1983 – 2010)
Appendix 3a & b. Plant common and Latin names.
Appendix 4.

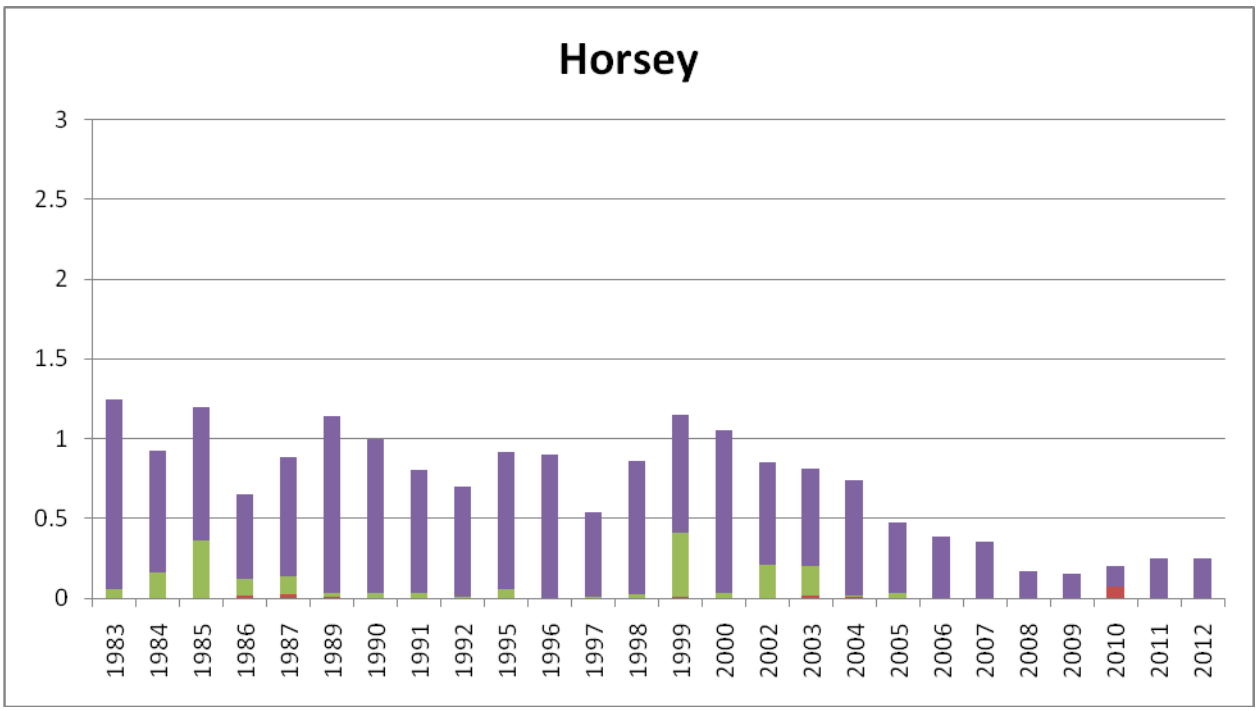
6.1 Appendix 1. Macrophyte groupings based on form

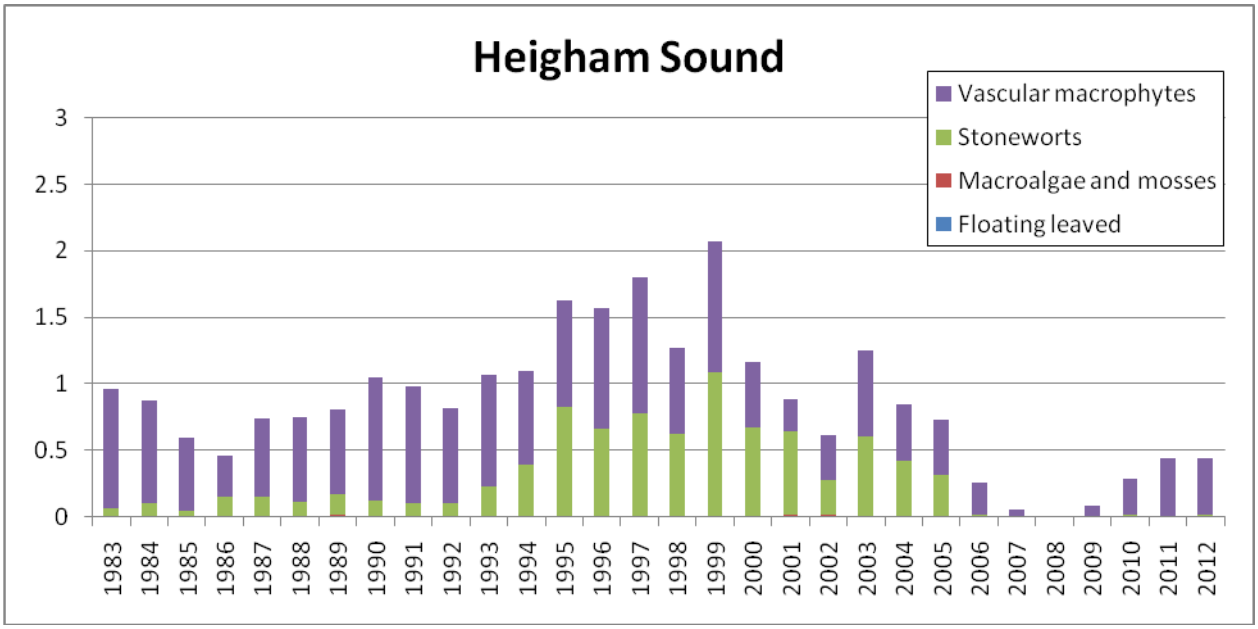
Stoneworts	**Free-floating or round floating-leaved**	**Vascular Macrophytes**	
Baltic stonewort	Amphibious bistort	Arrowhead	Lesser pondweed
Bristly stonewort	Common duckweed	Australian swamp stonecrop	Lesser reedmace
Common stonewort	Frogbit	Blunt-leaved pondweed	Mare's tail
Convergent stonewort	Greater duckweed	Branched bur-reed	Nuttall's waterweed
Delicate stonewort	Inflated duckweed	Broad –leaved pondweed	Perfoliate pondweed
Fragile stonewort	Ivy-leaved duckweed	Bulrush	Reed sweet grass
Hedgehog stonewort	Least duckweed	Canadian waterweed	Rigid hornwort
Intermediate stonewort	White water lily	Common reed	Sharp-leaved pondweed
Lesser bearded stonewort	Yellow water lily	Crowfoot sp.	Shining Pondweed
Opposite stonewort		Curled pondweed	Small pondweed
Pointed stonewort		Fan-leaved water crowfoot	Spiked water milfoil
Rough stonewort	**Macro-algae and mosses**	Fennel-leaved pondweed	Starwort sp.
Starry stonewort	*Enteromorpha*	Flat-stalked pondweed	Sweet flag
Translucent stonewort	Common water moss	Floating club-rush	Unbranched bur-reed
	Filamentous algae	Greater bladderwort	Water cress
	Stringy moss	Greater reedmace	Water-soldier
	Water net	Hair like pondweed	Whorled water milfoil
		Holly-leaved naiad	Willow-leaved pondweed
		Horned pondweed	

6.2 Appendix 2. Macrophyte abundance trends (1983 – 2012)

River Thurne



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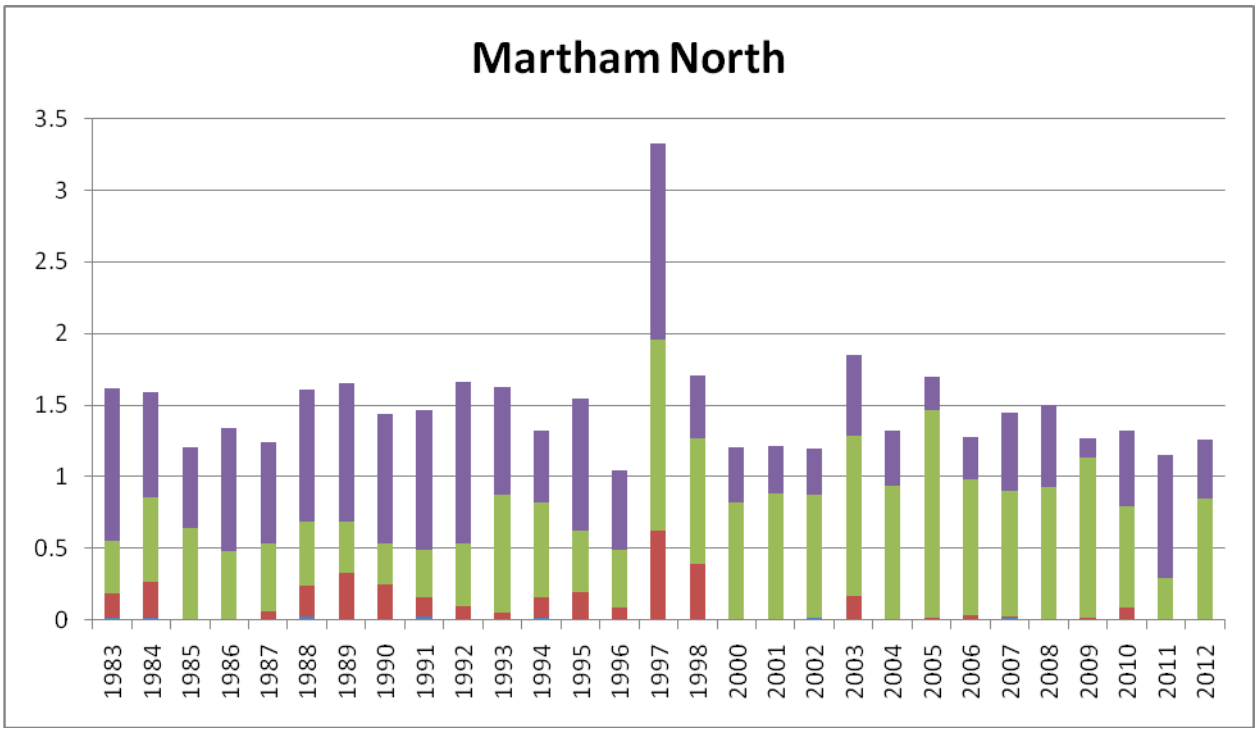
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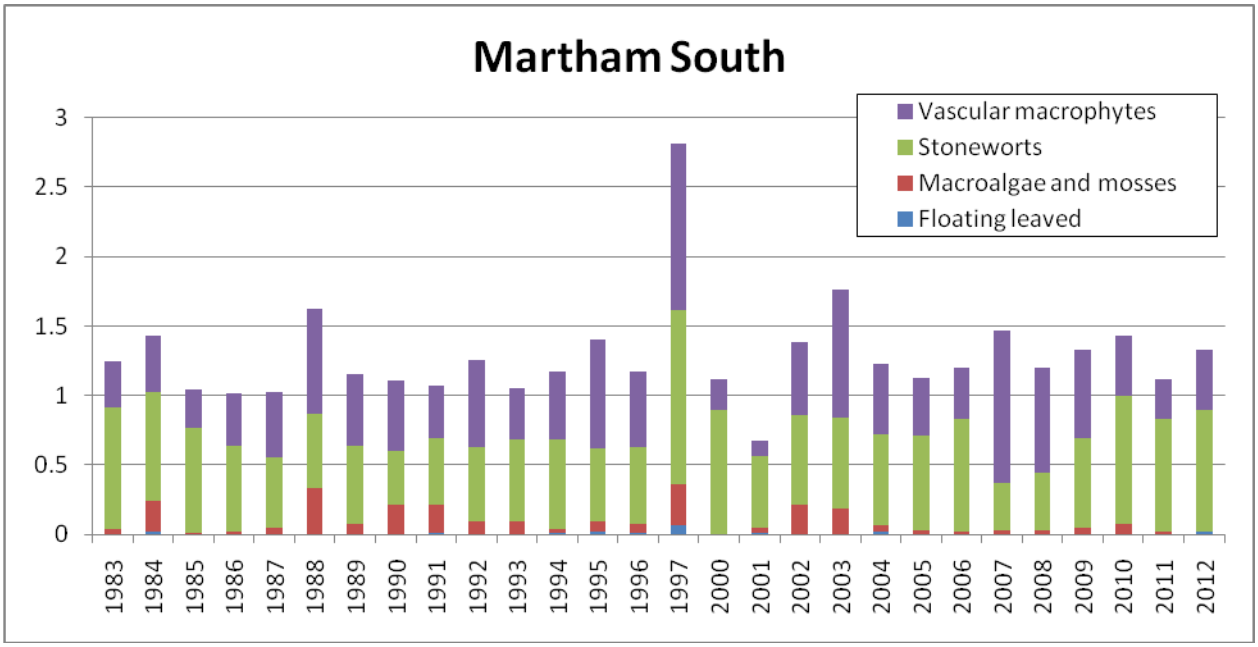
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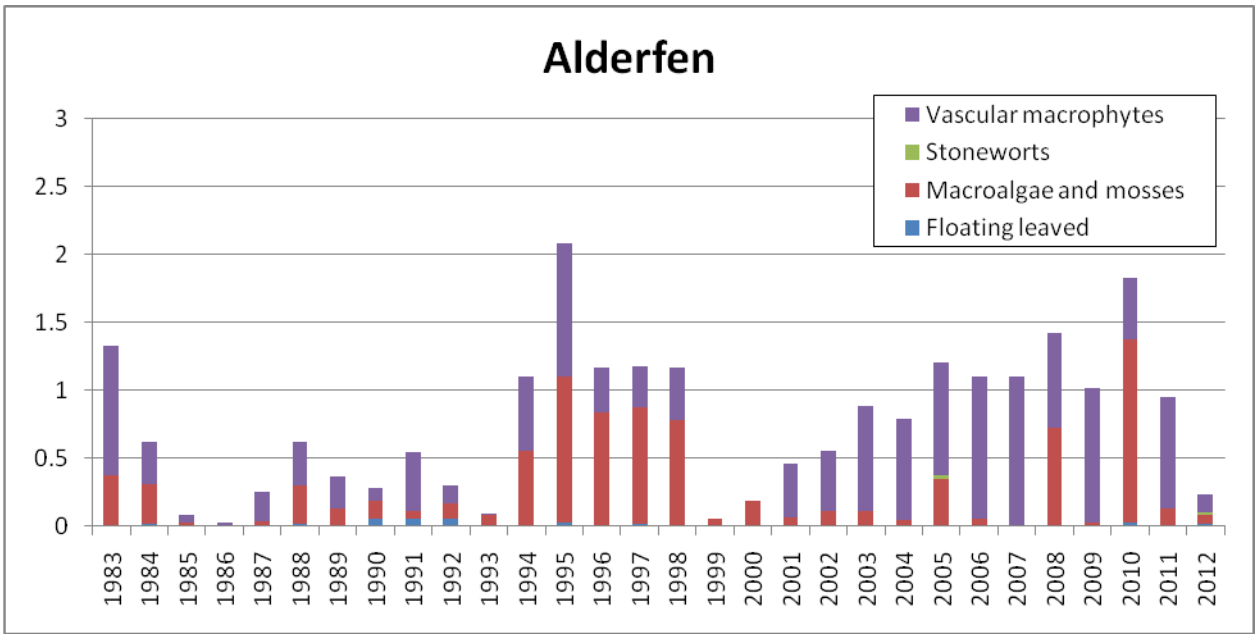
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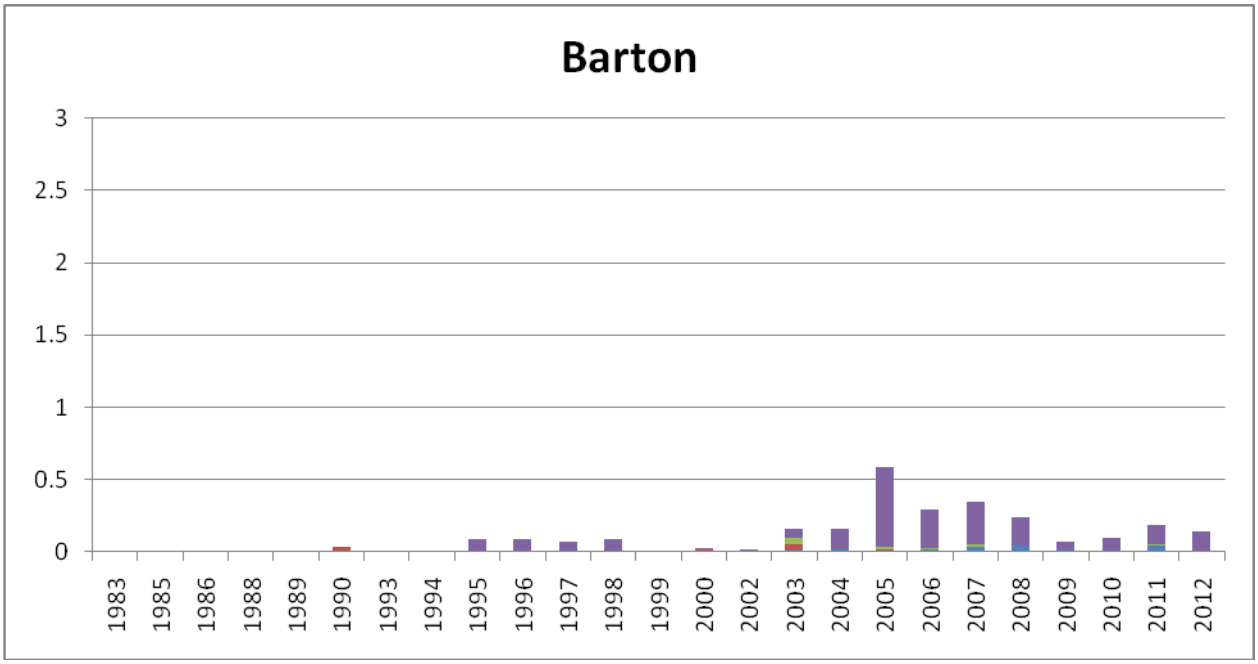
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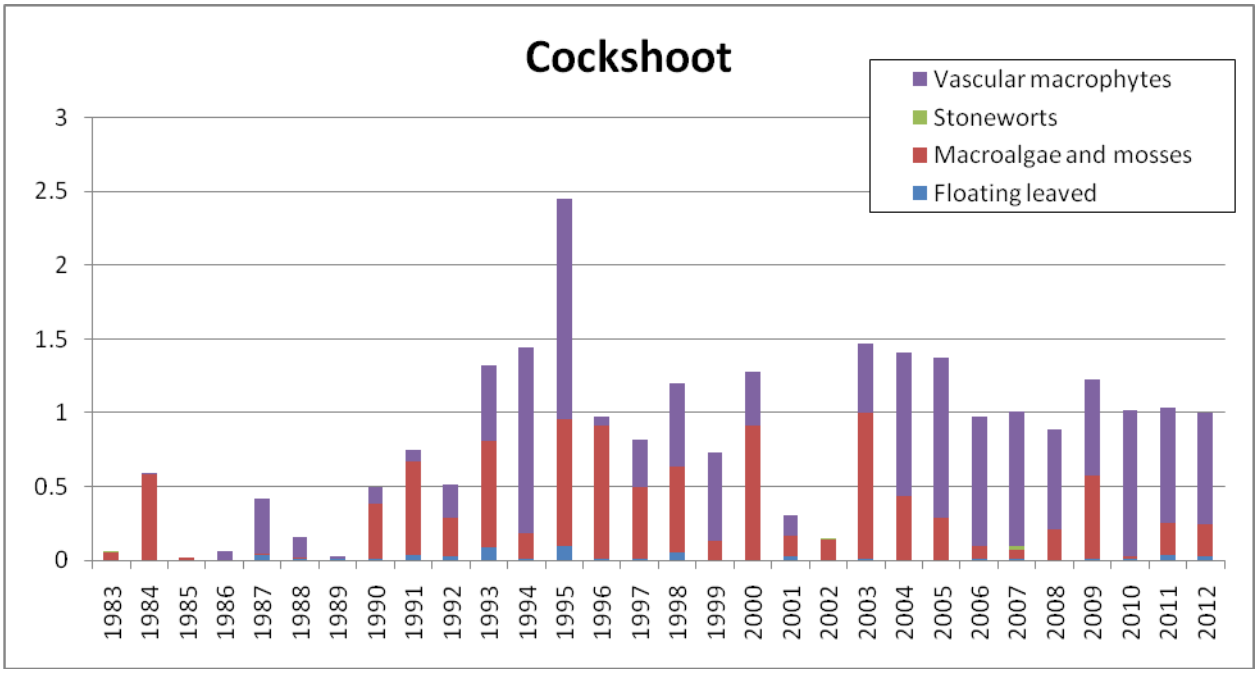
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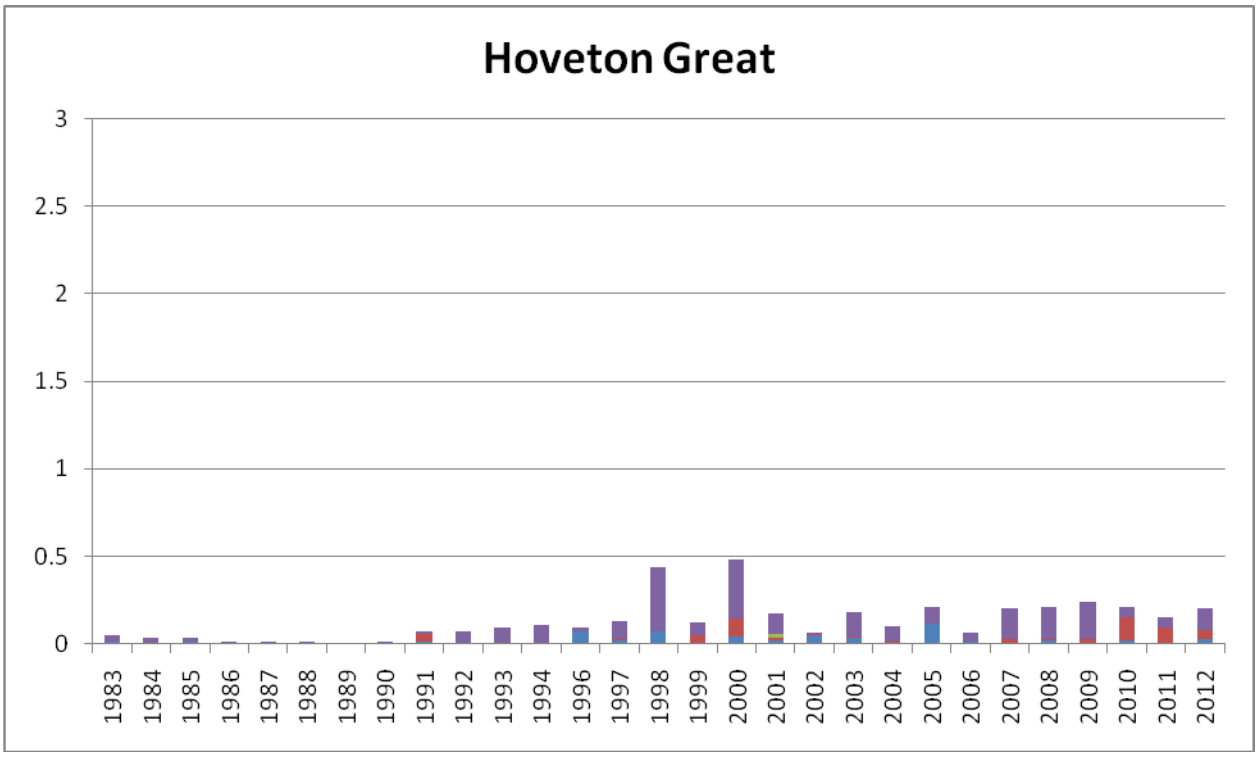
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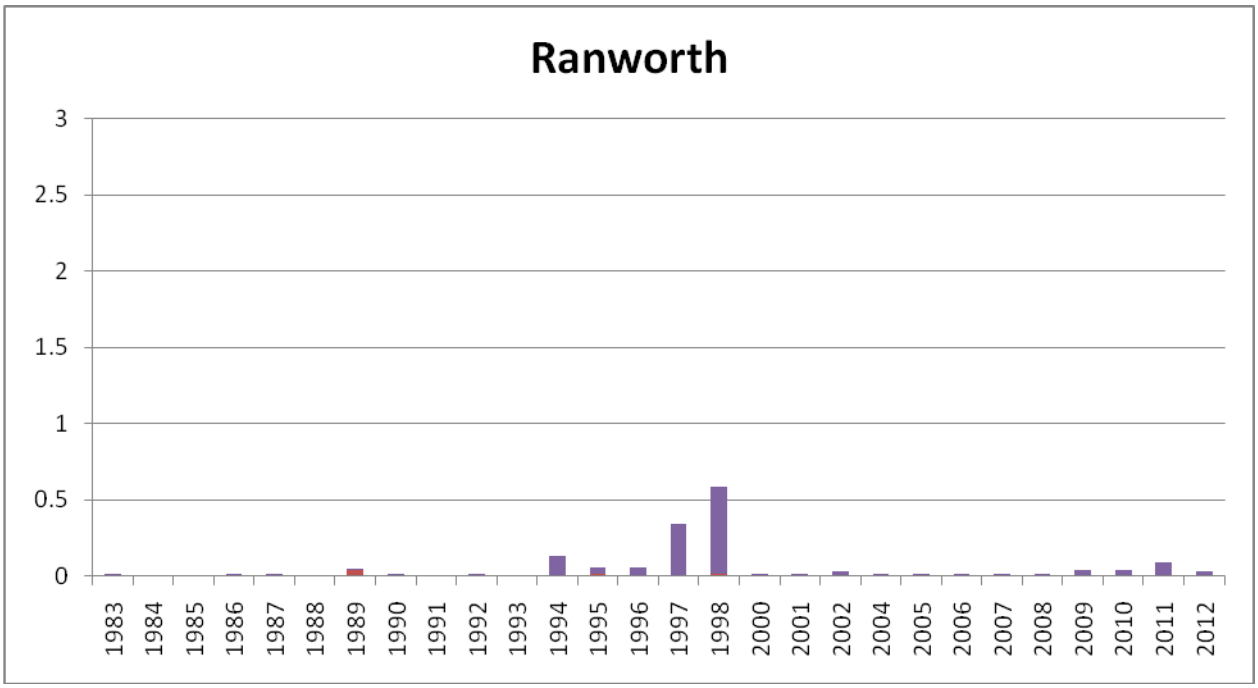
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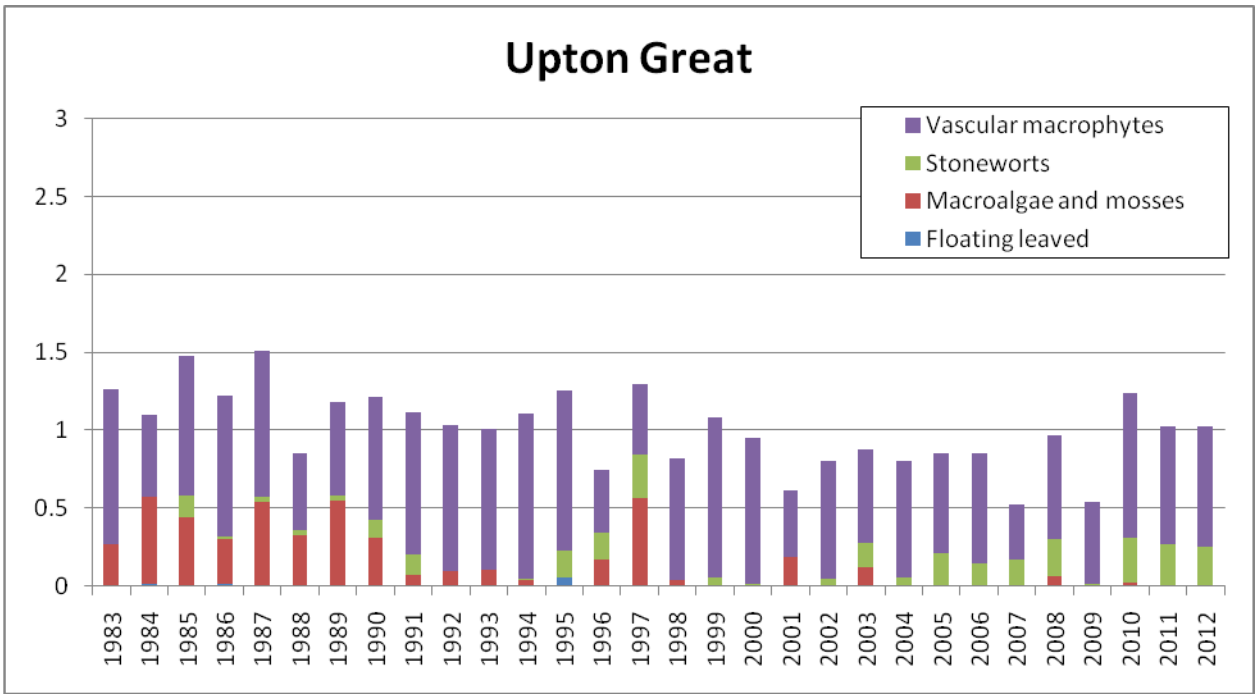
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Stoneworts
Macroalgae and mosses
Floating leaved
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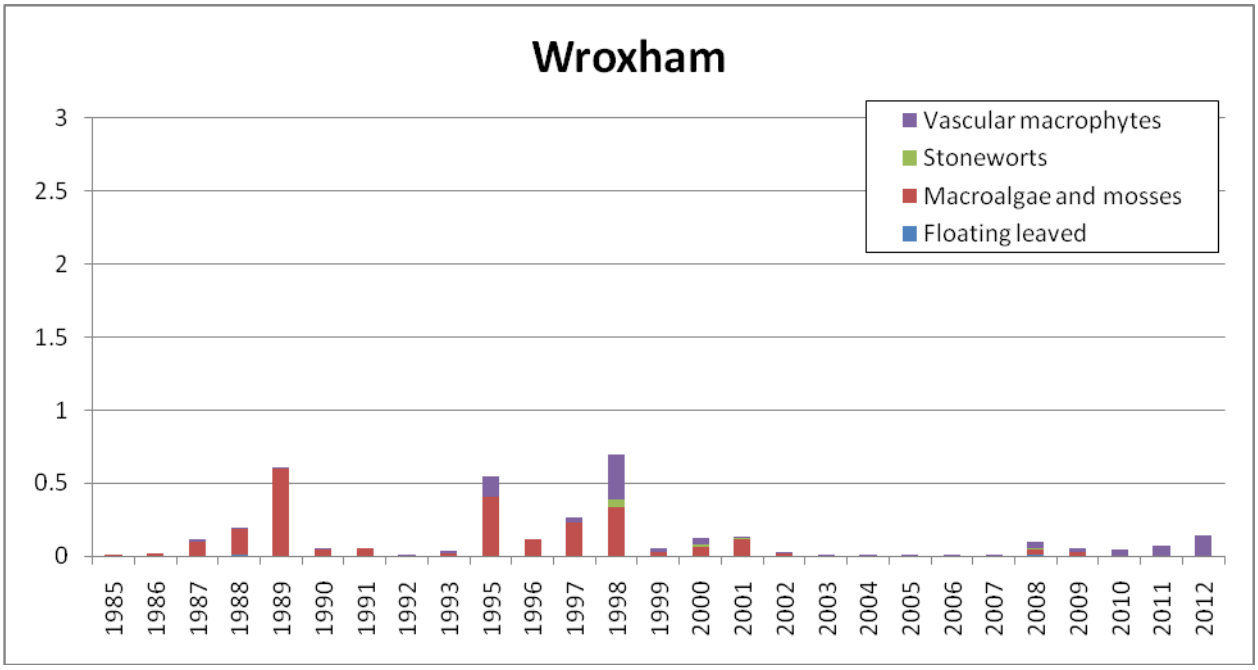
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Stoneworts
Macroalgae and mosses
Floating leaved
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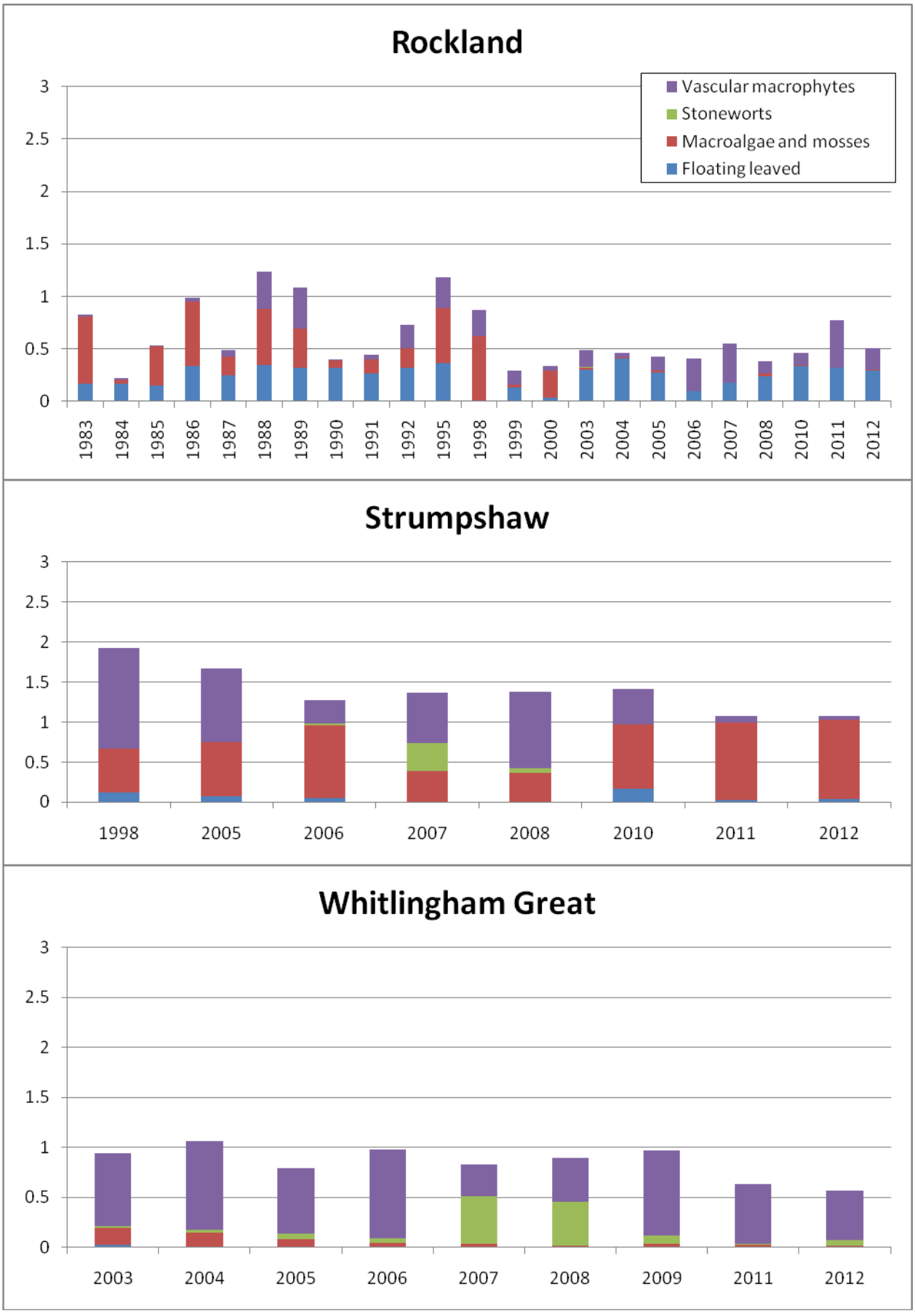
River Yare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Vascular macrophytes
Stoneworts
Macroalgae and mosses
Floating leaved
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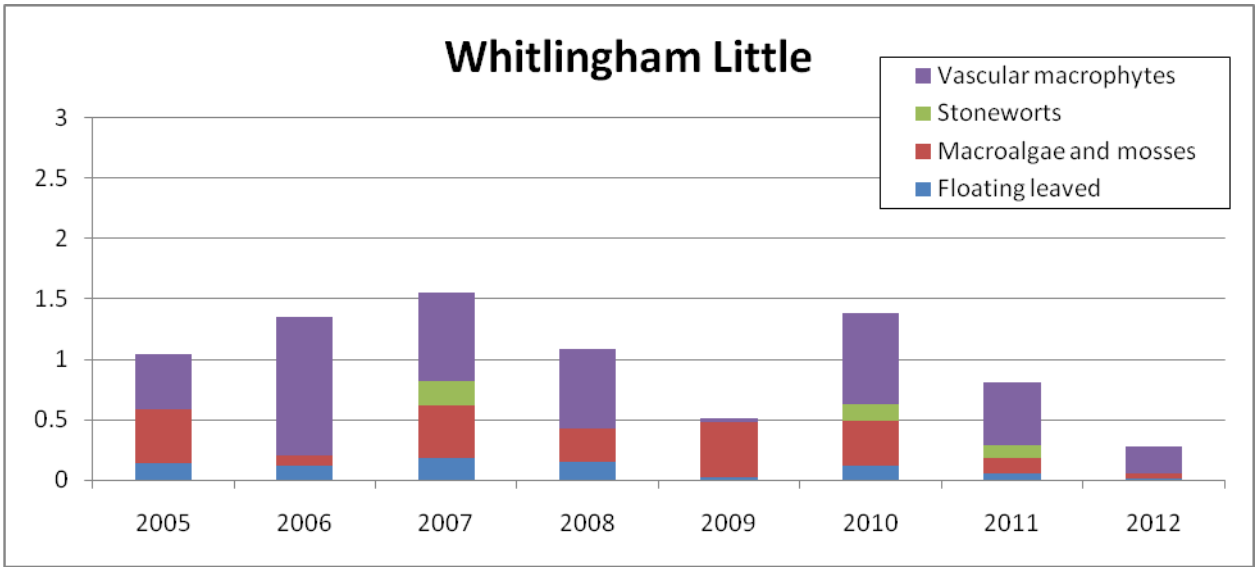
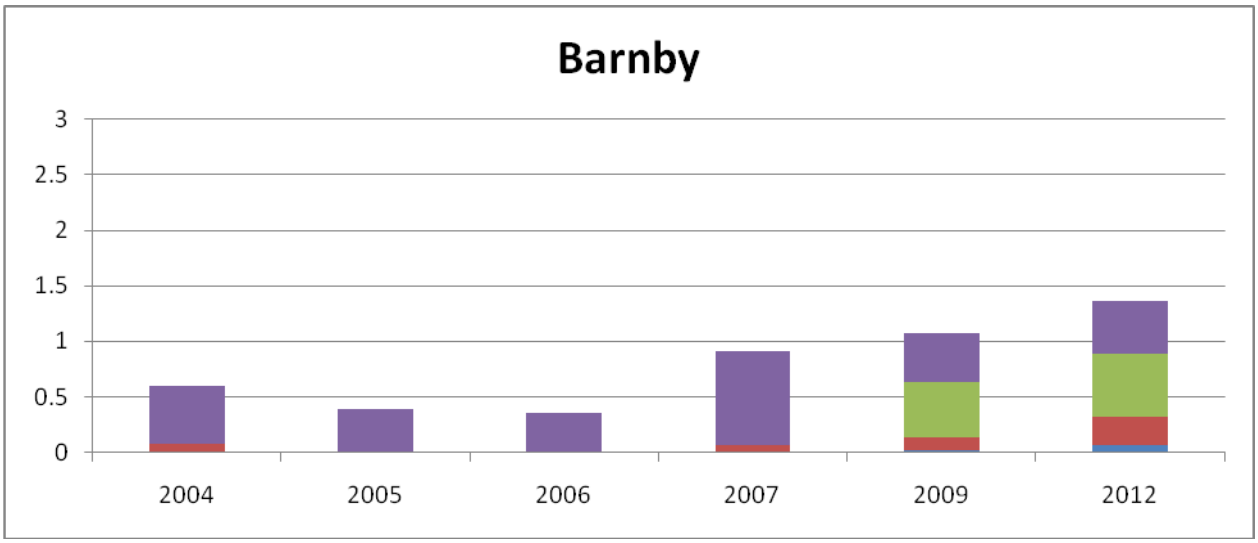


River Waveney



6.3 Appendix 3a. Latin to Common plant names.

Latin	Common
Acorus calamus	Sweet flag
Alisma plantago-aquatica	Common water-plantain
Chara aculeolata	Hedgehog stonewort
Callitriche stagnalis	Intermediate water-starwort
Callitriche sp	Starwort sp.
Ceratophyllum demersum	Rigid hornwort
Chara pedunculata	Hedgehog stonewort
Chara aspera	Rough stonewort
Chara baltica	Baltic stonewort
Chara connivens	Convergent stonewort
Chara contraria	Opposite stonewort
Chara curta	Lesser bearded stonewort
Chara globularis/connivens	Fragile/convergent stonewort
Chara globularis	Fragile stonewort
Chara hispida	Bristly stonewort
Chara intermedia	Intermediate stonewort
Chara sp.	Stonewort *(Chara)* species
Chara virgata	Delicate stonewort
Chara vulgaris	Common stonewort
Crassula helmsii	Swamp stonecrop
Elodea canadensis	Canadian waterweed
Eleogiton fluitans	Floating club-rush
Elodea nutalli	Nuttall's waterweed
Enteromorpha	*Enteromorpha*
Filamentous algae	Filamentous algae
Fontinalis antipyretica	Common water moss
Glyceria maxima	Reed sweet grass
Hippuris vulgaris	Mare's tail
Hydrocharis morsus-ranae	Frogbit
Hydrodictyon	Water net
Lemna gibba	Inflated duckweed
Lemna minor	Common duckweed
Lemna minuta	Least duckweed
Lemna trisulca	Ivy-leaved duckweed
Leptodictyum riparium	Stringy moss
Myriophyllum spicatum	Spiked water milfoil
Myriophyllum verticillatum	Whorled water milfoil
Najas marina	Holly-leaved naiad
Nitella flexilis	Smooth stonewort
Nitella mucronata	Pointed stonewort
Nitellopsis obtusa	Starry stonewort
Nitella translucens	Translucent stonewort
Nitella sp.	Stonewort *(Nitella)* species
Nuphar lutea	Yellow water lily
Nymphaea alba	White water lily
Persicaria amphibia	Amphibious bistort
Potamogeton acutifolius	Sharp-leaved pondweed
Potamogeton berchtoldii	Small pondweed
Potamogeton crsipus	Curled pondweed
Potamogeton friesii	Flat-stalked pondweed
Potamogeton lucens	Shining pondweed
Potamogeton natans	Broad –leaved pondweed
Potamogeton obtusifolius	Blunt-leaved pondweed
Potamogeton pectinatus	Fennel-leaved pondweed
Potamogeton perfoliatus	Perfoliate pondweed
Potamogeton pusillus	Lesser pondweed
Potamogeton x salicifolius	Willow-leaved pondweed
Potamogeton sp.	Pondweed sp.
Potamogeton trichoides	Hair like pondweed
Phragmites australis	Common reed
Ranunculus circinatus	Fan-leaved water crowfoot
Ranunculus fluitans	River water crowfoot
Ranunculus sp.	Crowfoot sp.
Rorippa nasturtium-aquaticum	Water cress
Saggitaria sagittifolia	Arrowhead
Schoenoplectus lacustris	Bulrush
Sparganium emersum	Unbranched bur-reed
Sparganium erectum	Branched bur-reed
Spirodela polyrhiza	Greater duckweed
Stratiotes aloides	Water-soldier
Typha angustifolia	Lesser reedmace
Typha latifollia	Greater reedmace
Utricularia vulgaris	Bladderwort
Veronica catenata	Pink water speedwell
Zanichellia palustris	Horned pondweed

6.4 Appendix 3b. Common to Latin plant names.

Common	*Latin*
Amphibious bistort	*Persicaria amphibia*
Arrowhead	*Saggitaria sagittifolia*
Baltic stonewort	*Chara baltica*
Bladderwort	*Utricularia vulgaris*
Blunt-leaved pondweed	*Potamogeton obtusifolius*
Branched bur-reed	*Sparganium erectum*
Bristly stonewort	*Chara hispida*
Broad –leaved pondweed	*Potamogeton natans*
Bulrush	*Schoenoplectus lacustris*
Canadian waterweed	*Elodea canadensis*
Common duckweed	*Lemna minor*
Common reed	*Phragmites australis*
Common stonewort	*Chara vulgaris*
Common water moss	*Fontinalis antipyretica*
Common water-plantain	*Alisma plantago-aquatica*
Convergent stonewort	*Chara connivens*
Crowfoot sp.	*Ranunculus sp.*
Curled pondweed	*Potamogeton crispus*
Delicate stonewort	*Chara virgata*
Enteromorpha	*Enteromorpha*
Fan-leaved water crowfoot	*Ranunculus circinatus*
Fennel-leaved pondweed	*Potamogeton pectinatus*
Filamentous algae	*Filamentous algae*
Flat-stalked pondweed	*Potamogeton friesii*
Floating club-rush	*Eleogiton fluitans*
Fragile stonewort	*Chara globularis*
Fragile/convergent stonewort	*Chara globularis/connivens*
Frogbit	*Hydrocharis morsus-ranae*
Greater duckweed	*Spirodela polyrhiza*
Greater reedmace	*Typha latifollia*
Hair like pondweed	*Potamogeton trichoides*
Hedgehog stonewort	*Chara aculeolata/pedunculata*
Holly-leaved naiad	*Najas marina*
Horned pondweed	*Zanichellia palustris*
Inflated duckweed	*Lemna gibba*
Intermediate stonewort	*Chara intermedia*
Intermediate water-starwort	*Callitriche stagnalis*
Ivy-leaved duckweed	*Lemna trisulca*
Least duckweed	*Lemna minuta*
Lesser bearded stonewort	*Chara curta*
Lesser pondweed	*Potamogeton pusillus*
Lesser reedmace	*Typha angustifolia*
Mare's tail	*Hippuris vulgaris*
Nuttall's waterweed	*Elodea nutalli*
Opposite stonewort	*Chara contraria*
Perfoliate pondweed	*Potamogeton perfoliatus*
Pink water speedwell	*Veronica catenata*
Pointed stonewort	*Nitella mucronata*
Pondweed sp.	*Potamogeton sp.*
Reed sweet grass	*Glyceria maxima*

Common	*Latin*
Rigid hornwort	*Ceratophyllum demersum*
River water crowfoot	*Ranunculus fluitans*
Rough stonewort	*Chara aspera*
Sharp-leaved pondweed	*Potamogeton acutifolius*
Shining pondweed	*Potamogeton lucens*
Small pondweed	*Potamogeton berchtoldii*
Smooth stonewort	*Nitella flexilis*
Spiked water milfoil	*Myriophyllum spicatum*
Starry stonewort	*Nitellopsis obtusa*
Starwort sp.	*Callitriche sp*
Stonewort *(Chara)* species	*Chara sp.*
Stonewort *(Nitella)* species	*Nitella sp.*
Stringy moss	*Leptodictyum riparium*
Swamp stonecrop	*Crassula helmsii*
Sweet flag	*Acorus calamus*
Translucent stonewort	*Nitella translucens*
Unbranched bur-reed	*Sparganium emersum*
Water cress	*Rorippa nasturtium-aquaticum*
Water net	*Hydrodictyon*
Water-soldier	*Stratiotes aloides*
White water lily	*Nymphaea alba*
Whorled water milfoil	*Myriophyllum verticillatum*
Willow-leaved pondweed	*Potamogeton x salicifolius*
Yellow water lily	*Nuphar lutea*

6.5 Appendix 4. Trinity Broads Aquatic Macrophyte Survey 2012

Trinity Broads Aquatic Macrophyte Survey 2012

(Hannah Gray – December 2012)

1. Introduction

This paper summarises the monitoring of aquatic plants in the Trinity Broads in the summer of 2012. It focuses on the point survey which has been undertaken on these broads since 1997, as opposed to the transect survey, which was not carried out on the Trinity Broads in 2012.

2. Methodology

The survey was carried out twice, once in June (6 days) and once in August (5 days), according to the methods described in Schutten (2001), with some changes summarised in Gray (2009). On most days two boats were surveying, with at least one experienced member of staff present during each day of the survey to provide identification skills and to ensure consistency on the methodology. Colleagues from the partner organisations and volunteers assisted, with particular assistance from Kate Harvey, a work placement student from Plymouth University, who also entered all the data. The sample points were located using a handheld GPS to ensure accuracy.

Since 2009 there have been a few adjustments to the method: only two rake throws have been carried out at each point, and percentage cover and plant height are not recorded in the point survey (they are better ascertained through the hydroacoustic surveys that are now carried out).

3. Results

The following is a list of figures referred to in this report:

- Figure 1 - Species of aquatic macrophytes occurring in each broad
- Figure 2 - Targets for natural eutrophic lake communities
- Figure 3 - Change in species richness of aquatic macrophytes in the Trinity Broads (excluding algae)
- Figure 4 - Change in species richness of aquatic macrophytes in the Trinity Broads (characteristic species only)
- Figure 5 - Mean wet weight of aquatic macrophytes at the Trinity Broads
- Figure 6 - Mean wet weight of aquatic macrophytes (excluding algae)
- Figure 7 - Mean wet weight of Elodea species at the Trinity Broads
- Figure 8 - Change in mean wet weight (g) of aquatic macrophytes in the Trinity Broads (excluding algae): June survey
- Figure 9 - Change in mean wet weight (g) of aquatic macrophytes in the Trinity Broads (excluding algae): August survey
- Figure 10 - Change in mean wet weight (g) of aquatic macrophytes in the Trinity Broads (excluding algae): average of June and August surveys

The results are discussed in relation to the targets outlined in the Trinity Broads Management Plan (Gray, 2011) for the 'standing open water' feature, which are taken from the Common Standards Monitoring guidance (JNCC, 2005) and in comparison with data and reports from previous surveys.

3.1 Species Richness of Aquatic Plants in 2012

Figure 1 lists the species found in each broad, and also shows which species are characteristic species and associated species, according to the Common Standard Monitoring prescription for the open water feature.

Figure 1 – Species of aquatic plants occurring in each of the Trinity Broads

KEY:	Associated species	Characteristic species	Algae species	Other species

SPECIES CODE	SPECIES	Ormesby	Rollesby	Lily	O. Little	Filby
CER_DEMER	*C. demersum*	x	x	x	x	x
CER_SUBME	*C. submersum*				x	x
CHA_CONNI	*C. connivens*					x
CHA_CONTR	*C. contraria*					x
CHA_GLOBU	*C. globularis*	x	x	x	x	x
CHA_VIRGA	*C. virgata*					x
CHA_VULGA	*C. vulgaris*	x	x			x
ELO_CANAD	*E. canadensis*	x	x	x	x	x
ELO_NUTTA	*E. nuttallii*	x	x	x	x	x
ENTEROMOR	*Enteromorpha*	x	x	x	x	x
FIL_ALGAE	*Filamentous Algae*	x	x	x	x	x
FON_ANTIP	*F. antipyretic*					x
GRE_JELLY	*Green Jelly Algae*	x	x	x	x	x
HYDRODICT	*Hydrodictyon*	x		x	x	x
LEM_TRISU	*L. trisulca*	x	x	x	x	x
NAI_MARIN	*N. marina*	x		x	x	
NUP_LUTEA	*N. lutea*	x	x	x	x	
NYM_ALBA	*N. alba*			x		
POT_CRISP	*P. crispus*				x	x
POT_FRIES	*P. freisii*	x	x	x	x	x
POT_PECTI	*P. pectinatus*	x	x	x	x	x
POT_PUSIL	*P. pusillus*	x	x	x	x	x
RAN_CIRCI	*R. circinatus*		x		x	
ZAN_PALUS	*Z. palustris*	x	x	x	x	x
	Total	16	15	16	18	20
	Total excl. algae	12	12	12	14	15
	Characteristic spp	5	6	4	6	9
	Associated spp	4	4	5	4	4

Figure 1 shows that 2012 was quite different to previous year's aquatic plant growth, with Filby having the highest overall species richness (15 macrophytes), and highest number of characteristic species (9 species). Ormesby Little Broad was close behind, with 14 macrophyte species and 6 characteristic species. The remaining broads had 12 macrophyte species each. Rollesby Broad equalled Ormesby Little Broad with 6 characteristic species, Ormesby Broad had 5 characteristic species and Lily Broad only 4.

Figure 2 shows whether each broad met the targets set out in the Common Standards Monitoring guidelines for the standing open water communities. Every broad met the target for proportion of points with at least one characteristic species in. Only Filby Broad met the target for charophyte species distribution, with 93% of points containing at least one Chara species. The other broads were a long way short of the 70% target. The distribution of algae was above the target 50% level for Rollesby, Ormesby Little and Filby Broad, and approaching this level in Ormesby and Lily Broads, though the actual abundance of algae at each of these points was variable. The distribution of Elodea spp. was also above the target level of 40% in Rollesby, Lily and Ormesby Little Broads.

Figure 2 – Performance of each of the Trinity Broads against targets for standing open water

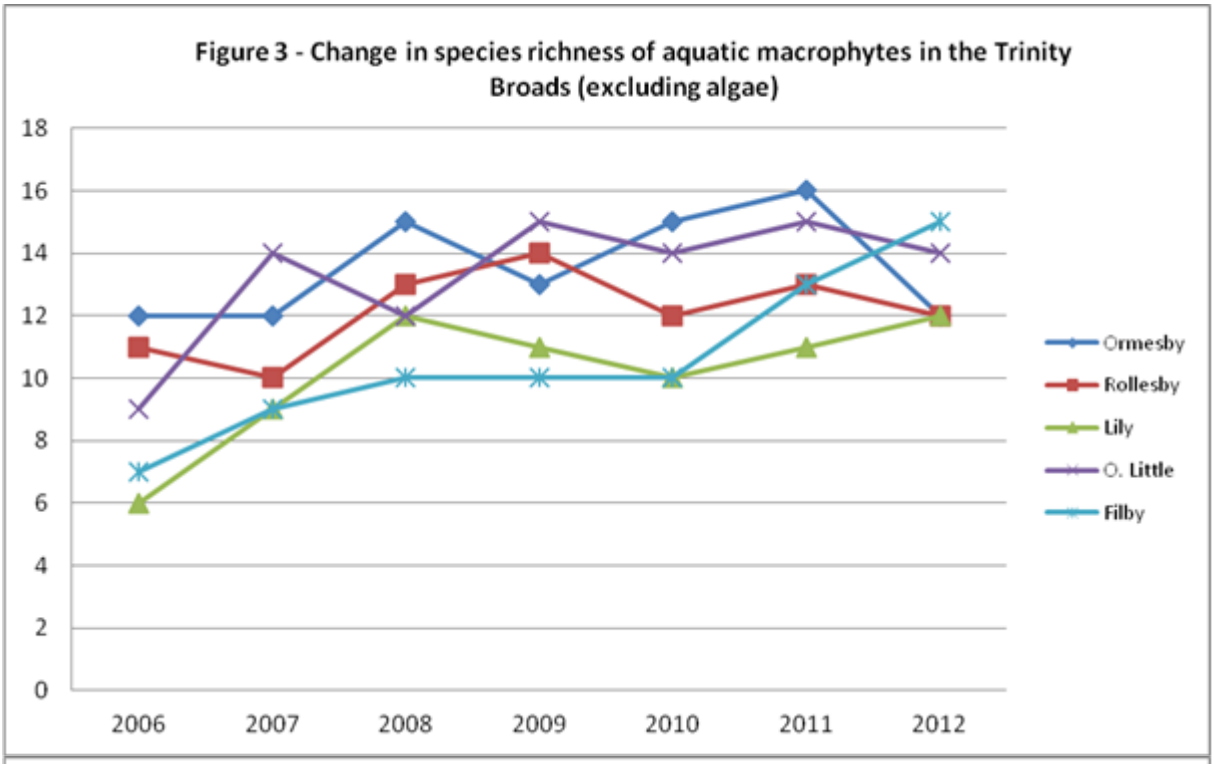
	Ormesby	Rollesby	Lily	O. Little	Filby	Targets
Total points	51.00	26.00	17.00	60.00	41.00*	
Points with characteristic spp	49.00	26.00	17.00	60.00	40.00	
% of points with characteristic spp	96.08	100.00	100.00	100.00	97.56	60
Points with associated spp	36.00	15.00	14.00	47.00	39.00	
% of points with associated spp	70.59	57.69	82.35	78.33	95.12	0
Points with Chara spp	14.00	14.00	8.00	14.00	38.00	
% points with Chara spp	27.45	53.85	47.06	23.33	92.68	70
Points with algae spp (not incl chara)	23.00	16.00	8.00	52.00	31.00	
% points with algae spp	45.10	61.54	47.06	86.67	75.61	<50
Points with Elodea spp	14.00	23.00	15.00	42.00	8.00	
% points with Elodea spp	27.45	88.46	88.24	70.00	19.51	40

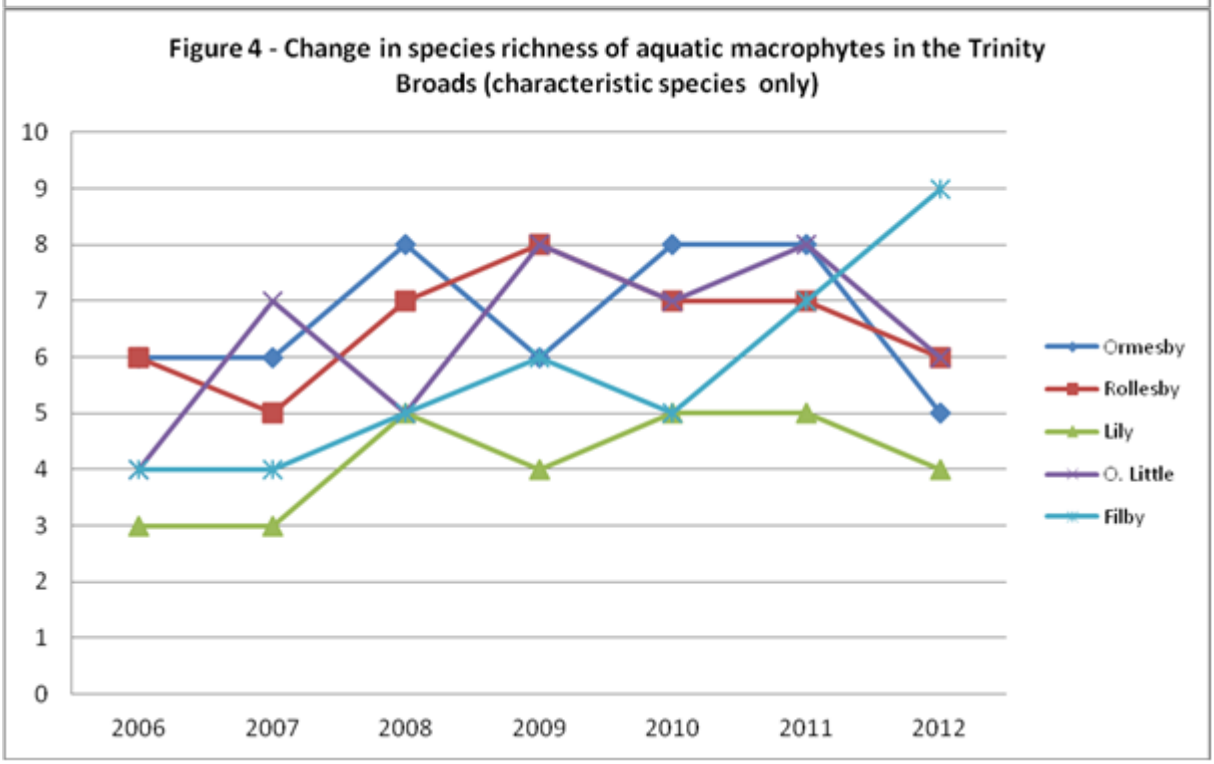
*One point in Filby Broad (D1) is no longer monitored as it is located in a dyke that has become difficult to get into, hence the number of points is down to 41 instead of 42 in the original survey.

N.B. the figures highlighted in red indicate that the target has not been reached in 2012.

3.2 Change in Species Richness of Aquatic Plants in since 2006

Figures 3 and 4 demonstrate the change since 2006 in species richness in each of the Trinity Broads.





3.3 Abundance of Aquatic Plants in 2012

Figures 5, 6 and 7 compare the wet weight of plant species in the Trinity Broads in the 2012 survey.

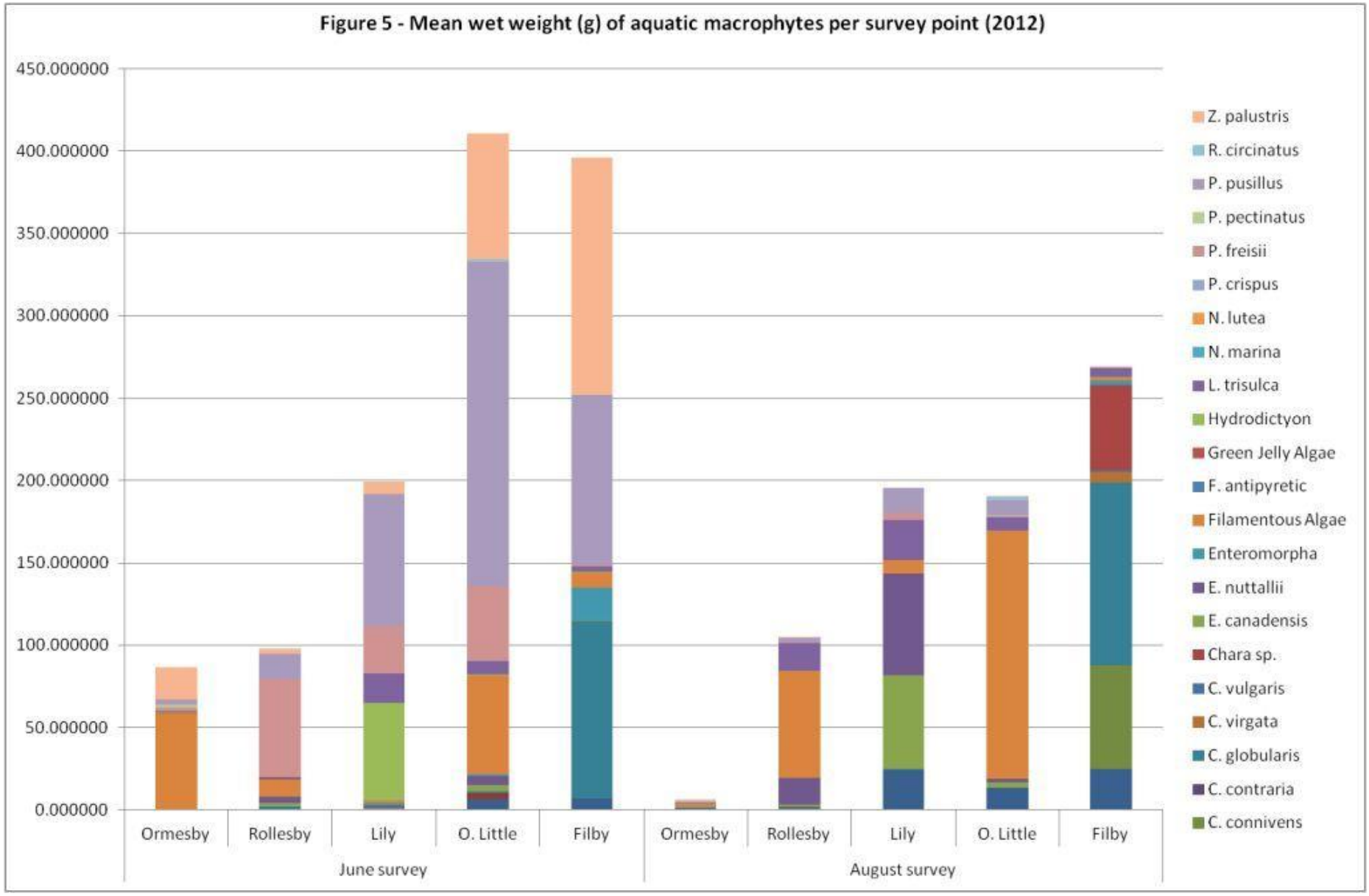


Figure 5 - Mean wet weight (g) of aquatic macrophytes per survey point (2012)
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0.000000
Ormesby
Rollesby
Lily
O. Little
Filby
Ormesby
Rollesby
Lily
O. Little
Filby
June survey
August survey
Z. palustris
R. circinatus
P. pusillus
P. pectinatus
P. freisii
P. crispus
N. lutea
N. marina
L. trisulca
Hydrodictyon
Green Jelly Algae
F. antipyretic
Filamentous Algae
Enteromorpha
E. nuttallii
E. canadensis
Chara sp.
C. vulgaris
C. virgata
C. globularis
C. contraria
C. connivens

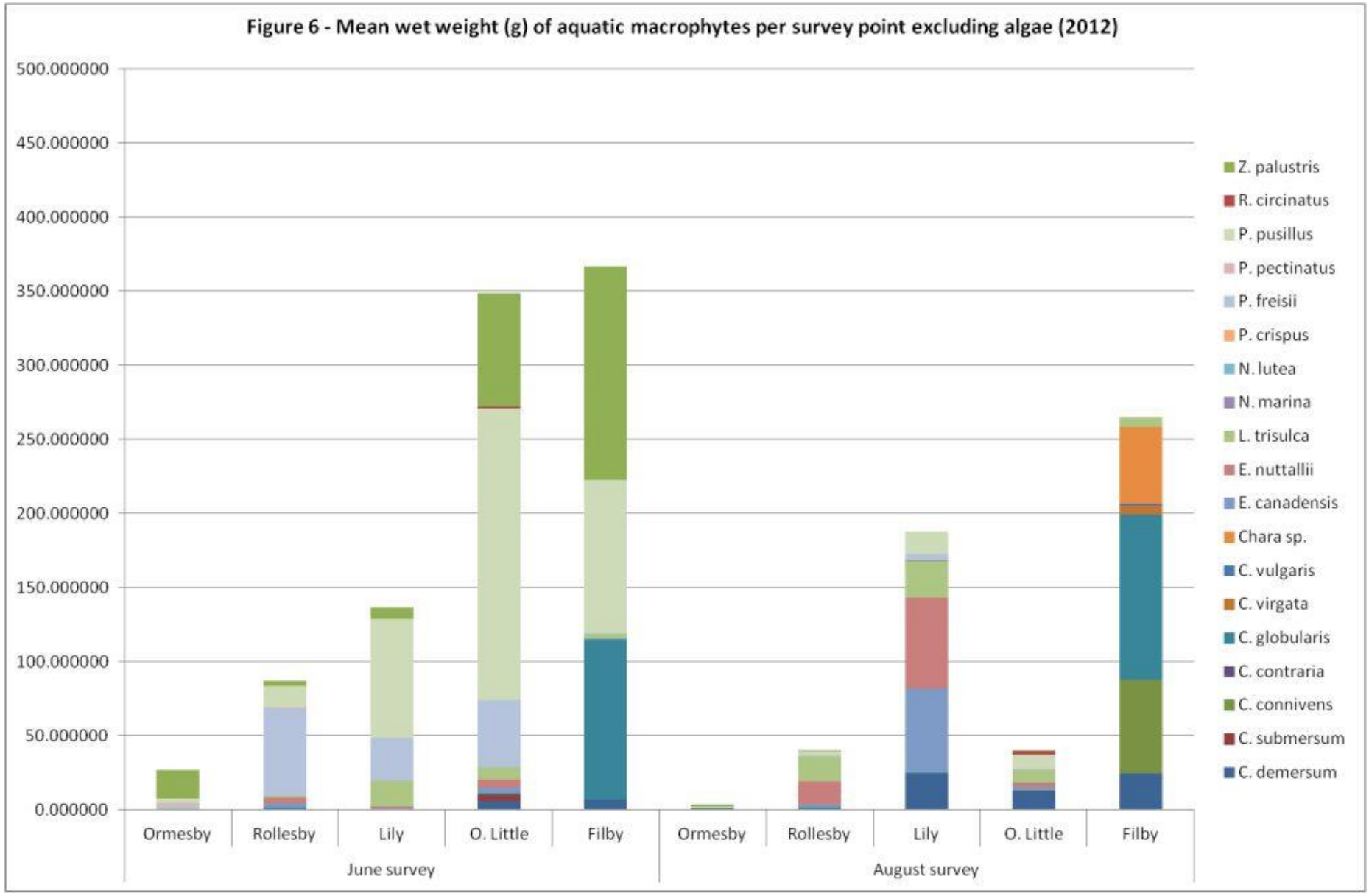
Figure 6 - Mean wet weight (g) of aquatic macrophytes per survey point excluding algae (2012)
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Ormesby
Rollesby
Lily
O. Little
Filby
Ormesby
Rollesby
Lily
O. Little
Filby
June survey
August survey
Z. palustris
R. circinatus
P. pusillus
P. pectinatus
P. freisii
P. crispus
N. lutea
N. marina
L. trisulca
E. nuttallii
E. canadensis
Chara sp.
C. vulgaris
C. virgata
C. globularis
C. contraria
C. connivens
C. submersum
C. demersum

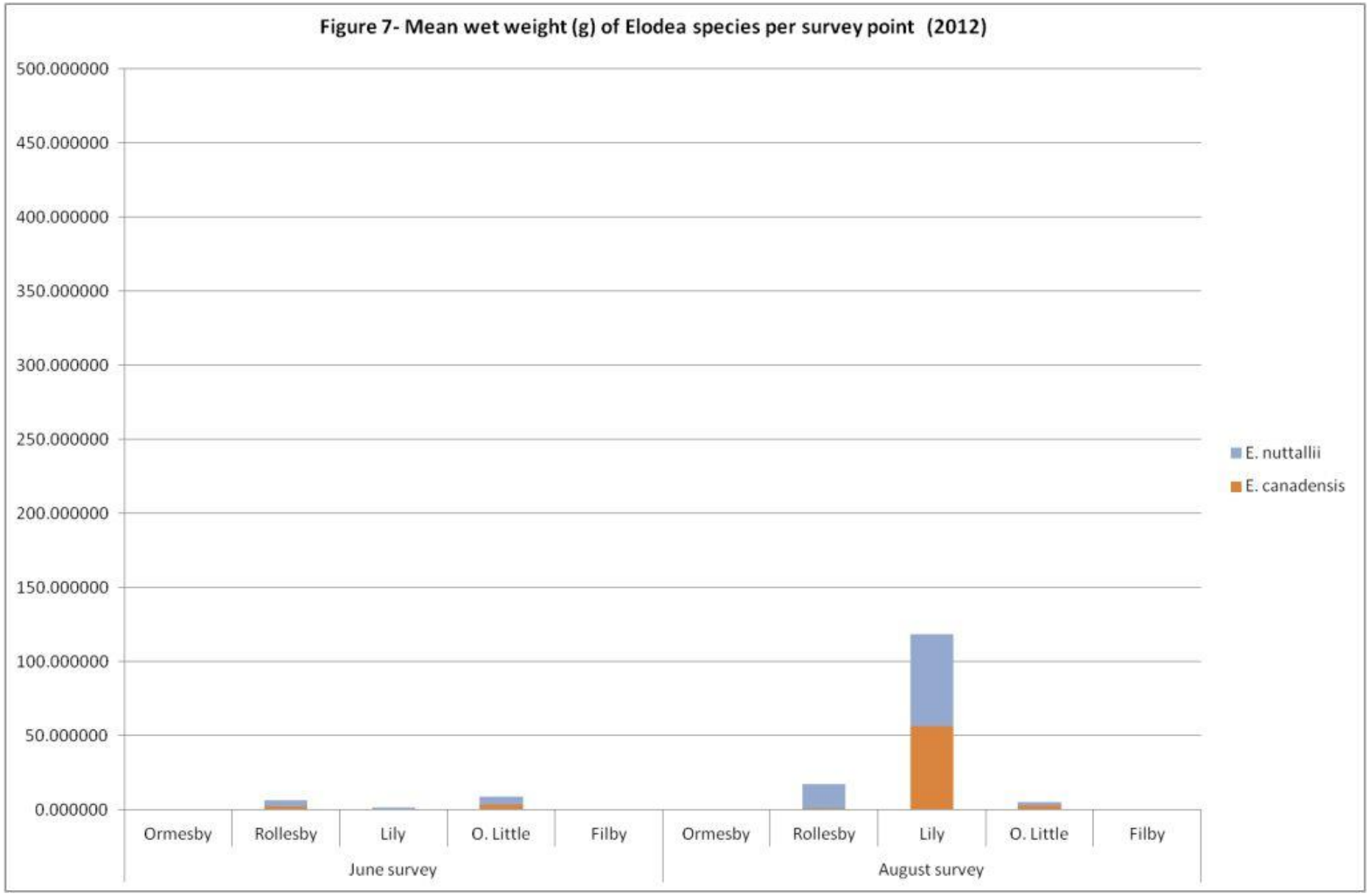
Figure 7- Mean wet weight (g) of Elodea species per survey point (2012)
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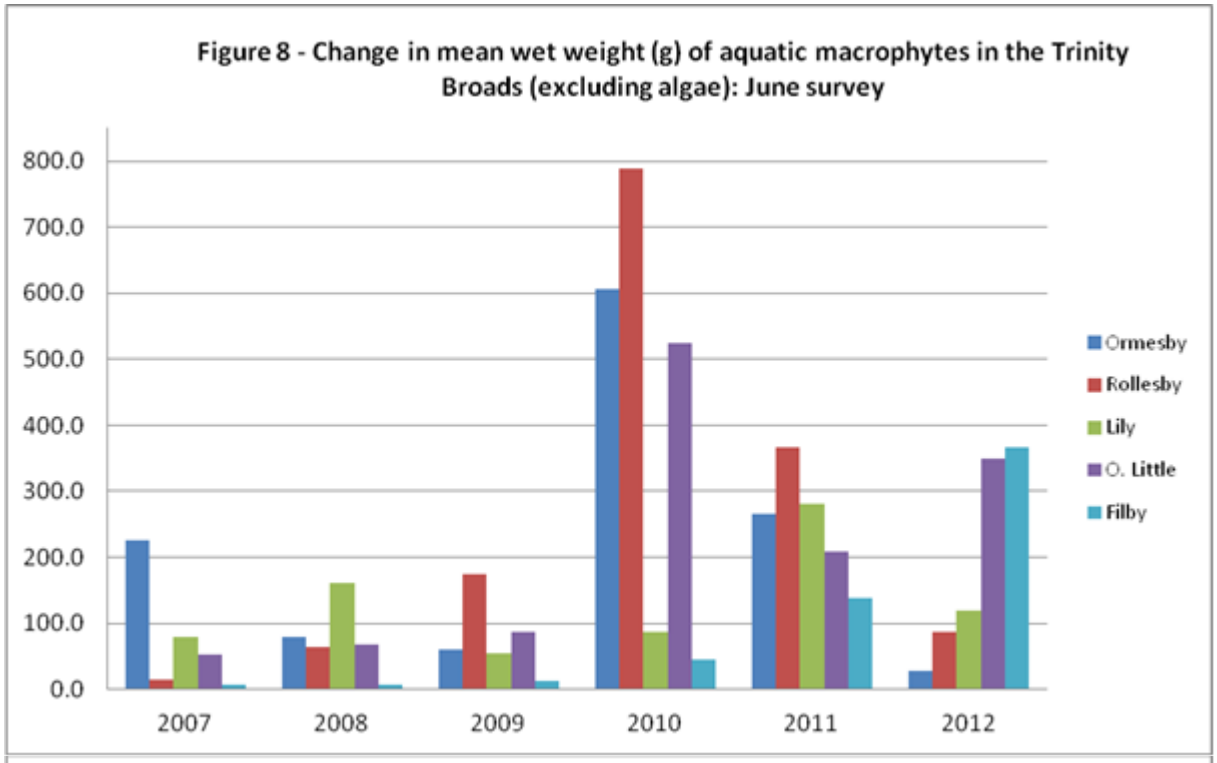
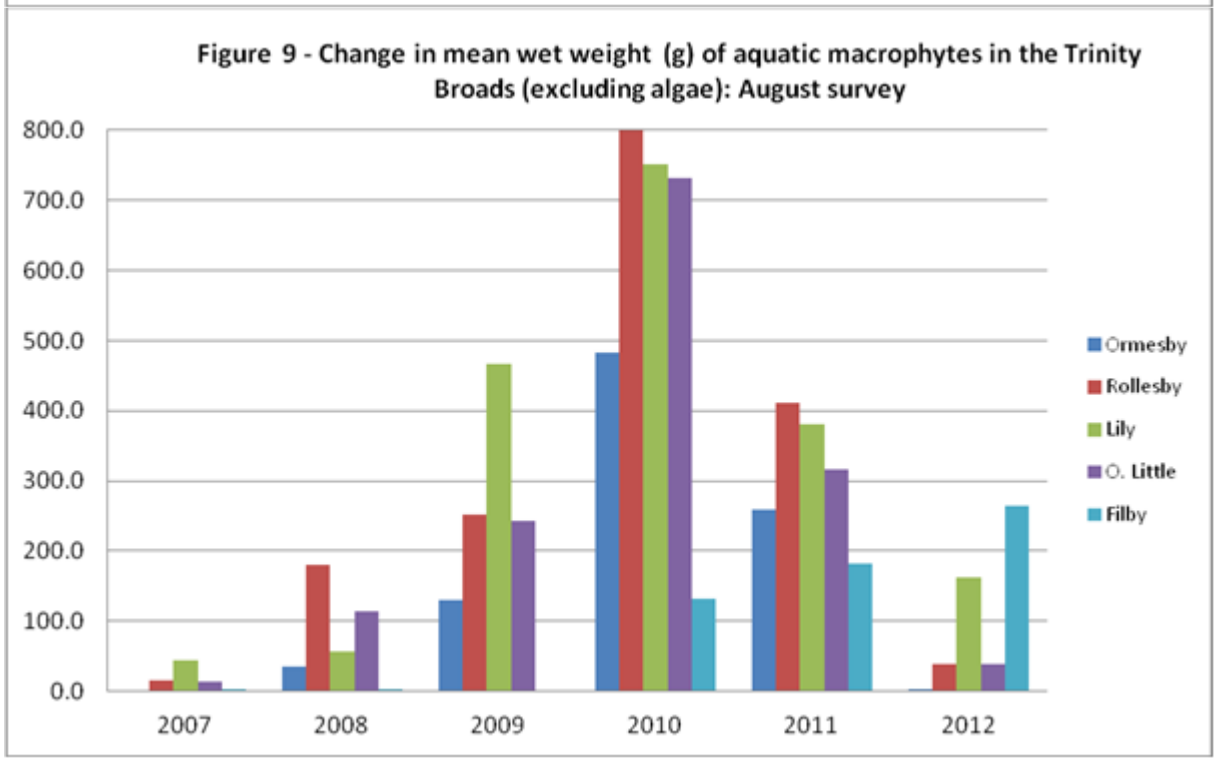
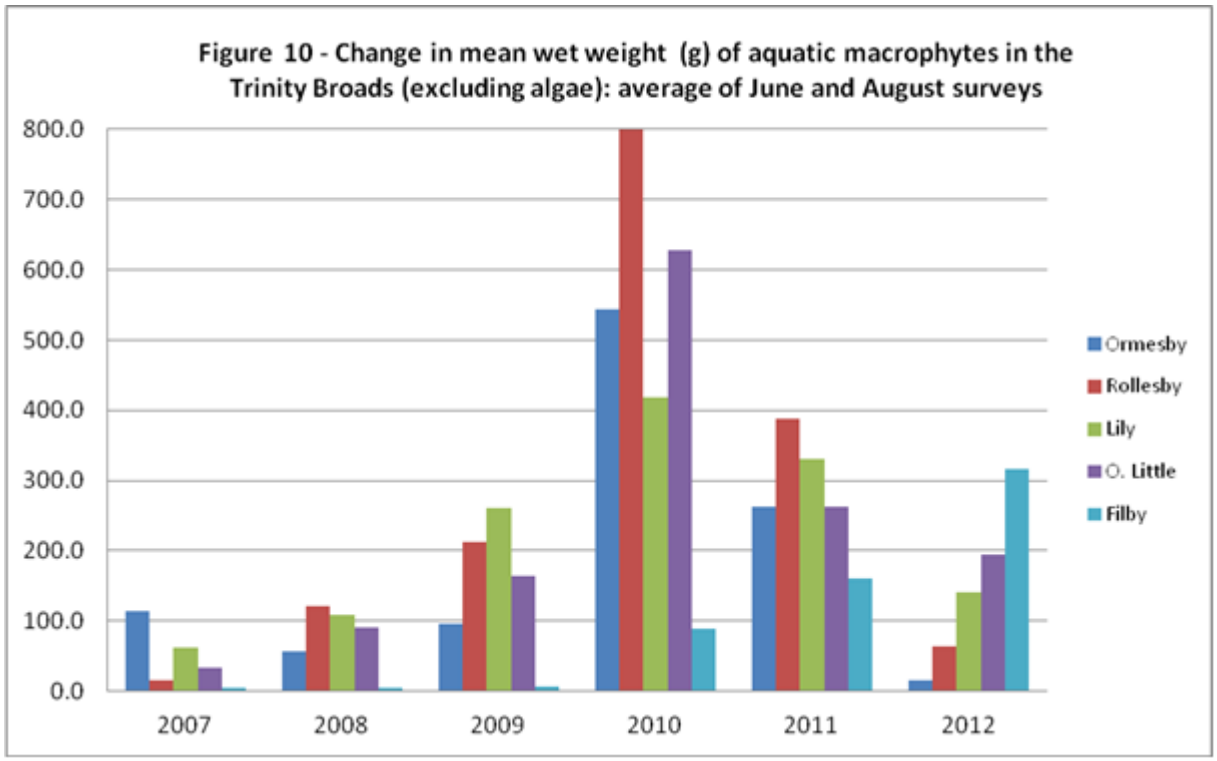
150.000000
100.000000
50.000000
0.000000
Ormesby
Rollesby
Lily
O. Little
Filby
Ormesby
Rollesby
Lily
O. Little
Filby
June survey
August survey
E. nuttallii
E. canadensis

3.4 Change in Abundance of Aquatic Plants since 2007

Figures 8, 9 and 10 show the change in abundance of plants in the Trinity Broads since 2007.







4. Discussion

4.1 Ormesby Broad

Ormesby Broad only had 12 different species of aquatic macrophytes in 2012, a significant drop from last year's peak of 16 species. Of these, only five species are classed as characteristic species (P. friesii, P. pusillus, L. trisulca, C. globularis and C. vulgaris), therefore in 2012 Ormesby Broad doesn't meet the target of six characteristic species present, which is set for natural eutrophic lake communities. Almost every sample point contained a characteristic species (96%), meaning the target of 6 out of 10 sample points to contain a characteristic species was exceeded. The target for 7 out of 10 sample points to contain a Chara species was not met, with only 27% of sample points containing a Chara species, which is a decrease from last year, but comparable with previous years (compared to 80% in 2011, 45.1% in 2010, 17.7% in 2009, 25.5% in 2008 and 19.7% in 2007).

The wet weight figures provide a good indication of the abundance of aquatic plants in Ormesby Broad. The mean wet weight of all plants found in Ormesby Broad for any given rake-pull in June 2011 was 86.5g. In 2012, only 32% of the total was accounted for by aquatic plants, the remaining 68% being algae. Filamentous algae makes up the majority, with 58g being the average weight per rake pull, followed by Z. palustris (19g).

The mean wet weight results for all plants in August are very low, with an average weight of 6.2g per rake pull (compared to 355g in 2011). Algae accounts for a 56% of the weight on each rake pull. The abundance of aquatic plant species is very low, with a mean wet weight of 1g or less for all species on each rake pull.

The abundance and species richness of plants in Ormesby Broad in 2012 are lower than previous years, and the virtual absence of plants in August is in stark contrast to the trend that has been observed over the past 10 years of late summer plant communities increasing.

4.2 Rollesby Broad

The survey on Rollesby Broad found 12 species of aquatic plants, 6 of which were characteristic species, therefore meeting this target. Rollesby also reached the target that at least 6 out of 10 sample points contained a characteristic species of this community type; in fact every point contained a characteristic species. This year, Rollesby didn't meet the target of 70% of points to contain a Chara species, with only 54% of points recording a Chara species. Rollesby Broad has met this target for the past four years.

In 2012 the abundance of plants in Rollesby Broad was lower than previous years also. 98g of plants were pulled in on average in June, 87% of which was aquatic macrophytes as opposed to algae. In August this was similar, 105g, but only 39% was macrophyte material, the remainder being algae. These figures are the lowest in Rollesby Broad since 2007, so it is not surprising that the growth of plants in the area outlined for plant cutting didn't reach the height required to allow cutting to be carried out (this was confirmed by a hydroacoustic survey in early July).

The species dominating the biomass in June was P. freisii (59g average on each rake pull), supplemented by P. pusillus (15g). By the time of the August survey, the potamogeton species had died back as is typical, with E. nuttallii and L. trisulca contributing 16g and 17g respectively. The majority was filamentous algae (65g, making up 62% of the biomass in August).

Rollesby Broad failed the Elodea target, which is that Elodea species should not occur at greater than 40% frequency – in fact, Elodea occurred in 88% of sample points.

4.3 Lily Broad

Lily Broad only had four characteristic species present in 2012 - P. pusillus, P. friesii, L. trisulca and C. globularis, hence not meeting the species diversity target of six characteristic species. Lily Broad had a characteristic species in every sample point, meaning it exceeded the 6 out of 10 sample point target. 2011 was the first year that stoneworts have been recorded in Lily Broad, and in 2012 the distribution of C. globularis had expanded to 47% of sample points, meaning it didn't meet the target for presence of Chara in 7 out of 10 sample points, but it is on an upward trend.

In June the mean wet weight per rake haul was 199g, 60% of which was aquatic plants as opposed to algae. The dominant species was P. pusillus (80g), followed by hydrodictyon algae (59g).

In August the mean wet weight was similar to June at 196g, with only 17% algae. The two Elodea species were evenly abundant, totalling 118g together. L. trisulca and C. demersum averaged 25g per rake pull each, and interestingly P. pusillus averaged 15g per rake pull in August, although the material was in a state of partial decay.

The plant abundance in Lily Broad has been variable over the past five years (see figures 8 and 9). Although abundance in 2012 was lower than 2011, Lily Broad performed well in 2012 in comparison to Ormesby, Rollesby and Ormesby Little Broads.

4.4 Ormesby Little Broad

Ormesby Little Broad had 14 species of plants not including algae, and also met the target of having six characteristic species - P. pusillus, P. friesii, P. crispus, R. circinatus, L. trisulca and C. globularis. This year 100% of sample points had a characteristic species, which exceeds the target value of 60%. Chara was only found in 14 out of 60 sample points (23%), meaning the target of 70% wasn't reached, which is a big decline from last year when 70% of sample points contained a Chara species. The abundance of Chara species in 2012 was also massively reduced, with less than 1g per rake haul in August, compared to the 104g in 2011.

The mean wet weights of aquatic plants were 411g in June and 190g in August, the June biomass being comparable with 2011, but the August biomass being significantly reduced. P. pusillus was the most dominant component of the June biomass, with an average of 197g per rake haul, followed by Z. palustris (77g) and P. friesii (45g). Algae accounted for 15% of the June biomass. The August survey saw a shift to an algae dominated community, with large amounts of filamentous algae (151g; 79%), with smaller amounts of C. demersum (13g), P. pusillus (9g) and L. trisulca (8g).

Ormesby Little broad didn't meet the target for Elodea, with 70% of sample points containing one or more of the Elodea species, but the biomass at each point was less than 7g on average.

4.5 Filby Broad

Filby Broad recorded 15 species of macrophytes in 2012, continuing the clear upward trend of the previous five years (figures 3 and 4). Filby had nine characteristic species (P. pusillus, P. friesii, P. crispus, L. trisulca, C. globularis, C. vulgaris, C. virgata, C. connivens and C. contraria) so exceeded the target for six characteristic species and indeed is the highest tally of characteristic species in all of the Trinity Broads since these surveys began. In addition, at least one of these species was found in 98% of sample points, meaning the target for 60% of sample points to contain a characteristic species was exceeded.

The species richness in 2012 is boosted by the variety of Chara species recorded. Part of the reason for this is that the August survey took place when several species were fruiting, so we were able to definitively identify species which usually have to be grouped when oospores are not present e.g. C. globularis and C. connivens. It is possible that C. connivens was and has been present in the other broads as well, but when oospores are not present the keys suggest we err on the side of caution and record it as C. globularis, the more widespread species.

With respect to the Chara target for 7 out of 10 sample points to contain a stonewort, Filby exceeded this with 93% of points containing a Chara species. This is a notable achievement, continuing the trend of increasing stoneworts in Filby Broad, which in recent times has typically had very few macrophytes.

The biggest change in the Trinity Broads aquatic plant communities in 2012 is the increase in biomass in Filby Broad. This can be seen in Figure 9. Filby Broad had the highest biomass of aquatic plants (excluding algae) of all the broads in the system, and 2012 was also the highest biomass of plants in Filby Broad since the surveys began.

In June, the mean wet weight per rake pull was 396g, of which 93% were plants as opposed to algae. The species dominating this biomass are Z. palustris (144g), C. globularis (108g) and P. pusillus (103g). In August, the mean wet weight per rake pull was 269g, of which 98% were plants as opposed to algae. The plants dominating are C. globularis (111g) and Chara sp. (52g) – due to the abundance of Chara species, much of the biomass at the bottom of the broad had degraded to such an extent that identification to species was impossible in the field.

In 2011, Filby Broad appeared to be recovering, with good species richness and increasing abundance, though the proportion of algae was significant at approximately one third of the biomass. In 2012, the species richness and abundance continued to increase, but the algae decreased, only making up 7% of the biomass in June and 2% in August, although it was distributed widely in 76% of the points.

5. Conclusion

The Trinity Broads aquatic plant populations are very changeable and unpredictable. Every year the species composition in each broad changes, sometimes considerably, and the abundance of plants in each broad is very variable year on year. This underlines the importance of undertaking the survey every year, so that the Partnership has a complete dataset.

The survey in 2012 was surprising in two respects. Firstly, Filby Broad appears to have stepped into the recovery phase which Rollesby, Lily and Ormesby Little moved into in 2008 and 2009. This is in terms of both abundance and species richness. This is an encouraging sign, which was by no means certain given the water depth and nutrient status of Filby Broad. Filby Broad had the highest species richness of all of the Trinity Broads in 2012, and the highest abundance of aquatic macrophytes in both June and August. The extent of the recovery is surprising, and is almost completely accounted for by Charaphyte diversity and abundance, with 93% of points containing a Chara species, and five species of Chara confirmed. In addition to this, the proportion of undesirable algae and Elodea species were negligible in Filby Broad.

Secondly, the 2012 survey was surprising because of the decline in plant communities in the rest of the Trinity Broads (apart from Filby Broad) following five years of recovery. Although Filby is usually the poor relation in terms of its aquatic macrophytes, this year was a complete reversal. Ormesby Broad, which in recent times has had the highest species diversity and a good abundance of aquatic plants, in 2012 had one of the lowest species counts, and the lowest abundance of plants in all of the Trinity broads in both June and August. Some sections of the Broad, particularly the northern end, were completely devoid of plant life. This is the poorest result since 2007 for Ormesby Broad, and a complete reversal in the fortunes of plant life between Ormesby and Filby Broads compared with the monitoring undertaken over the past two decades.

Rollesby Broad's plant community also appears to be in decline since the peak in 2010, with the lowest abundance since 2008, and also fewer species being recorded than the past four years. Lily Broad and Ormesby Little Broad are perhaps a bit more stable, with a similar number of species over the past four years, and the abundances recorded not quite as erratic as Ormesby and Rollesby.

The reasons for the significant changes in the plant communities of the Trinity Broads in 2012 are unclear. The weather in the spring was poor, resulting in less than favourable growing conditions for the fine leaved pondweed species that usually dominate in early summer in Ormesby and Rollesby, so that may be a factor. When the summer did get going in terms of sunshine and warm temperatures, the water in Ormesby and Rollesby Broads quickly coloured up with planktonic algae, and these blooms persisted for some weeks, which could have prevented later-growing plants such as Elodea and Chara species from establishing. In contrast, the water in Filby and the majority of Ormesby Little Broad remained clear throughout the summer, with huge numbers of zooplankton visible in the water grazing the algae before it bloomed. This would have enabled the large beds of Chara spp. in Filby Broad to grow unimpeded by water clarity issues.

The curious thing is that Ormesby Little Broad and Filby Broad both had good abundances of P. pusillus and Z. palustris in June, and in Ormesby Little Broad also P. friesii. The weather was constant across all the broads, and the water clarity was good during the June survey in Ormesby and Rollesby, so why did the fine leaved pondweeds grow in the southern broads of the system and not the northern broads? It could be that there was an in-lake mechanism affecting plant growth in Ormesby and Rollesby, but at this stage it is hard to determine what that might have been. It would be useful to look at the water quality data across the Trinity Broads in May and June. Unfortunately there was no zooplankton monitoring undertaken and no summer fish survey, so it will be hard to draw conclusions regarding the interactions between fish, water fleas and algae. The winter fish survey across the whole of the Trinity Broads in the winter of 2012-13 may shed some light on the matter.

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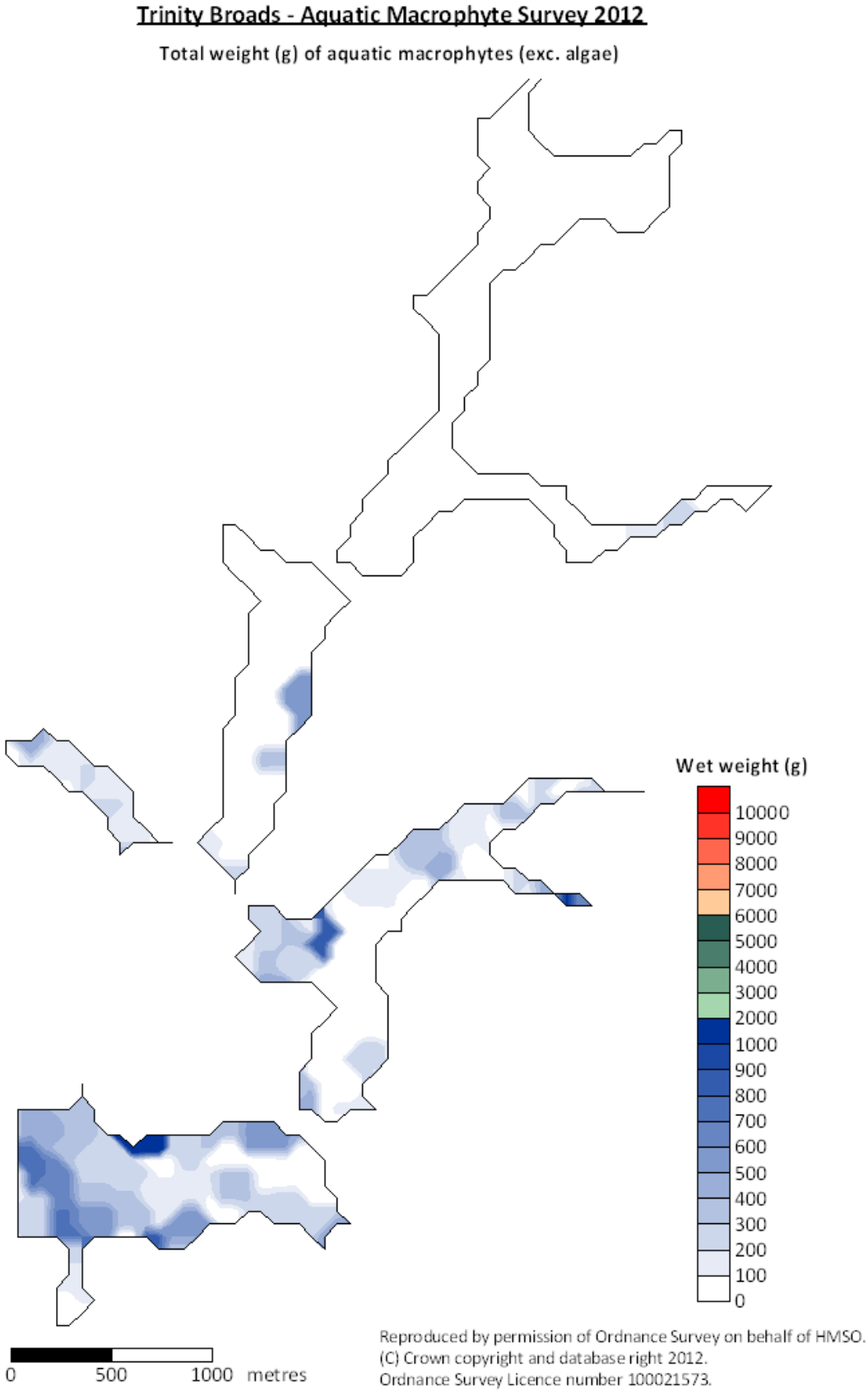
7. Appendix


Trinity Broads - Aquatic Macrophyte Survey 2012
Total weight (g) of aquatic macrophytes (exc. algae)
Wet weight (g)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
900
800
700
600
500
400
300
200
100
0
0
500
1000
metres
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