Broads Annual Water Plant Monitoring Report 2023

December 2023

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Contents

Broad plant survey: 2023 Annual Report

Executive Summary

The Broads Authority have surveyed the water plant communities within the Broads since 1983. The Broads Annual Water Plant monitoring programme provides information on the diversity of species and a measure of abundance. The programme has consistently surveyed key broads, such as Hickling Broad (a prime navigation site with high recreational value) and Cockshoot Broad (previously undergone restoration measures), providing long term datasets. Between 1983 and 2013, a transect-based technique was used for the monitoring programme. Due to limitations in the efficiency of the methodology along with the improvements in water plants generally across the Broads, a new point -based technique was developed and implemented. Point sample surveys have been conducted since 2014.

Water plants (also known as macrophytes) in the Broads are inherently highly variable in both abundance and species richness between years, so limited significance should be attached to variation in these parameters between one individual year and the next.

This report presents and discusses the findings from the annual water plant surveys carried out during 2023, which covered 19 broads and 4 water bodies, with a total of 600 survey points.

- Overall, 74% (17/23) of the broads surveyed showed an increase in total species abundance of water plants. 9% (2/23) of broads showed a decrease in total abundance. The remaining 17% (4/23) of the surveyed sites were new survey sites. Almost all the broads surveyed had more water plants than the previous surveys and continues the trend of increasing plant growth along with overall species abundance increasing over the last few years.

- Most of the broads connected to the Bure River recorded an increase in abundance, including Bridge Broad, Hoveton Great Broad and Hudson's Bay, Upton Great Broad and Cockshoot Broad. The clarity of the water in the river and therefore the river-connected broads was also of note. A decrease in abundance was recorded in Wroxham Broad and no macrophytes were found in South Walsham Broad.

- The Ant catchment showed increases in all the broads and water bodies surveyed. From having few water plant records in 2009 Reedham water now has a high summary abundance.

- Stoneworts were dominant in Alderfen Broad, Hickling Broad, Martham North and Martham South and were also recorded in Bargate Broad, Barton Broad, Bridge Broad, Buttle pools, Cromes Broad, Cockshoot Broad, Hassingham Broad, Heigham Sound, Reedham water, Rockland Broad, Upton Great Broad, and Wroxham Broad. Stonewort abundance levels vary across the broads but 61% (11/18) of the broads

surveyed showed an increase, 22% (4/18) a decrease and 17% (3/18) were new water bodies not surveyed before.

- Vascular macrophytes were dominant in 14/23 sites this year such as Cockshoot Broad, Wroxham Broad, Hoveton Great Broad, Upton Great Broad and Reedham Water. Abundance levels vary across the broads but 52% (12/23) showed an increase, 26% (6/23) a decrease and 13% (3/23) were new water bodies not surveyed before. South Walsham Broad did not record any plants, and Barton Broad stayed the same.

- Macro Algae and Mosses increased in 57% (13/23) of broads and Cromes Broad had the greatest abundance of macroalgae in 2023 of all the broads. Decreases were seen in 13% (3/23) of the broads surveyed and two broads recorded no macroalgae. Upton Great Broad showed little change.

- Free-floating or round floating leaved macrophytes had increases in 39% (9/23) of broads. Decreases were recorded in 22% (5/23) and none were found in 22% (5/23). Reedham Water and Buttle pools recorded presence of the macrophyte.

- Holly-leaved naiad saw lower abundance levels this year compared to 2022. Increases were recorded in Martham North, Upton Great Broad and Hassingham Broad and this Section 41 species was also recorded for the first time in Reedham Water. Decreases were seen in Alderfen Broad, Cockshoot Broad, Cromes Broad, Martham South and Hickling Broad. Heigham Sound did not have any records of Holly-leaved naiad this year which is unusual in recent years.

Introduction

Background information

The Broads Authority (the Authority hereafter) has monitored aquatic macrophytes (water plants hereafter) annually at numerous broads within its Executive Area since 1983. The water plant monitoring programme has provided data on species richness (number of species) and a measure of abundance of the water plants present in each of the broads surveyed. The surveys have created long-term datasets, provided vital information in monitoring the response of a number of broads to restoration measures such as suction dredging and / or biomanipulation and are contributing to scientific reviews of key broads (http://www.broads-authority.gov.uk/__data/assets/pdf_file/0006/549114/Broads-Lake-Review.pdf).

Following increased water plant growth across many of the broads, it was acknowledged that the transect methodology (employed until 2013), was difficult to implement in a robust and consistent manner required for analysis of long-term trends. Following consultation with Natural England, Environment Agency, Dr Nigel Wilby (University of Stirling) and other researchers, a point-based survey methodology was developed. Between 2011 and 2013, the point sample survey was conducted alongside the transect surveys. The purposes of the concurrent surveys was to understand if the data gathered was directly comparable and would allow long-term trend analysis. Whilst research undertaken by Dr Nigel Wilby, revealed the data gathered by the two techniques was not directly comparable, the point-based technique was adopted as the method for the Broads Annual Water Plant Monitoring programme from 2014 onwards.

Aims & objectives

The main objectives of the annual programme are to monitor key broads with long-term datasets, those that have undergone restoration measures or those that are known to be experiencing a change in their water plant community. Broads that have not received restoration efforts or are stable (with or without water plants) are monitored on a less frequent basis. When resources allow, the monitoring of sites not previously surveyed is an ongoing objective. River stretches are also surveyed annually, focusing on the upper reaches where plant growth is concentrated.

The general aim of the monitoring programme is to monitor water plant growth and provide an assessment of the condition, or health, of the broads and waterways within the Broads. The monitoring programme also provides an assessment of Section 41 species, Species “of principal importance for the purpose of conserving biodiversity” covered under section 41 (England) of the NERC Act (2006) and therefore need to be taken into consideration by a public body when performing any of its functions.

Two types of surveys are undertaken as part of the monitoring programme, point sample surveys to assess species diversity and provide a measure of abundance within a broad or

stretch of river and hydroacoustic surveys, which use sonar technology to estimate cover and volume of water plants along transects.

The purpose of this report is to present the results of the 2022 survey season.

The data gathered through the water plant and hydroacoustic surveys and presented within these reports are used to:

- Report the status of conservation priority species, e.g. certain stoneworts and Holly-leaved naiad (Section 41 priority species)
- Assess the condition of designated sites (SSSIs) and WFD waterbodies in partnership with NE and EA respectively.
- Assess the success of restoration measures such as catchment or in-lake projects by managers and research scientists as well as assessing long-term trends
- Assess the impact of and ability to cut water plants to allow the safe passage of boats.

Methodology

Survey design

The point sample survey was designed in consultation with Dr Nigel Wilby using Broad's species accumulation data. The data generated a relationship (y = 4.6242ln(x) + 17.149) between the area of the open water of a broad and the required number of points to be sampled (see Figure 1). Using ArcGIS, the area of open water of each broad to be surveyed was measured in hectares (ha) and the number of sample points calculated. Once the required number of points was calculated, a grid system was applied over an aerial image of the open water areas of each broad. Sample points were set equidistant from each other and the co-ordinates generated (see Figure 2). The maps and sample point co-ordinates were loaded onto a Samsung tablet for the survey teams to use.

Figure 1

The relationship between the area of open water and the required number of points sampled.

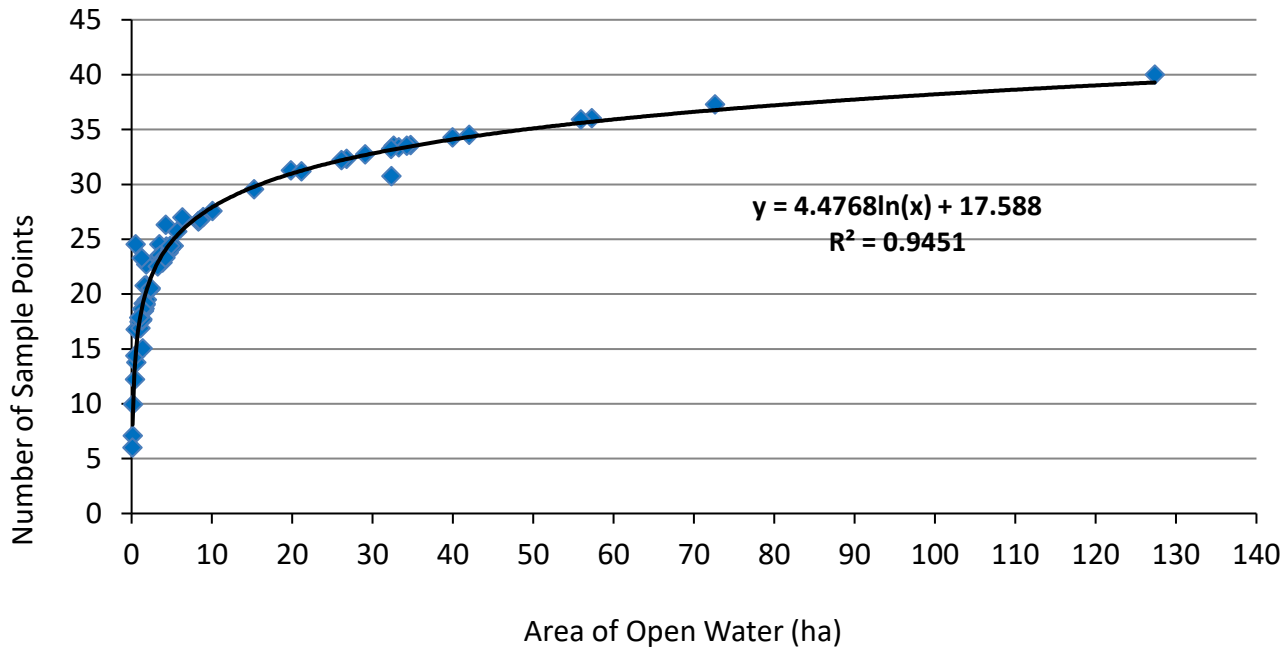
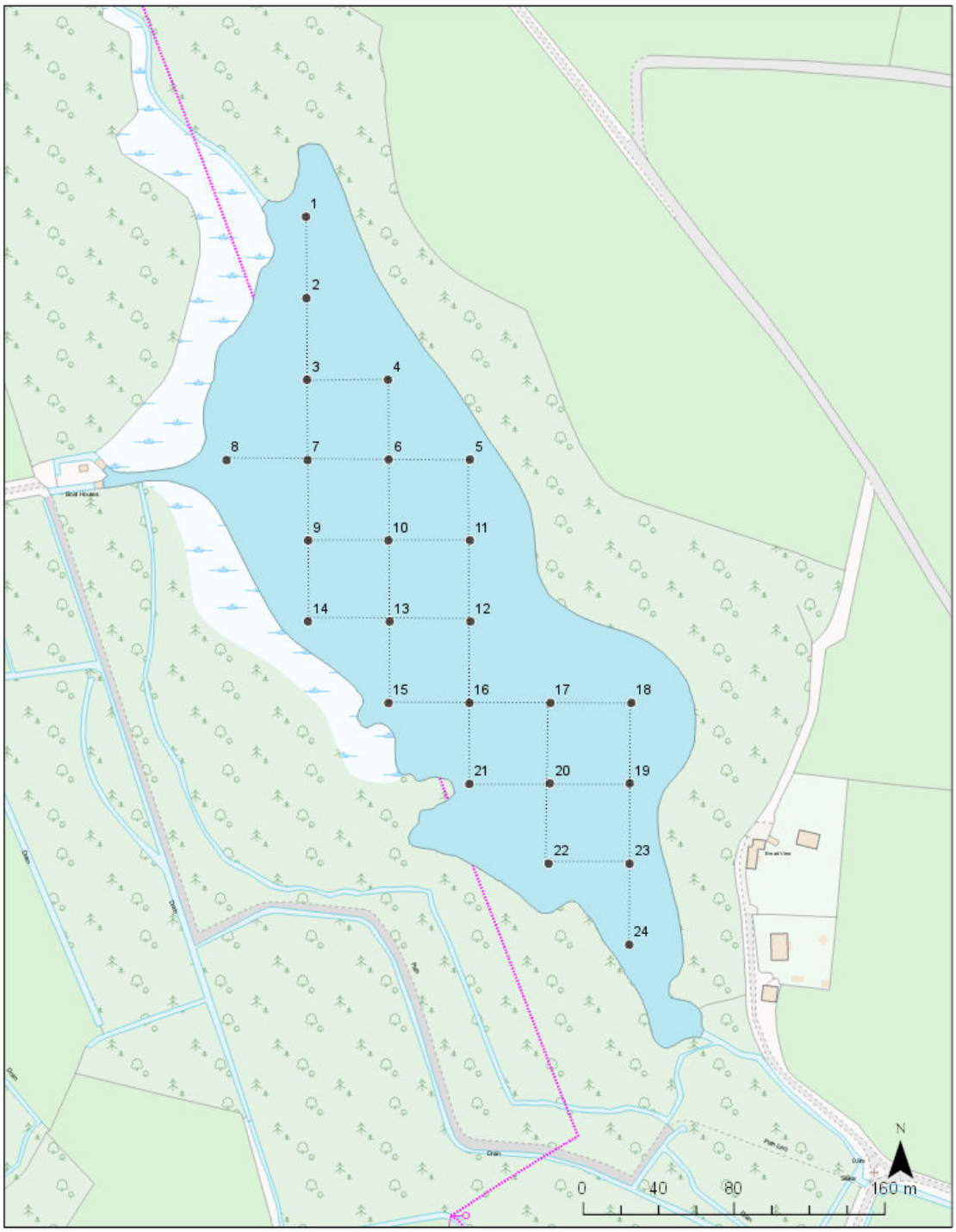


Figure 2

Map showing the sample points of Alderfen Broad



Sample points at Alderfen Broad

Point sample survey technique

At each broad, the surveyors used the maps and grid references on the Samsung tablet and GPS to navigate by boat to each of the sample points. Once within 5 m of the plotted grid reference, mud weights were deployed to keep the boat in the correct location.

At each sample point, a double headed survey rake was thrown north and south, at each sample point, at a distance of 5 m from the boat edge. The rake was left for 10 seconds to sink to the bottom after which the rake was pulled slowly and steadily back towards the boat. For points that were in known deeper water, additional rope was thrown to allow the rake to sink and rest on the bed of the lake at a distance of 5m from the edge of the boat.

On retrieval of the rake, the plants attached to the rake head were collected in a white survey tray. If necessary, plants were washed to remove excess sediment to aid identification. All the live plant material was identified to species level wherever possible. For example, some particularly difficult groups e.g. any non-fruiting starworts *Callitriche* sp. were only identified to genus level. Any unidentified plant specimens (or where identification was uncertain) were collected in plastic bags and labelled using the station number reference. These samples were then taken for subsequent observation using a high-powered microscope, or sent for expert identification. Wherever possible, voucher specimens were pressed and dried using standard herbarium techniques.

To assign a level of abundance for each species, the total volume of live water plant material was scored based on the maximum trap-ability on the rake. Scores attributed to each species present range from 10% (low abundance) and 100% (the maximum trappable) in increments of 10%. For example, if the maximum plant volume was present on the rake, but split equally between two species then each species would be scored 50%. In addition, scores of 1% were given to trace and very small amounts of identifiable plant material.

The ‘trap-ability’ of a particular species on the rake, was taken into account so that a score of 100% represents the maximum amount trappable on the rake. For example, a fine leaved species such as Unbranched bur-reed *Sparganium emersum* is not as ‘trappable’ on the rake as a more structured species such as Spiked water milfoil *Myriophyllum spicatum*. Surveyor experience and judgement is therefore important in scoring the less trappable species based on the likelihood of being retrieved in the rake and possibly other visual indications. The risk being that high abundances of less trappable species are routinely under-scored compared to more easily retrieved species. Other less trappable water plant families include duckweeds Lemna sp. and water lilies.

The maximum total of all species abundance scores on an individual rake sample cannot really be more than 100%, although ± 10% is considered acceptable to account for the varying trap-ability of different species.

The broads that have been sampled between 2014 and 2022 are presented in Table 1. Surveys are conducted during the summer period, July to September.

Table 1

Sites surveyed as part of the monitoring programme between 2014 and 2022.

Broad	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Alderfen Broad	X	X	X	X	X	X	X	X	X	X
Bargate Broad	X			X			X			X
Barnby Broad		X								
Barton Broad	X	X	X	X	X	X	X	X	X	X
Belaugh Broad				X					X	
Blackfleet broad			X							
Bridge Broad		X					X			X
Buckenham Broad		X		X						X
Burntfen Broad			X						X	
Buttle Pools										X
Calthorpe Broad	X							X		
Catfield Broad		X								
Cockshoot Broad	X	X	X	X	X	X	X	X	X	X
Cromes Broad	X	X	X	X	X	X	X	X	X	X
Decoy Broad	X		X		X		X		X	
Hassingham Broad		X		X						X
Heigham Sound	X	X	X	X	X	X	X	X	X	X
Hickling Broad	X	X	X	X	X	X	X	X	X	X
Horsey Mere	X	X	X	X	X	X	X	X	X	X
Hoveton Great Broad	X	X	X	X	X	X	X	X	X	X
Hoveton Little Broad	X			X			X		X	
Hudson's Bay		X			X		X	X	X	X
Little Broad			X						X	
Malthouse Broad							X			
Martham Broad North	X	X	X	X	X	X	X	X	X	X
Martham Broad South	X	X	X	X	X	X	X	X	X	X
Mautby Decoy			X							

Broad	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Norton's Broad			X						X	
Oulton Broad			X							
Pound End		X					X		X	
Ranworth Broad	X	X		X		X	X	X		
Reedham Water										X
Rockland Broad	X	X	X	X	X	X	X	X	X	X
Round Water Broad			X						X	
Salhouse Great Broad									X	
Sotshole Broad			X							
South Walsham Broad										X
Sprat's Water			X						X	
Strumpshaw broad		X			X			X		
Upton Broad	X	X	X	X	X	X	X	X	X	X
Upton Little Broad	X		X		X				X	
Wheatfen Broad & Channels		X			X			X		
Whitlingham Great Broad	X	X	X	X	X					
Whitlingham Little Broad		X	X	X	X	X				
Woolner's Carr			X						X	
Wroxham Broad	X	X	X	X	X	X	X	X	X	X

Data processing

For each sample point, an abundance score for each species was calculated, derived from the data from the north and south throws;

$$\frac{\text{(Score from north + Score from south)}}{2}$$

The abundance score for each species was then totalled to produce an abundance score for each sample point. An overall mean abundance for each species for the whole broad was then calculated by summing the scores from each sample point and dividing by the number of sample points. The overall mean abundance score for each species was then added together to give the overall total abundance score for the broad. Assuming maximum plant abundance on the site, the site abundance score should have a maximum of 100 (± 10%).

The water plants present in the surveys were also categorised into groups, such as stoneworts or macro-algae, and abundance scores were calculated for each group in each broad, as described above. The water plant groups and the species within them are presented in Appendix I.

Results

Section 41 Species

Species "of principal importance for the purpose of conserving biodiversity" covered under Section 41 (England) of the NERC Act (2006). These species need to be taken into consideration by a public body when performing any of its functions.

Table 2

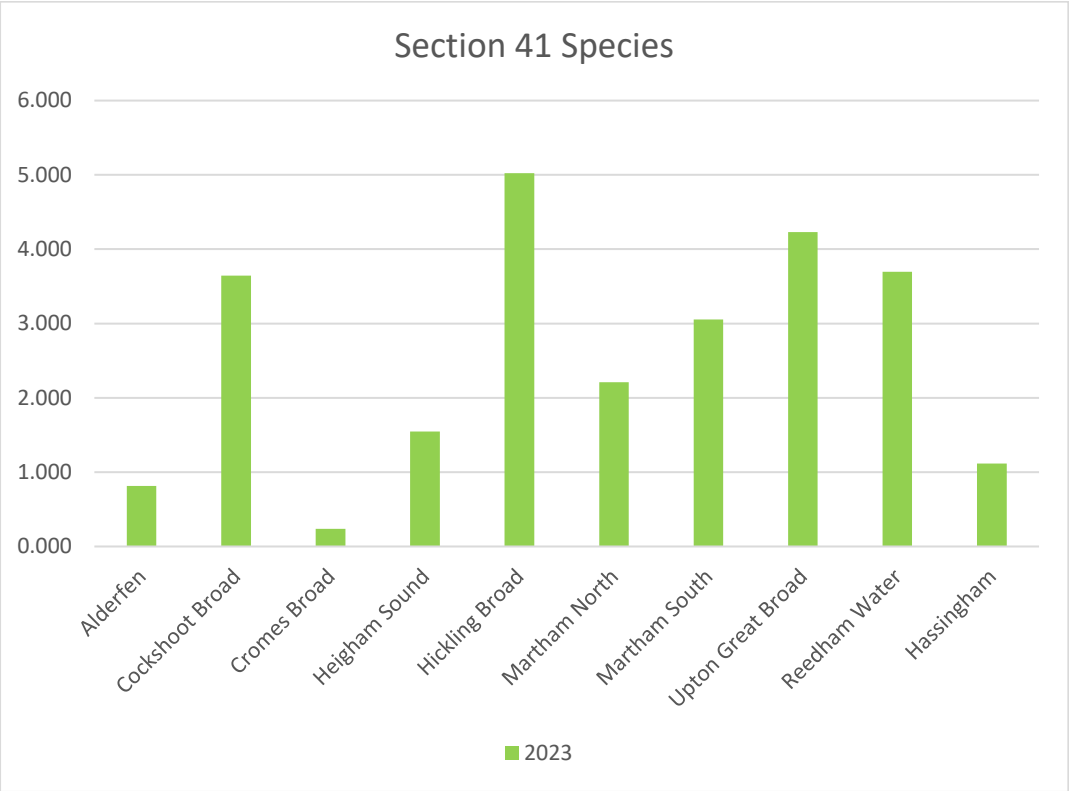
Ten broads were found to have Section 41 species in 2023.

Species	**Broads**
Holly-leaved naiad- *Najas marina*	Alderfen Broad, Cockshoot Broad, Cromes Broad, Heigham Sound, Hickling Broad, Martham South, Martham North, Upton Great Broad, Reedham Water
Baltic stonewort - *Chara baltica*	Heigham Sound, Hickling Broad, Martham North, Martham South
Intermediate stonewort - *Chara intermedia*	Heigham Sound, Hickling Broad, Martham North
Convergent stonewort - Chara connivens	Heigham Sound, Hickling Broad, Martham South, Upton Great Broad
Starry stonewort *Nitellopsis obtusa*	Heigham Sound, Hickling Broad, Martham South

As can be seen from this table, the broads in the Thurne are an important site for Section 41 species. Increases were seen in Heigham Sound, Martham North, Martham South, Upton Great Broad and Reedham water. Holly-leaved naiad saw lower abundance levels this year compared to 2022. This species was also recorded for the first time in Reedham water.

Graph 1

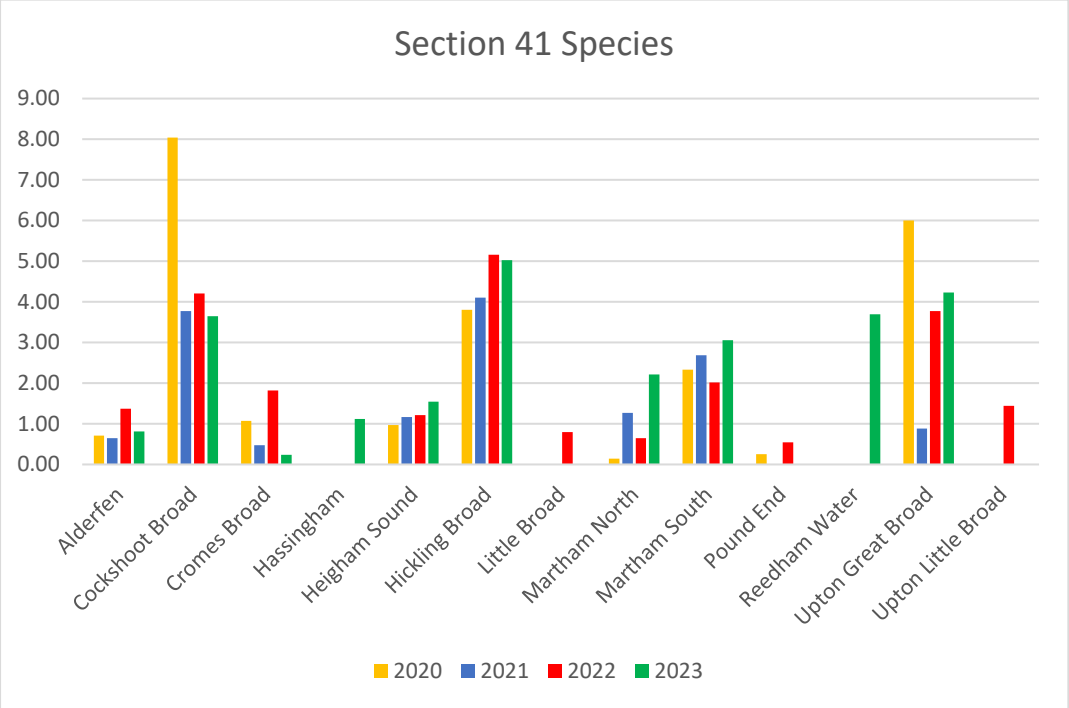
2023 abundance scores for Broads with Section 41 species



NB: Summary abundance axis usually sees ranges up to 10 in score, but to show the smaller values for section 41 species the axis has been reduced for this graph.

Graph 2

Section 41 species abundance between 2021 - 2023.



Holly-leaved naiad abundance decreased in many broads in 2023 which is reflected in the corresponding areas most prolific with the plant, Cockshoot Broad and Alderfen. The broads more dominant with stoneworts in the Upper Thurne Valley actually saw increases in overall section 41 species this year. See main results for more details. There was also a first appearance for Holly-leaved naiad in Reedham water. Starry stonewort increased in the 3 broads where it was found, Heigham sound (from 0.167 to 0.439), Hickling (from 0.013 to 0.138) and Martham South (from 0.160 to 0.463).

Table 3
Holly-leaved naiad distribution.

Broad	2020 Number of Points with Holly-leaved naiad	2021 Number of Points with Holly-leaved naiad	2022 Number of Points with Holly-leaved naiad	2023 Number of Points with Holly-leaved naiad
Alderfen Broad	30/48	19/48	34/48	15/48
Cockshoot Broad	47/48	36/48	44/48	42/48
Cromes Broad	31/40	18/42	26/44	9/42
Heigham Sound	2/66	2/66	4/66	/
Hickling Broad	11/80	5/80	18/80	10/80
Martham North	/	10/52	7/48	8/52
Martham South	17/54	24/54	14/50	8/54
Upton Great Broad	44/48	18/42	44/48	27/48
Little Broad	/	/	20/28	/
Pound End	11/44	/	8/44	/
Upton Little	/	/	6/36	/
Reedham Water	/	/	/	41/46
Hassingham Broad	/	/	/	15/34

The only increase seen this year was seen in Upton Broad. All the other broads and water bodies which recorded Holly-leaved naiad saw a decrease in overall abundance levels from 2022. Reedham water had its first record of Holly-leaved naiad.

Main Survey Results

The data collected from each broad is presented as species richness (the number of species recorded) and abundance (the amounts of each species recorded) according to the point survey and scoring method (outlined in Section 2.2).

The results tables also illustrate the number of points at which each species was recorded, giving an indication of the frequency of occurrence.

Appendix 1 lists the common and Latin names for all plants found to date during water plant surveys in the Broads.

Thurne Valley

The Thurne valley broads contain two Annex I open water habitats and form a key part of the Broads Special Area of Conservation (SAC) designation. (Hard oligo-mesotrophic waters with benthic vegetation of stonewort species (3140), and Natural eutrophic lakes with Magnopotamion or Hydrocharition - type vegetation (3150)).

These bodies of water are a sanctuary for vulnerable and rare species which are stated in the Joint Nature Conservation Committee (JNCC) Red Data Book, including three vulnerable species: Baltic stonewort, Convergent stonewort and Starry stonewort, and one Rare species: Intermediate stonewort (Stewart and Church, 1992). They also provide a safe haven for the rare Holly-leaved naiad, which is a Section 41 priority species along with…., as well as more common vascular plants such as Spiked water milfoil and Mare's tail.

2023 Summary

This year there has been an assortment of results with increases and decreases. Hickling, Martham North, Martham South and Horsey increased in their overall abundances compared with 2022. Heigham Sound has slightly decreased in abundance levels. The high variability of plant abundance between years highlights the importance of surveys carried out frequently and looking across multiple years to establish trends. Horsey Mere continues to show low macrophyte levels compared to the other broads in the Thurne Valley.

Heigham Sound

Table 4

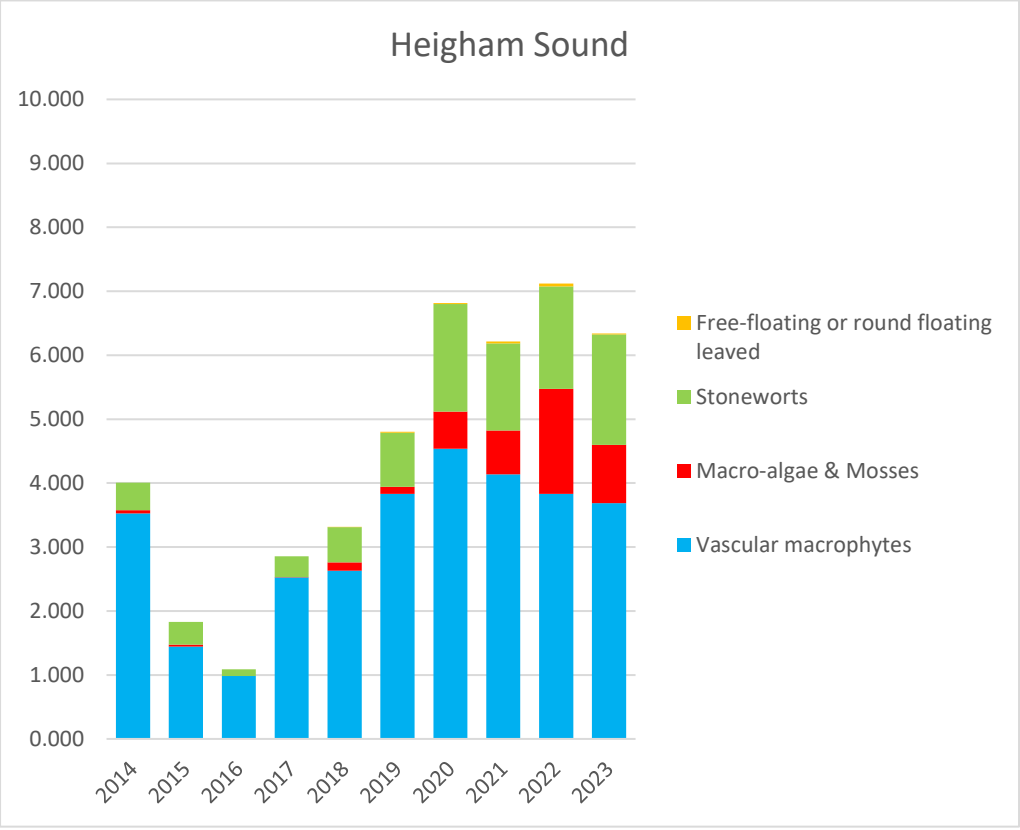
Common Name	Scientific Name	Summary Abundance	Occurrences
Spiked water milfoil	*Myriophyllum spicatum*	1.062	31
Intermediate stonewort	*Chara intermedia*	0.985	15
Filamentous algae	*Zygnematales*	0.911	28
Rigid hornwort	*Ceratophyllum demersum*	0.621	31
Mare's tail	*Hippuris vulgaris*	0.561	20
Starry stonewort	*Nitellopsis obtusa*	0.439	11
Nuttall's waterweed	*Elodea nuttallii*	0.364	15
Canadian waterweed	*Elodea canadensis*	0.212	13
Curled pondweed	*Potamogeton crispus*	0.197	13
Starwort species	*Callitriche sp*	0.183	12
Shining pondweed	*Potamogeton lucens*	0.152	6
Fragile/convergent stonewort	*Chara globularis/connivens*	0.106	2
Baltic stonewort	*Chara baltica*	0.106	6
Fan-leaved water crowfoot	*Ranunculus circinatus*	0.106	7
Willow-leaved pondweed	*Potamogeton x salicifolius*	0.077	5
Bristly stonewort	*Chara hispida*	0.076	4
Fennel-leaved pondweed	*Potamogeton pectinatus*	0.030	2
Intermediate water-starwort	*Callitriche stagnalis*	0.030	1
Enteromorpha	*Enteromorpha*	0.030	2
Whorled water milfoil	*Myriophyllum verticillatum*	0.030	2
Perfoliate pondweed	*Potamogeton perfoliatus*	0.030	2
Ivy-leaved duckweed	*Lemna trisulca*	0.015	1
Convergent stonewort	*Chara connivens*	0.015	1
Long-stalked Pondweed	*Potamogeton praelongus*	0.015	1
Pondweed species	*Potamogeton sp.*	0.015	1
No plants	*No plants*	0.000	6

Common Name	Scientific Name	Summary Abundance	Occurrences
Total number of species recorded		**25**	**Total samples taken: 66**

This year has seen a slight decrease for Heigham Sound, with the level dropping to 2021 abundance levels. However, species numbers increased from 21 to 25. Filamentous algae decreased from 1.638 to 0.911 abundance, with the number of occurrences staying the same. Spiked water milfoil saw similar levels to last year, while Intermediate stonewort stayed the same in occurrences but increased in abundance from 0.818 to 0.985. Starry stonewort also increased in abundance from 0.167 to 0.439 and from 6 occurrences to nearly double at 11 this year. Rigid hornwort saw a slight increase while Mare's Tail and Curled pondweed saw decreases from last year.

Graph 3

Heigham Sound summary abundance shown in plant groups (see Appendix 1 for more detail)



Hickling Broad

Table 5

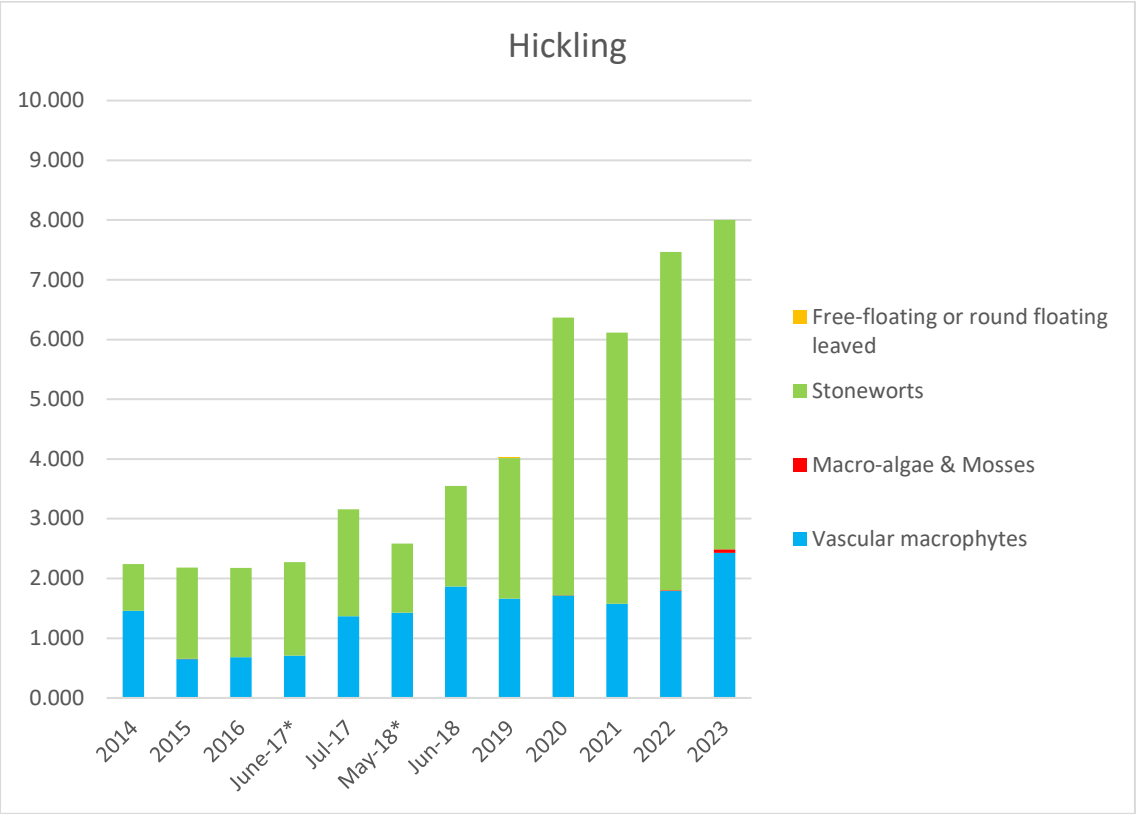
Common Name	Scientific Name	Summary Abundance	Occurrences
Intermediate stonewort	Chara intermedia	3.750	52
Spiked water milfoil	Myriophyllum spicatum	1.201	49
Baltic stonewort	Chara baltica	0.838	36
Fennel-leaved pondweed	Potamogeton pectinatus	0.525	25
Intermediate water-starwort	Callitriche stagnalis	0.250	2
Hedgehog stonewort	Chara aculeolata	0.250	2
Bristly stonewort	Chara hispida	0.238	11
Holly-leaved naiad	Najas marina	0.213	10
Starry stonewort	Nitellopsis obtusa	0.138	5
Rough stonewort	Chara aspera	0.138	7
Curled pondweed	Potamogeton crispus	0.100	7
Mare's tail	Hippuris vulgaris	0.100	2
Convergent stonewort	Chara connivens	0.088	7
Filamentous algae	Zygnematales	0.063	5
Fragile/convergent stonewort	Chara globularis/connivens	0.050	2
Rigid hornwort	Ceratophyllum demersum	0.025	2
Lesser bearded stonewort	Chara curta	0.025	2
Canadian waterweed	Elodea canadensis	0.013	1
Total number of species recorded		**18**	**Total samples taken: 80**

This year the summary abundance within Hickling increased from 7.456 to 8.001 and there were four dominant species compared with six in 2022. Intermediate stonewort is the most

dominant stonewort with other Stonewort (*Chara*) species this year having less dominance. There were similar number of species this year and plants were found in all locations. The vascular macrophytes increased slightly this year along with macro algae & mosses.

Graph 4

Hickling Broad summary abundance shown in plant groups (see Appendix 1 for more detail)



Horsey Mere

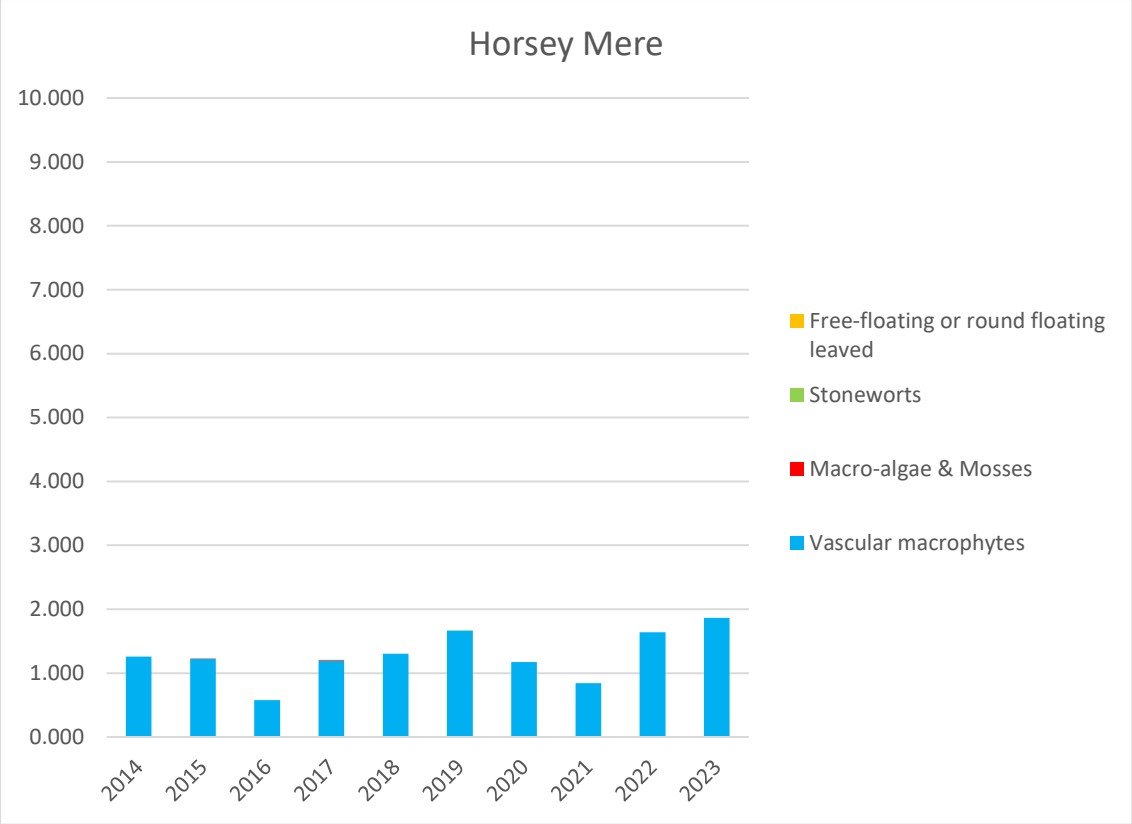
Table 6

Common Name	Scientific Name	Summary Abundance	Occurrences
Spiked water milfoil	*Myriophyllum spicatum*	1.412	38
Mare's tail	*Hippuris vulgaris*	0.394	11
Fennel-leaved pondweed	*Potamogeton pectinatus*	0.030	2
Curled pondweed	*Potamogeton crispus*	0.015	1
Perfoliate pondweed	*Potamogeton perfoliatus*	0.015	1
No plants	*No plants*	0.000	28
Total number of species recorded		**5**	**Total samples taken: 66**

Species increased from three to five this year. Spiked water milfoil increased in abundance from 1.291 to 1.412 and from 29 to 38 occurrences. Mare's tail increased in abundance from 0.333 to 0.394. The number of sample points with no plant records decreased to 28 from 37 in 2022. Curled pondweed and Perfoliate pondweed also made an appearance this year.

Graph 5

Horsey Mere summary abundance shown in plant groups (see Appendix 1 for more detail)



Martham North

Table 7

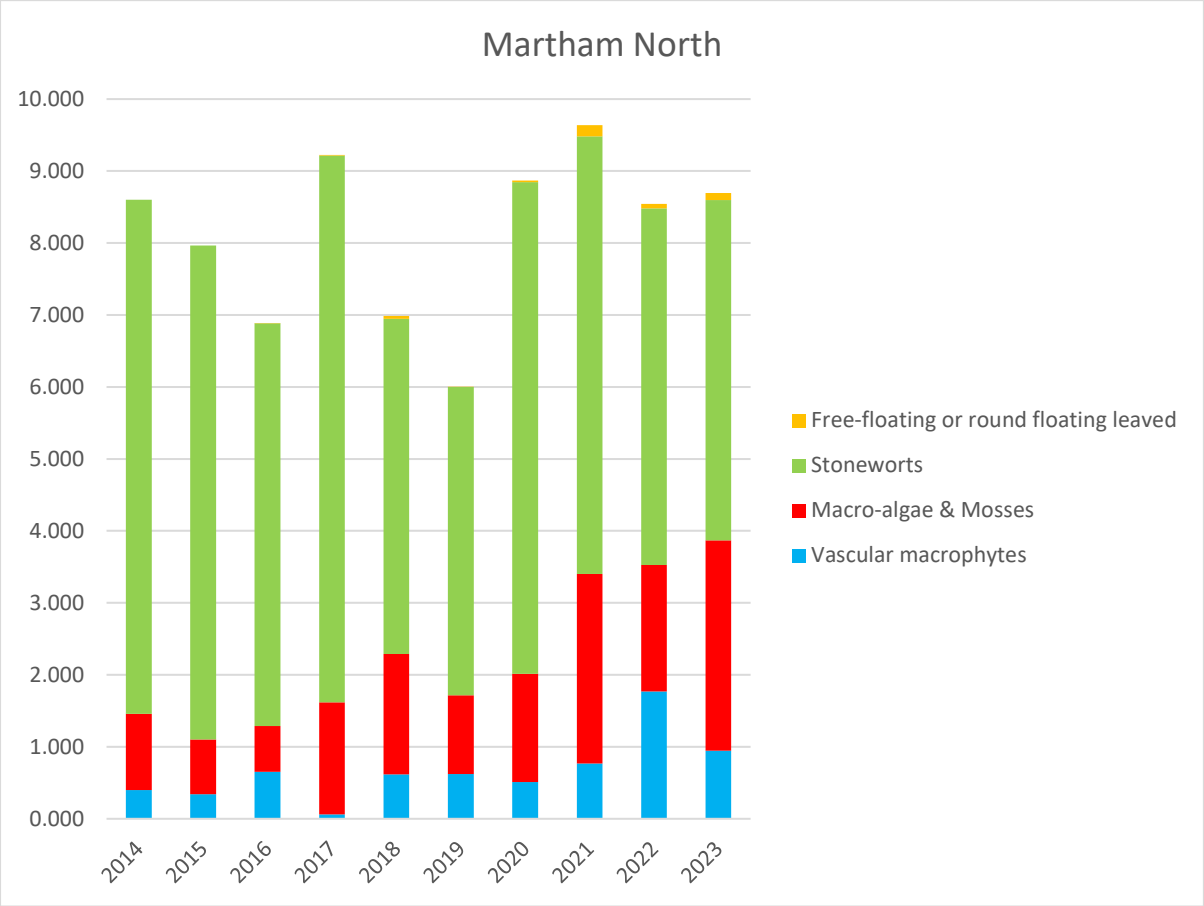
Common Name	Scientific Name	Summary Abundance	Occurrences
Bristly stonewort	*Chara hispida*	2.769	35
Filamentous algae	*Zygnematales*	2.692	27
Intermediate stonewort	*Chara intermedia*	1.558	31
Fennel-leaved pondweed	*Potamogeton pectinatus*	0.577	16
Baltic stonewort	*Chara baltica*	0.385	11
Holly-leaved naiad	*Najas marina*	0.269	8
Common water moss	*Fontinalis antipyretica*	0.231	9
Ivy-leaved duckweed	*Lemna trisulca*	0.096	5
Nuttall's waterweed	*Elodea nuttallii*	0.038	2
Spiked water milfoil	*Myriophyllum spicatum*	0.019	1
Starwort species	*Callitriche sp*	0.019	1
Stonewort (Chara) species	*Chara sp.*	0.019	1

Common Name	Scientific Name	Summary Abundance	Occurrences
Canadian waterweed	*Elodea canadensis*	0.019	1
Yellow water lily	*Nuphar lutea*	0.002	1
Pondweed species	*Potamogeton sp.*	0.002	1
Total number of species recorded		**15**	**Total samples taken: 52**

Species numbers increased this year from 11 to 15. Decreases were seen in the abundance of Bristly stonewort and Fennel-leaved pondweed with Bristly stonewort recording a large decrease from 4.458 to 2.769. The southern end of the broad was difficult to access due to the large amount of Filamentous algae which is reflected in the overall abundance increase from 1.608 to 2.692 with occurrences from 15-27. Intermediate stonewort also increased from 0.229 to 1.558 with occurrences from 6 to 31, with Baltic stonewort also recording a slight increase. Decreases in vascular macrophytes and stoneworts were seen with the biggest increase in filamentous algae.

Graph 6

Martham North Broad summary abundance shown in plant groups (see Appendix 1 for more detail)



Martham South

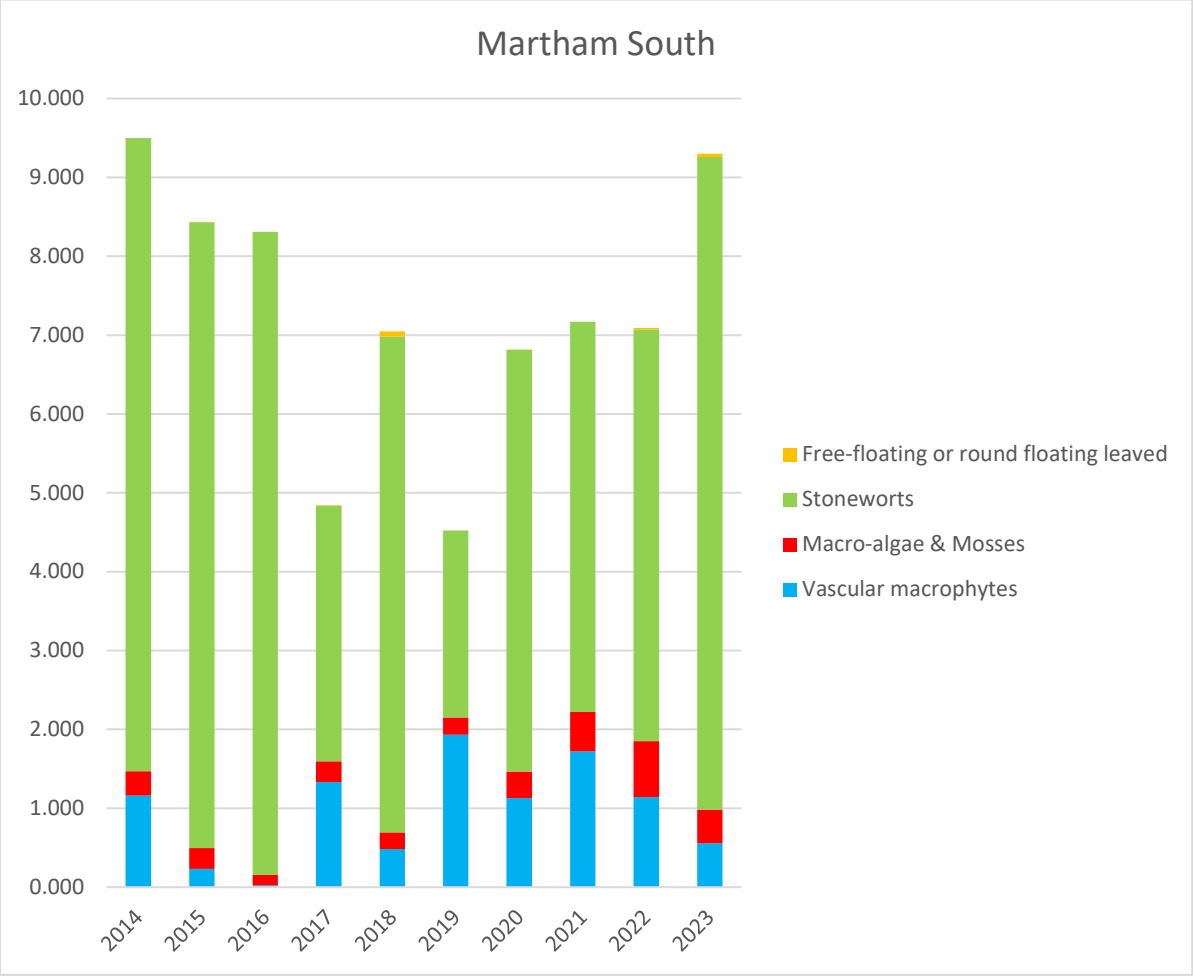
Table 8

Common Name	Scientific Name	Summary Abundance	Occurrences
Bristly stonewort	*Chara hispida*	4.852	44
Intermediate stonewort	*Chara intermedia*	1.870	29
Baltic stonewort	*Chara baltica*	0.463	15
Starry stonewort	*Nitellopsis obtusa*	0.463	9
Hedgehog stonewort	*Chara aculeolata*	0.389	4
Holly-leaved naiad	*Najas marina*	0.241	8
Common water moss	*Fontinalis antipyretica*	0.222	5
Filamentous algae	*Zygnematales*	0.185	2
Fennel-leaved pondweed	*Potamogeton pectinatus*	0.148	8
Spiked water milfoil	*Myriophyllum spicatum*	0.130	7
Fragile/convergent stonewort	*Chara globularis/connivens*	0.130	4
Rough stonewort	*Chara aspera*	0.074	4
Ivy-leaved duckweed	*Lemna trisulca*	0.037	2
Mare's tail	*Hippuris vulgaris*	0.037	1
Convergent stonewort	*Chara connivens*	0.019	1
Lesser bearded stonewort	*Chara curta*	0.019	1
Jelly algae	*Nostoc*	0.019	1
Stonewort (Chara) species	*Chara sp.*	0.002	1
Total number of species recorded		**18**	**Total samples taken: 54**

Martham South Broad has seen quite a large increase overall this year. Bristly stonewort, Intermediate stonewort, Starry stonewort and Hedgehog stonewort recorded increases in abundance. Overall, the proportion of vascular macrophytes decreased whereas stoneworts increased by over 2 points in the summary abundance score. Stoneworts also increased in species number from 8 to 9 from 2022. Decreases were seen in Baltic stonewort, Holly-leaved naiad, Spiked water milfoil and Filamentous algae.

Graph 7

Martham South Broad summary abundance shown in plant groups (see Appendix 1 for more detail)



Ant Valley

In the Ant Valley, Alderfen, Cromes and Barton Broad were some of the first broads to be surveyed, starting in 1983 and have been regularly surveyed since. These water bodies have been subject to extensive restoration effort over the last 25 years and have all experienced improvements to water quality.

2023 Summary

2023 has seen Alderfen, Cromes and Barton Broad increase in overall abundance. Buttle Pools and Reedham water both show high levels of plant abundance.

Alderfen

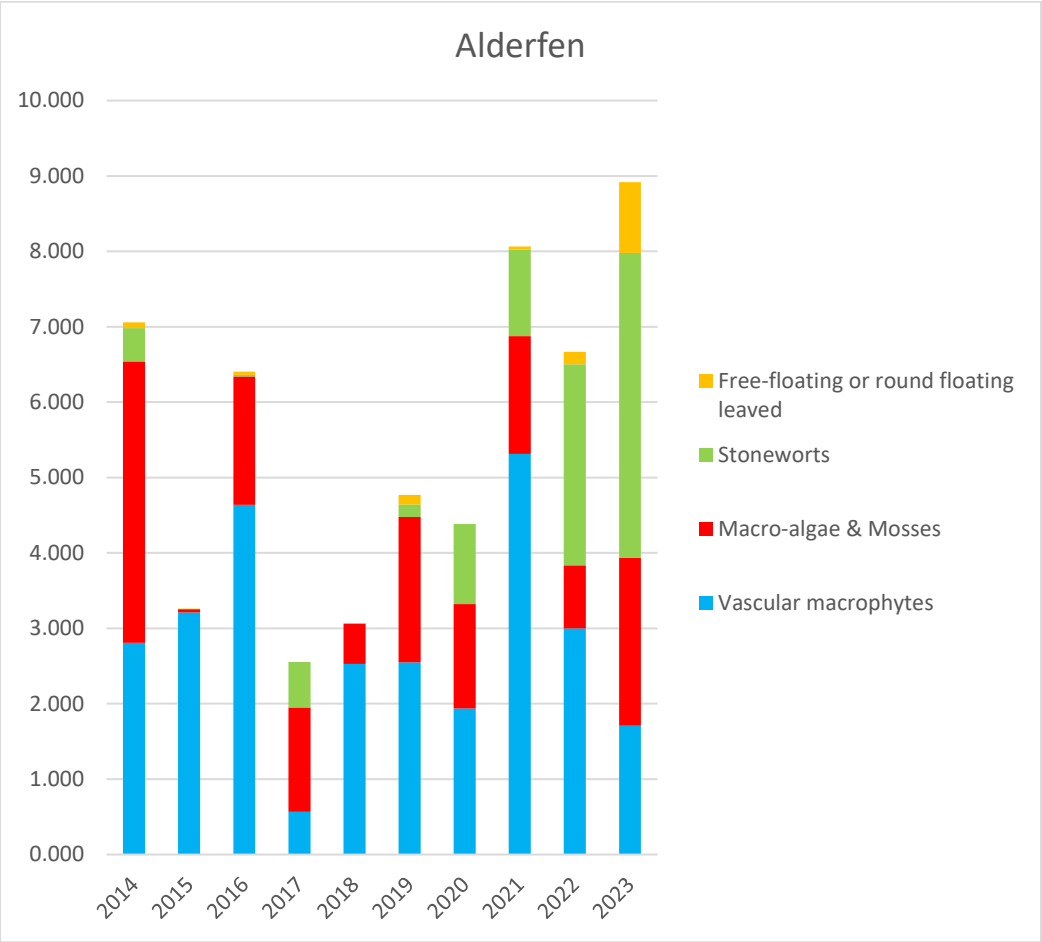
Table 9

Common Name	Scientific Name	Summary Abundance	Occurrences
Delicate stonewort	*Chara virgata*	4.042	35
Filamentous algae	*Zygnematales*	1.667	24
Ivy-leaved duckweed	*Lemna trisulca*	0.938	26
Rigid hornwort	*Ceratophyllum demersum*	0.896	31
Holly-leaved naiad	*Najas marina*	0.813	15
Jelly algae	*Nostoc*	0.563	27
Total number of species recorded		**6**	**Total samples taken: 48**

Alderfen has seen an overall increase in summary abundance this year recording its highest score in the last 10 years. Delicate stonewort increased (2.667 to 4.042) along with Filamentous algae and Ivy-leaved duckweed, whereas Holly-leaved naiad and Rigid hornwort decreased. The increase in stoneworts, macro-algae and mosses and free floating or round floating leaved plants accounts for the up-turn in summary abundance. The overall species count decreased from 10 to 6 this year and jelly algae was seen at more points, increasing from 3 to 27.

Graph 8

Alderfen Broad summary abundance shown in plant groups (see Appendix 1 for more detail)



Barton Broad

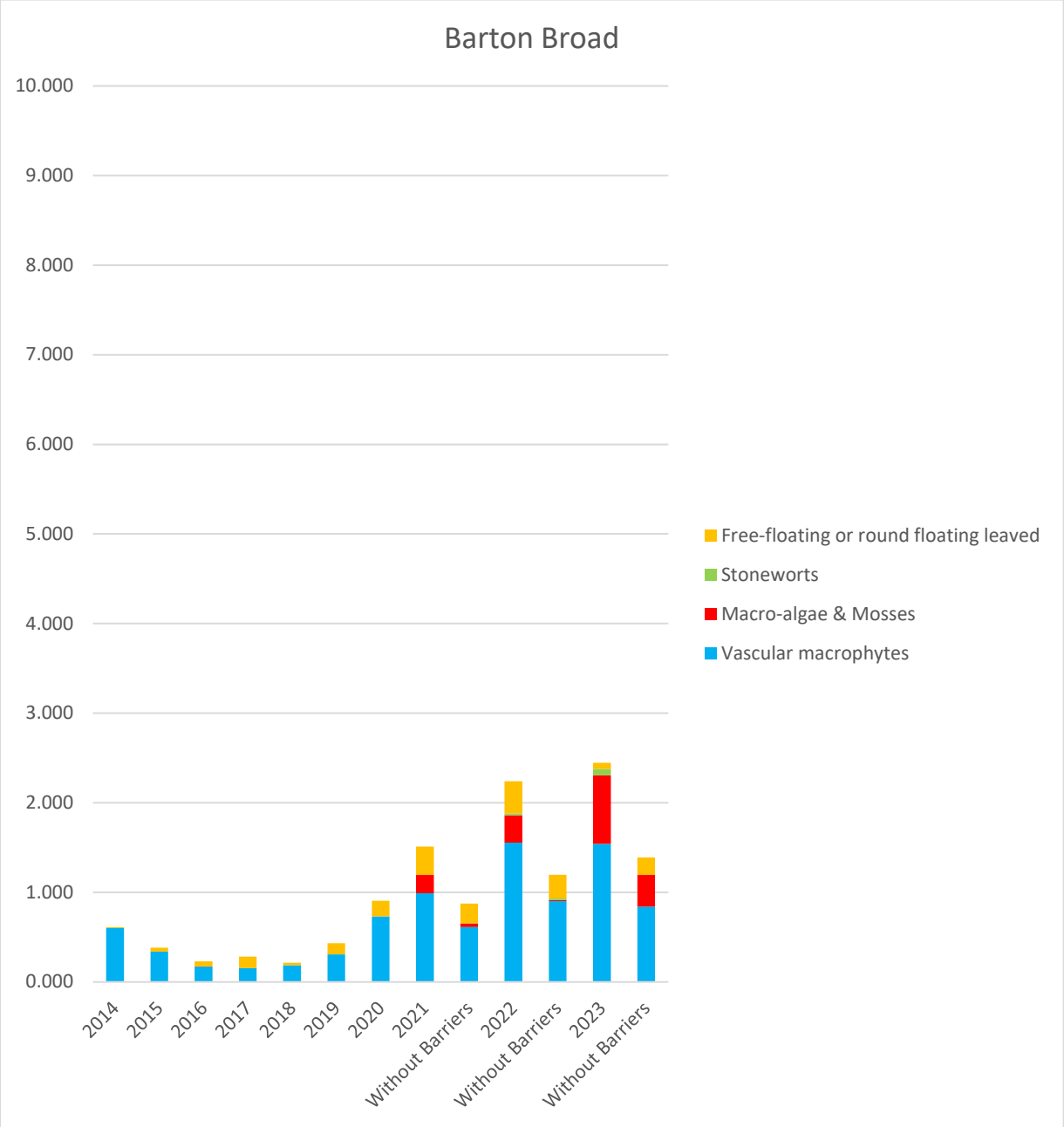
Table 10

Common Name	Scientific Name	Summary Abundance	Occurrences
Filamentous algae	*Zygnematales*	0.747	30
Rigid hornwort	*Ceratophyllum demersum*	0.516	40
Nuttall's waterweed	*Elodea nuttallii*	0.418	32
Unbranched bur-reed	*Sparganium emersum*	0.221	19
Fennel-leaved pondweed	*Potamogeton pectinatus*	0.198	23
Long-stalked Pondweed	*Potamogeton praelongus*	0.090	10
Pointed stonewort	*Nitella mucronata*	0.074	9
Ivy-leaved duckweed	*Lemna trisulca*	0.034	5
Starwort species	*Callitriche sp*	0.033	4
Arrowhead	*Saggitaria sagittifolia*	0.033	2
Enteromorpha	*Enteromorpha*	0.016	2
Common duckweed	*Lemna minor*	0.016	2
Perfoliate pondweed	*Potamogeton perfoliatus*	0.016	1
Greater duckweed	*Spirodela polyrhiza*	0.016	2
Shining pondweed	*Potamogeton lucens*	0.008	1
Fan-leaved water crowfoot	*Ranunculus circinatus*	0.008	1
No plants	*No plants*	0.000	50
Total number of species recorded		**1**	**Total samples taken: 72**

Barton Broad recorded all four major plant groups this year. Four freshwater mussel species were observed including duck, swan, painters and zebra mussels. The increase seen this year can mostly be attributed to increases in macro-algae and mosses, stoneworts and free floating or round floating leaved macrophytes. An increase in plant species from 13 to 16 was seen. The species abundance is the highest seen since the new survey method commenced, despite there also being 50 survey points with no plants. Unbranched bur-reed, Long-stalked Pondweed and Pointed stonewort were recorded this year. The graph shows the 2023 plant data with and without the survey points that are located within the fish exclusion barriers. The barriers were installed in 2019 after the plant survey was undertaken and in 2020, only outside the barriers was surveyed due to Covid limitations.

Graph 9

Barton Broad summary abundance shown in plant groups (see Appendix 1 for more detail)



Buttle Pools

Table 11 - Pool 1

Common Name	Scientific Name	Summary Abundance	Occurrences
Lesser pondweed	*Potamogeton pusillus*	0.906	28
Fennel-leaved pondweed	*Potamogeton pectinatus*	0.688	22
Nuttall's waterweed	*Elodea nuttallii*	0.438	14
Delicate stonewort	*Chara virgata*	0.094	3
Opposite stonewort	*Chara contraria*	0.063	2
Common water moss	*Fontinalis antipyretica*	0.031	1
Broad –leaved pondweed	*Potamogeton natans*	0.031	1
Fan-leaved water crowfoot	*Ranunculus circinatus*	0.031	1
Total number of species recorded		**8**	**Total samples taken: 32**

Table 12 - Pool 4

Common Name	Scientific Name	Summary Abundance	Occurrences
Fennel-leaved pondweed	*Potamogeton pectinatus*	0.607	17
Broad –leaved pondweed	*Potamogeton natans*	0.250	2
Common stonewort	*Chara vulgaris*	0.214	6
Unbranched bur-reed	*Sparganium emersum*	0.179	3
Filamentous algae	*Zygnematales*	0.143	4
Lesser pondweed	*Potamogeton pusillus*	0.036	1
No plants	*No plants*	0.000	5
Total number of species recorded		**7**	**Total samples taken: 28**

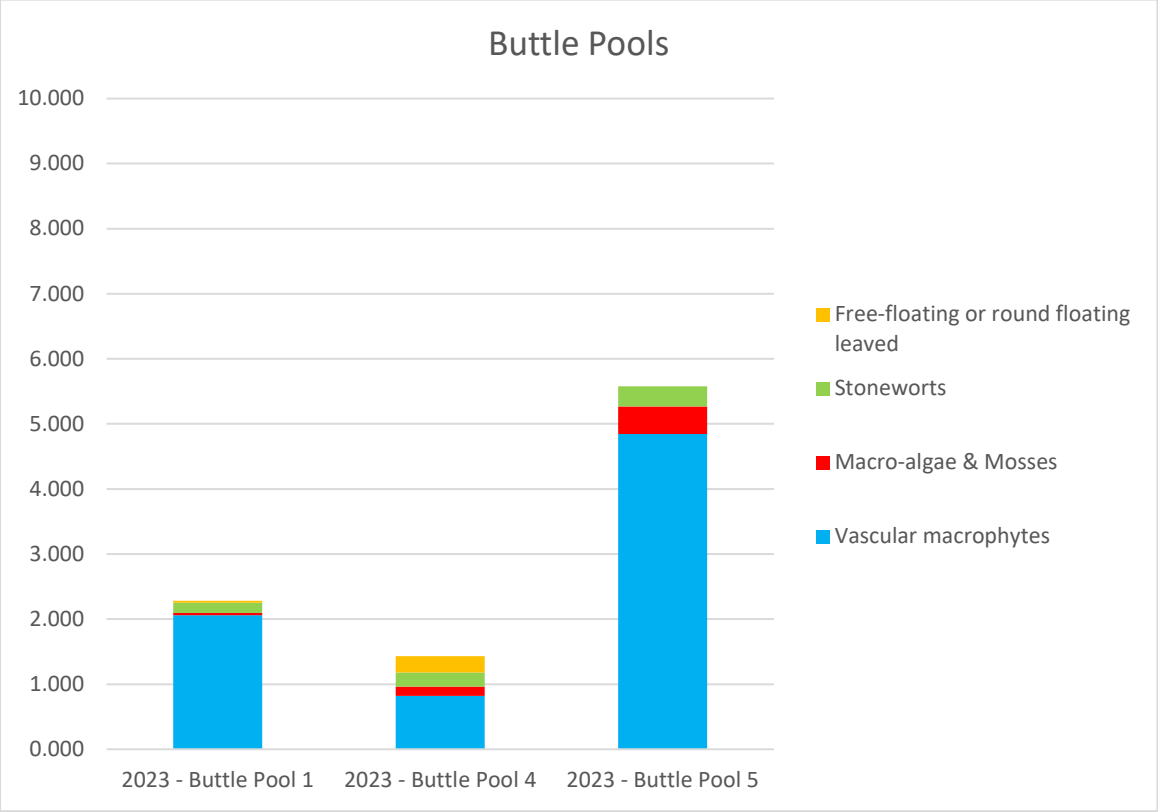
Table 13 - Pool 5

Common Name	Scientific Name	Summary Abundance	Occurrences
Fennel-leaved pondweed	*Potamogeton pectinatus*	4.500	26
Common stonewort	*Chara vulgaris*	0.269	7
Filamentous algae	*Zygnematales*	0.269	7
Jelly algae	*Nostoc*	0.154	4
Arrowhead	*Saggitaria sagittifolia*	0.115	3
Canadian waterweed	*Elodea canadensis*	0.077	2
Curled pondweed	*Potamogeton crispus*	0.077	2
Delicate stonewort	*Chara virgata*	0.038	1
Rigid hornwort	*Ceratophyllum demersum*	0.038	1
Nuttall's waterweed	*Elodea nuttallii*	0.038	1
Total number of species recorded		**10**	**Total samples taken: 26**

This is the first time the pools have been surveyed since the grazing meadows of Buttle were left to re-wild and the scrapes were created in **2006**. Fennel-leaved pond weed is dominant in two of the pools (4&5) and Lesser pondweed is dominant in pool 1. Stoneworts were found in all three pools and Filamentous algae was only recorded at 7 points.

Graph 10

Buttle Pools summary abundance shown in plant groups (see Appendix 1 for more detail)



Cromes Broad

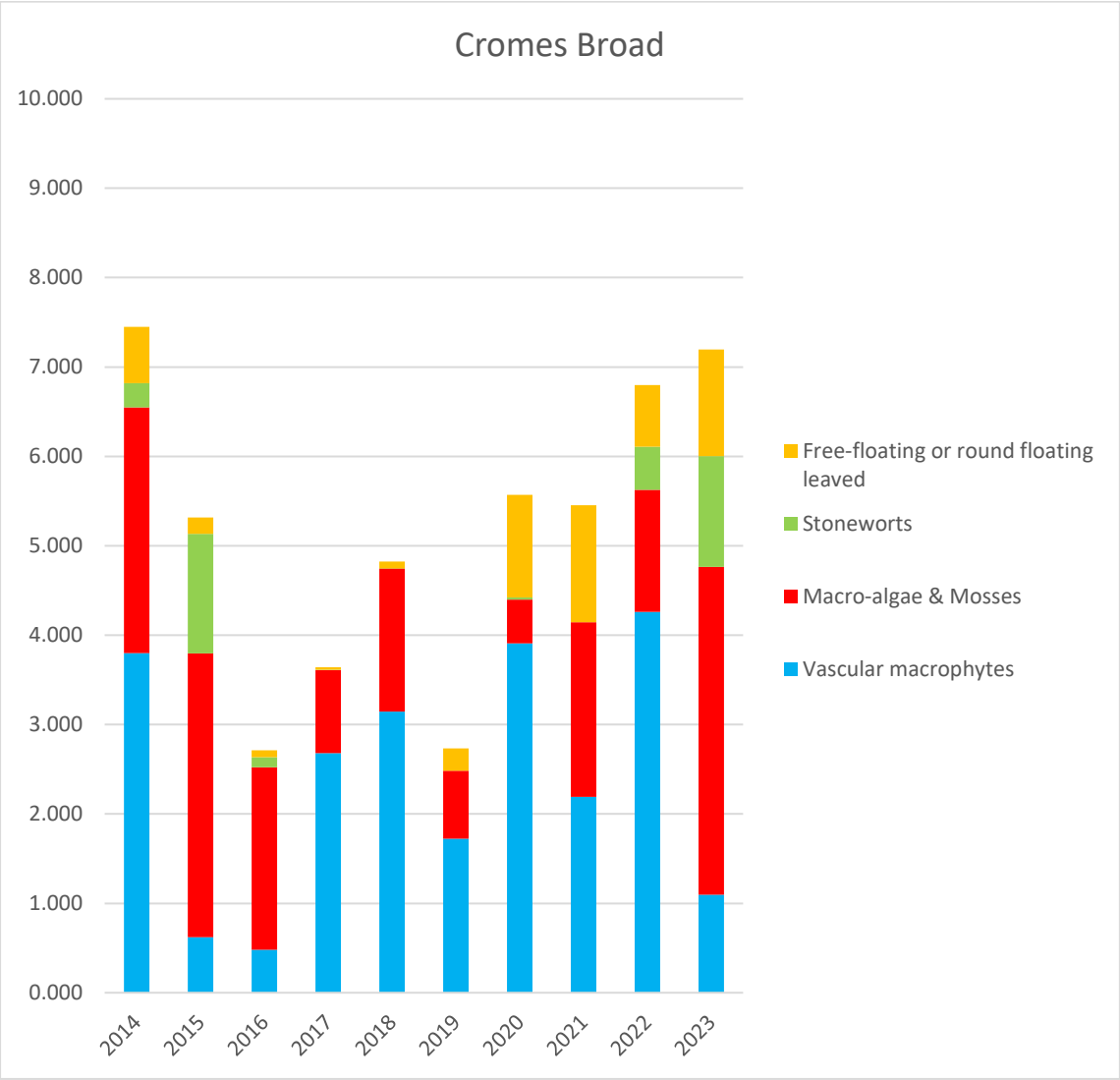
Table 14

Common Name	Scientific Name	Summary Abundance	Occurrences
Filamentous algae	*Zygnematales*	3.598	36
Delicate stonewort	*Chara virgata*	1.214	13
White water lily	*Nymphaea alba*	0.905	7
Rigid hornwort	*Ceratophyllum demersum*	0.786	27
Holly-leaved naiad	*Najas marina*	0.238	9
Ivy-leaved duckweed	*Lemna trisulca*	0.238	10
Greater duckweed	*Spirodela polyrhiza*	0.026	2
Nuttall's waterweed	*Elodea nuttallii*	0.024	1
Fragile/convergent stonewort	*Chara globularis/connivens*	0.024	1
Enteromorpha	*Enteromorpha*	0.024	1
Water net	*Hydrodictyon*	0.024	1
Least duckweed	*Lemna minuta*	0.024	1
Jelly algae	*Nostoc*	0.024	1
Lesser reedmace	*Typha angustifolia*	0.024	1
Total number of species recorded		**16**	**Total samples taken: 44**

There was a noticeable decrease in vascular plants within Cromes Broad this year, mostly Rigid hornwort and Holly-leaved naiad. Rigid hornwort decreased in occurrences from 33 to 27, and, abundance reduced from 2.186 to 0.786. Holly-leaved naiad abundance decreased from 1.823 to 0.238. Filamentous algae increased substantially from 1.364 to 3.598 along with White water lily, 0.409 to 0.905 and Delicate stonewort from 0.482 to 1.214. Of particular note was the increase in Filamentous algae although the algae was mainly submerged rather than on the surface as in other years. Delicate stonewort was recorded this year with higher abundance but at lower occurrence. Bladderwort was also seen in six spots and a swan mussel was found during the survey.

Graph 11

Cromes Broad summary abundance shown in plant groups (see Appendix 1 for more detail)



Reedham Water

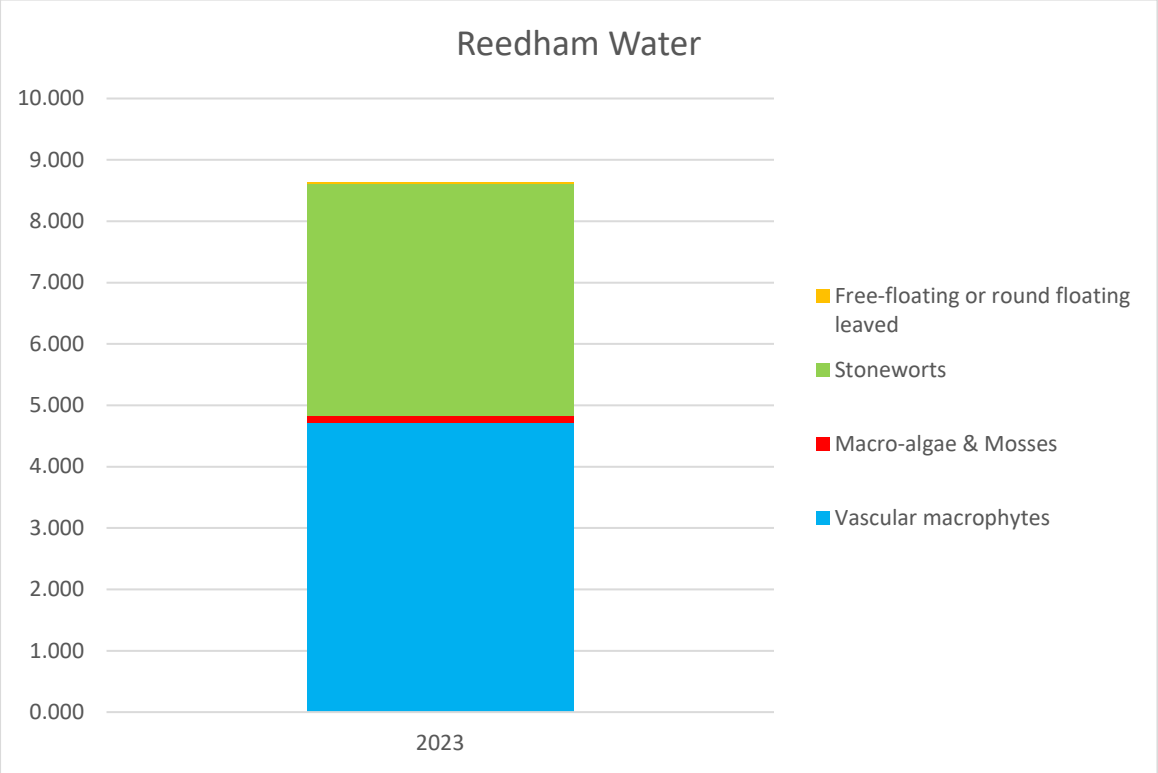
Table 15

Common Name	Scientific Name	Summary Abundance	Occurrences
Holly-leaved naiad	*Najas marina*	3.696	41
Common stonewort	*Chara vulgaris*	2.630	27
Delicate stonewort	*Chara virgata*	0.674	21
Rigid hornwort	*Ceratophyllum demersum*	0.478	22
Fennel-leaved pondweed	*Potamogeton pectinatus*	0.457	19
Fragile/convergent stonewort	*Chara globularis/connivens*	0.457	10
Lesser pondweed	*Potamogeton pusillus*	0.043	2
Filamentous algae	*Zygnematales*	0.022	1
Ivy-leaved duckweed	*Lemna trisulca*	0.022	1
Fragile stonewort	*Chara globularis*	0.022	1
Enteromorpha	*Enteromorpha*	0.022	1
Flat-stalked pondweed	*Potamogeton friesii*	0.022	1
Horned pondweed	*Zannichellia palustris*	0.022	1
No plants	*No plants*	0.000	2
Total number of species recorded		**13**	**Total samples taken: 46**

When this water body was last surveyed in 2009, only four macrophyte species (Enteromorpha, Fliamentous algae, Lesser pond weed and Rigid hornwort) were found whereas in 2023, 13 were found. Holly-leaved naiad was found at most of the points and a new species for this site. Other records included Common, Delicate and Fragile/Convergent stonewort, Rigid hornwort and Fennel-leaved pondweed. Even though water birds use this area, macrophyte growth is strong here now.

Graph 12

Reedham Water summary abundance shown in plant groups (see Appendix 1 for more detail)



Bure Valley

In recent years, Upton and Cockshoot Broads, both isolated from the river, have been a stronghold for the rare Holly-leaved naiad. Conversely, those broads directly connected to the river, such as Wroxham and Hoveton Great, have tended to have minimal plant diversity. However this year, most of the broads connected to the Bure River (which we have past data for) have seen an increase in summary abundance.

Bridge Broad

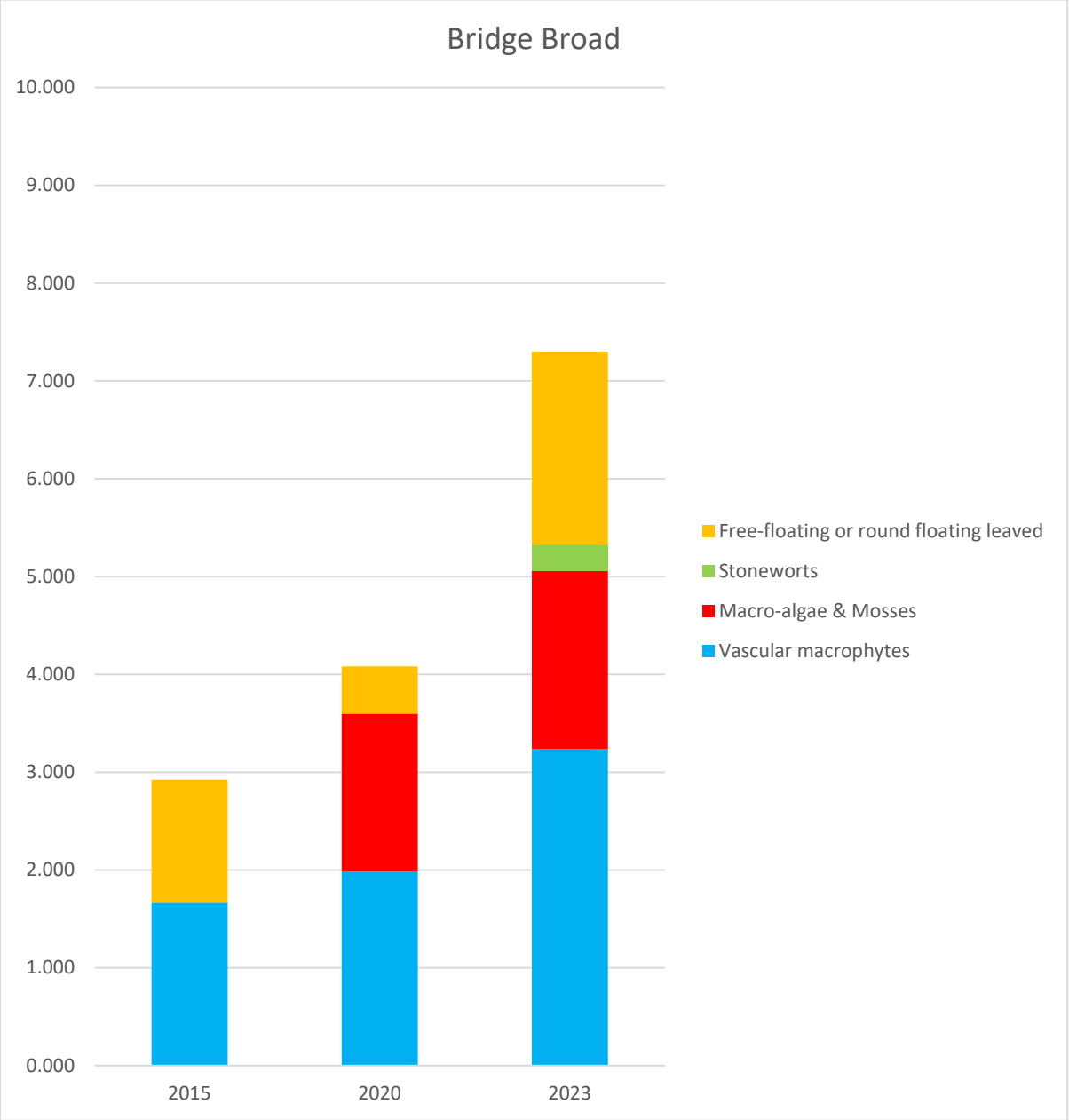
Table 16

Common Name	Scientific Name	Summary Abundance	Occurrences
Filamentous algae	*Zygnematales*	1.765	25
Yellow water lily	*Nuphar lutea*	1.738	17
Nuttall's waterweed	*Elodea nuttallii*	1.294	25
Unbranched bur-reed	*Sparganium emersum*	0.794	19
Rigid hornwort	*Ceratophyllum demersum*	0.647	14
Long-stalked Pondweed	*Potamogeton praelongus*	0.324	10
Pointed stonewort	*Nitella mucronata*	0.265	9
Ivy-leaved duckweed	*Lemna trisulca*	0.121	5
Starwort species	*Callitriche sp*	0.118	4
Arrowhead	*Saggitaria sagittifolia*	0.118	2
Enteromorpha	*Enteromorpha*	0.059	2
Common duckweed	*Lemna minor*	0.059	2
Perfoliate pondweed	*Potamogeton perfoliatus*	0.059	1
Greater duckweed	*Spirodela polyrhiza*	0.059	2
Fresh water sponge	*Spongillidae*	0.029	1
Total number of species recorded		**15**	**Total samples taken: 36**

The top three species have all increased since 2020. Filamentous algae increased from 1.529 to 1.765 , Yellow water lily from 0.394 to 1.738 and Nuttall's waterweed from 0.629 to 1.294. Free floating or round floating leaves, vascular and stoneworts groups increased and species number increased from 11 to 14. Freshwater sponge was also recorded.

Graph 13

Bridge Broad summary abundance shown in plant groups (see Appendix 1 for more detail)



Cockshoot

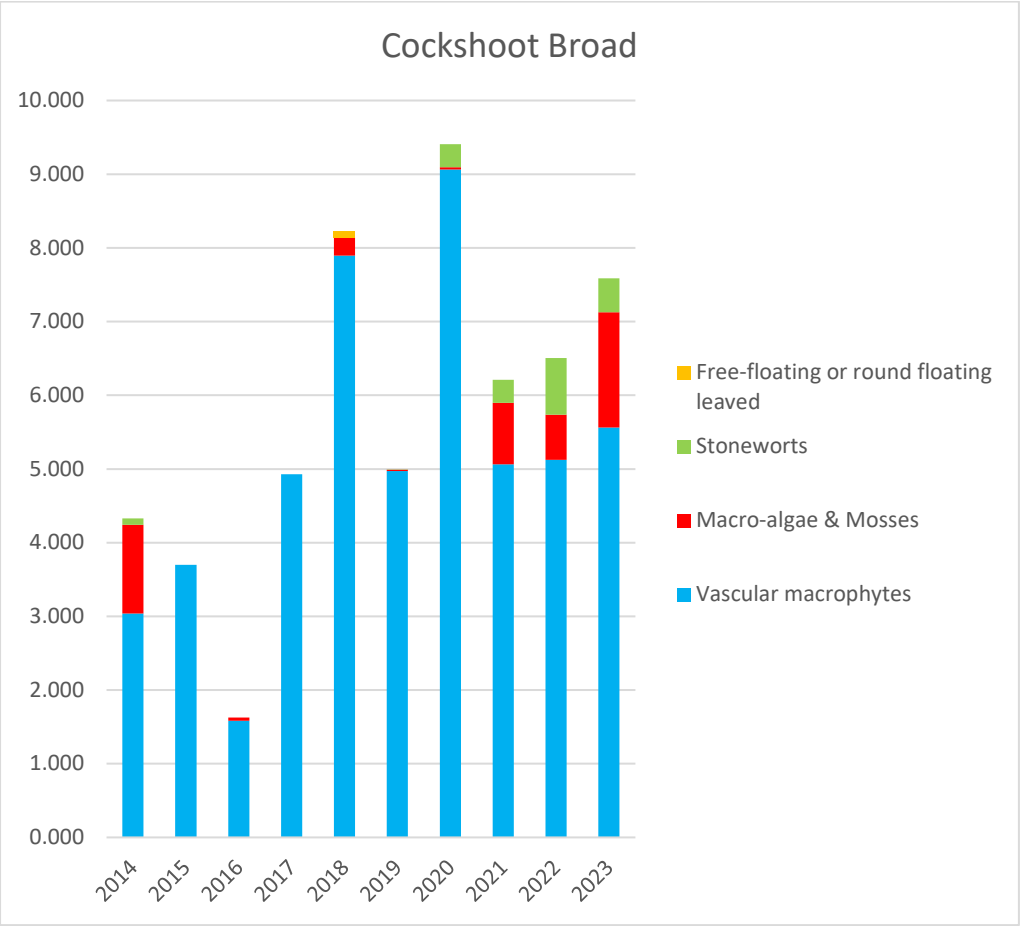
Table 17

Common Name	Scientific Name	Summary Abundance	Occurrences
Holly-leaved naiad	*Najas marina*	3.646	42
Rigid hornwort	*Ceratophyllum demersum*	1.604	43
Filamentous algae	*Zygnematales*	0.940	39
Enteromorpha	*Enteromorpha*	0.583	23
Fragile/convergent stonewort	*Chara globularis/connivens*	0.354	16
Common stonewort	*Chara vulgaris*	0.146	7
Canadian waterweed	*Elodea canadensis*	0.146	7
Fresh water sponge	*Spongillidae*	0.104	5
Delicate stonewort	*Chara virgata*	0.083	4
Water net	*Hydrodictyon*	0.042	2
Nuttall's waterweed	*Elodea nuttallii*	0.021	1
(blank)	*(blank)*	0.021	1
Stonewort (Chara) species	*Chara sp.*	0.021	1
No plants	*No plants*	0.000	1
Total number of species recorded		**9**	**Total samples taken: 48**

This year, Cockshoot has seen increases in vascular macrophytes and macro algae & mosses. Rigid hornwort increased from 0.917 to 1.604 and Filamentous algae from 0.517 to 0.940. Holly-leaved naiad decreased from 4.167 to 3.646 over a similar number of occurrences. Common stonewort decreased from 14 to 7 occurrences and overall stonewort occurrence has stayed similar to 2022 numbers.

Graph 14

Cockshoot Broad summary abundance shown in plant groups (see Appendix 1 for more detail)



Hoveton Great Broad

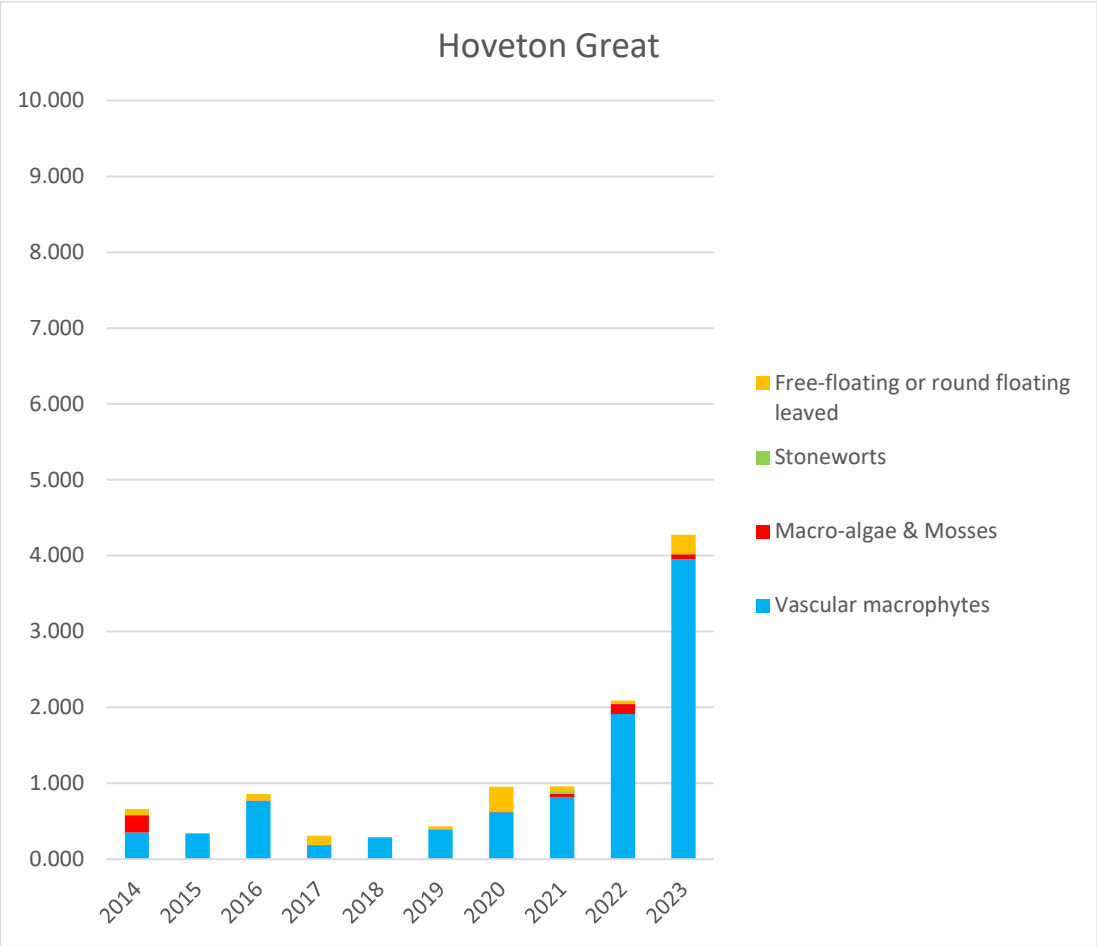
Table 18

Common Name	Scientific Name	Summary Abundance	Occurrences
Fennel-leaved pondweed	*Potamogeton pectinatus*	1.694	27
Rigid hornwort	*Ceratophyllum demersum*	1.034	33
Nuttall's waterweed	*Elodea nuttallii*	0.984	34
Yellow water lily	*Nuphar lutea*	0.258	3
Curled pondweed	*Potamogeton crispus*	0.210	5
Filamentous algae	*Zygnematales*	0.066	5
Canadian waterweed	*Elodea canadensis*	0.032	2
No plants	*No plants*	0.000	16
Total number of species recorded		**7**	**Total samples taken: 62**

Vascular plants doubled again this year with Fennel-leaved pondweed (0.173 to 1.694), Rigid hornwort (0.659 to 1.034) and Nuttall's water weed (0.892 to 0.984) being the prominent species. This is the highest summary abundance seen in the last 10 years and follows the general improving trend of the broads connected to the River Bure. Four mussel species were found including Duck, Painters, Swan and Zebra throughout the survey and an Asiatic clam. There are a few key places such as the eastern edge of the Broad near the new reedbed installations which continue to show encouraging signs of plants establishing in the area. Plants were seen at the surface of the water which is not usual for the broad, although the edges of the broad are still where the plants are found the vast majority of the time, with the centre points remaining largely plant free.

Graph 15

Hoveton Great Broad summary abundance shown in plant groups (see Appendix 1 for more detail)



Hudson's Bay

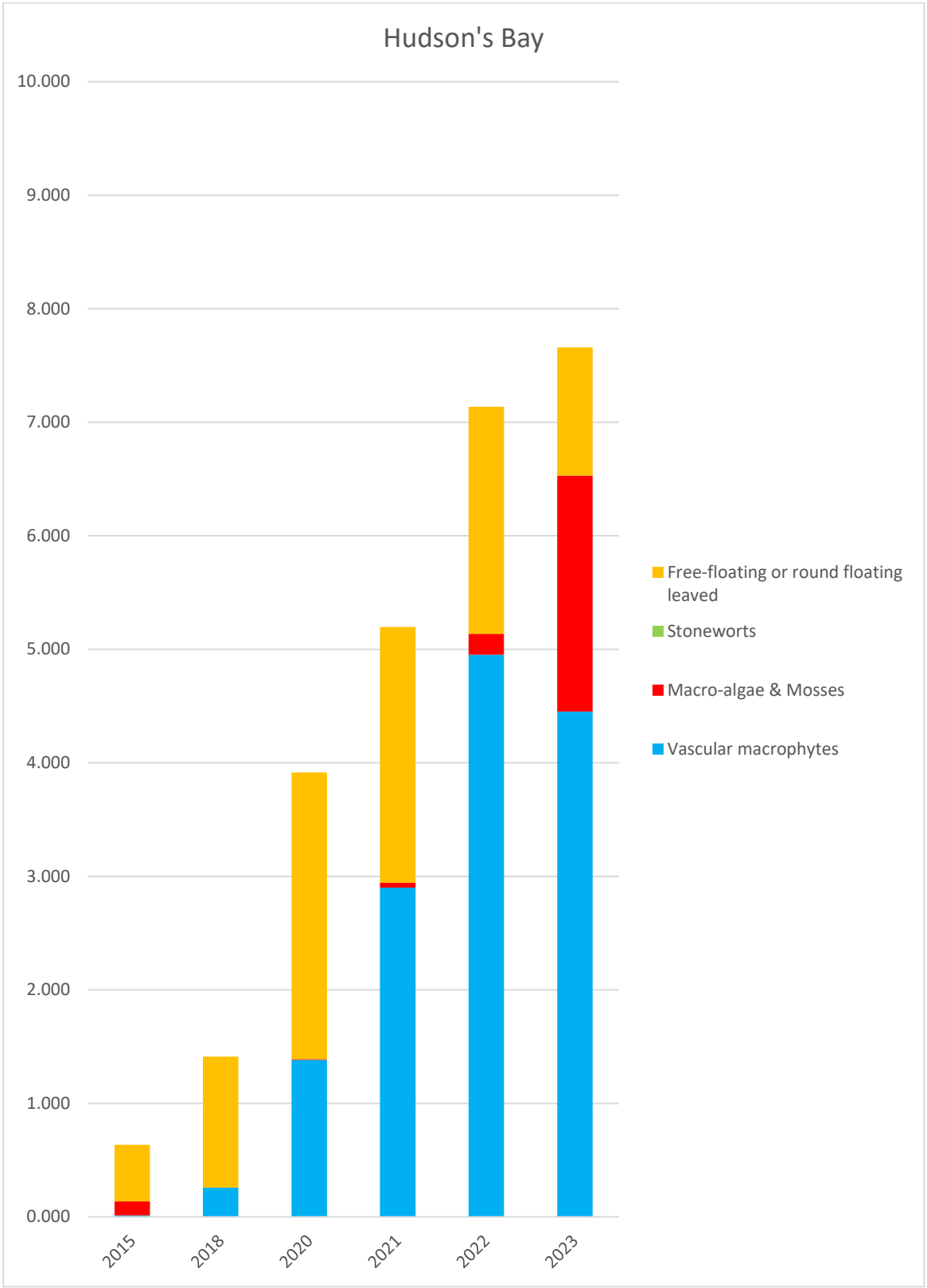
Table 19

Common Name	Scientific Name	Summary Abundance	Occurrences
Rigid hornwort	*Ceratophyllum demersum*	4.228	40
Filamentous algae	*Zygnematales*	0.700	31
Water net	*Hydrodictyon*	0.678	14
Enteromorpha	*Enteromorpha*	0.625	30
White water lily	*Nymphaea alba*	0.550	3
Yellow water lily	*Nuphar lutea*	0.425	11
Fennel-leaved pondweed	*Potamogeton pectinatus*	0.175	5
Common duckweed	*Lemna minor*	0.105	6
Jelly algae	*Nostoc*	0.075	3
Canadian waterweed	*Elodea canadensis*	0.050	2
Frogbit	*Hydrocharis morsus-ranae*	0.025	1
Greater duckweed	*Spirodela polyrhiza*	0.025	1
Total number of species recorded		**12 (from 5 in 2022)**	**Total samples taken: 40**

Hudson's Bay has recorded another increase in 2023 with summary abundance from below one in 2015 to above 7.6 this year. Filamentous algae increased from 0.183 to 0.700, which makes up the majority of the marked increase in macro algae and mosses in 2023. Rigid hornwort is the notable species for 2023, although it has decreased from 4.953 to 4.228 in summary abundance this year. One species of mussels was present in the survey which was a Duck mussel and only found at one point. Freshwater sponge was also observed. There were plants at every survey point.

Graph 16

Hudson's Bay summary abundance shown in plant groups (see Appendix 1 for more detail)



South Walsham Broad

Although the connecting dykes had notable signs of water lilies and common reed was growing around the edges there were no macrophytes found in the Broad at all. There were many birds using the site for feeding.

Upton Great Broad

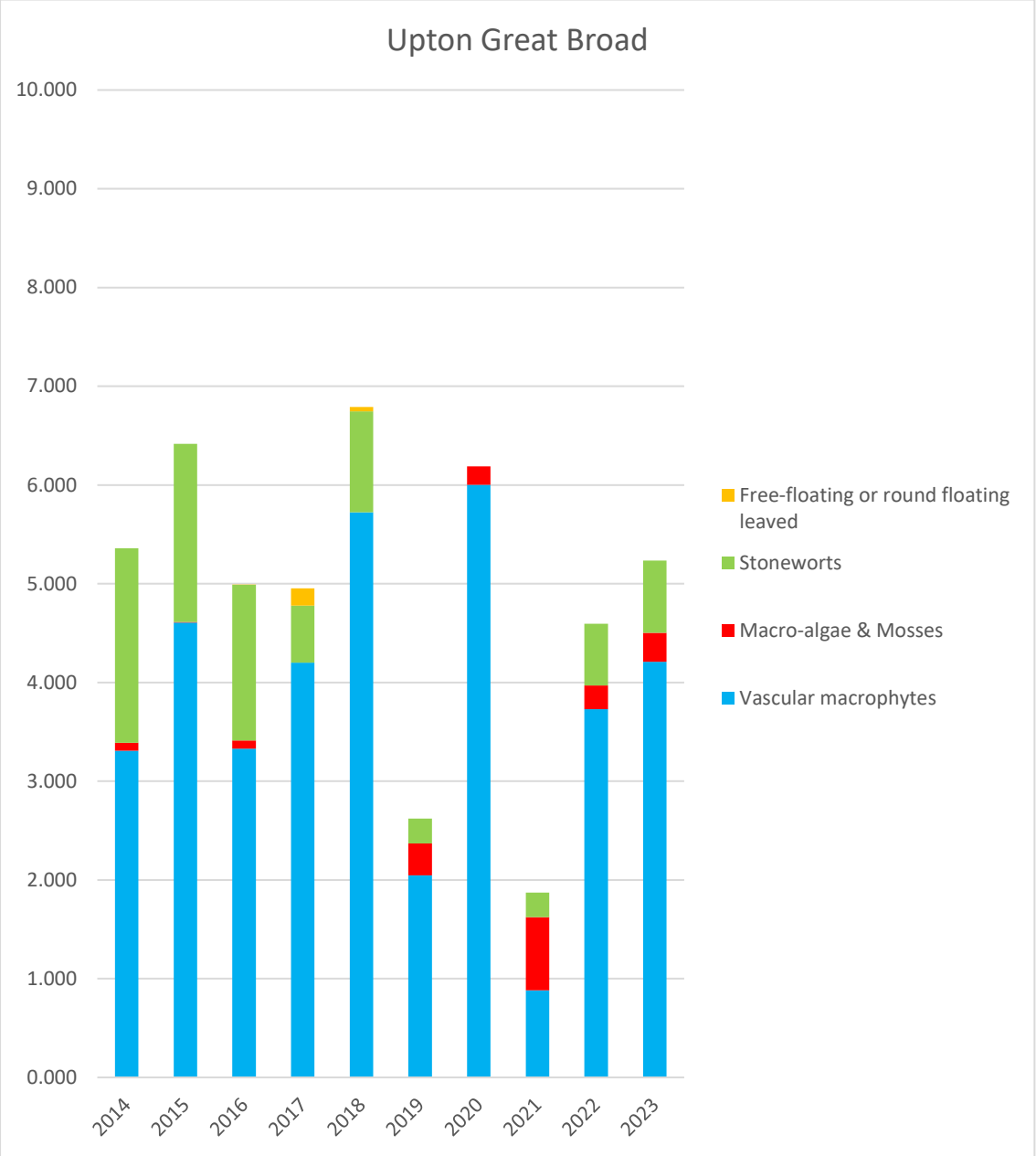
Table 20

Common Name	Scientific Name	Summary Abundance	Occurrences
Holly-leaved naiad	*Najas marina*	4.208	27
Bristly stonewort	*Chara hispida*	0.521	4
Filamentous algae	*Zygnematales*	0.294	15
Opposite stonewort	*Chara contraria*	0.188	8
Convergent stonewort	*Chara connivens*	0.023	2
No plants	*No plants*	0.000	4
Total number of species recorded		**6**	**Total samples taken: 48**

This year Holly-leaved naiad recovered to previous levels with an increase from 3.729 to 4.208. Bristly stonewort also increased from 0.333 to 0.521 and Opposite and Convergent were recorded this year. Filamentous algae increased from 0.242 to 0.294 and 'no plants' occurrences went from 1 to 4.

Graph 17

Upton Great Broad summary abundance shown in plant groups (see Appendix 1 for more detail)



Wroxham Broad

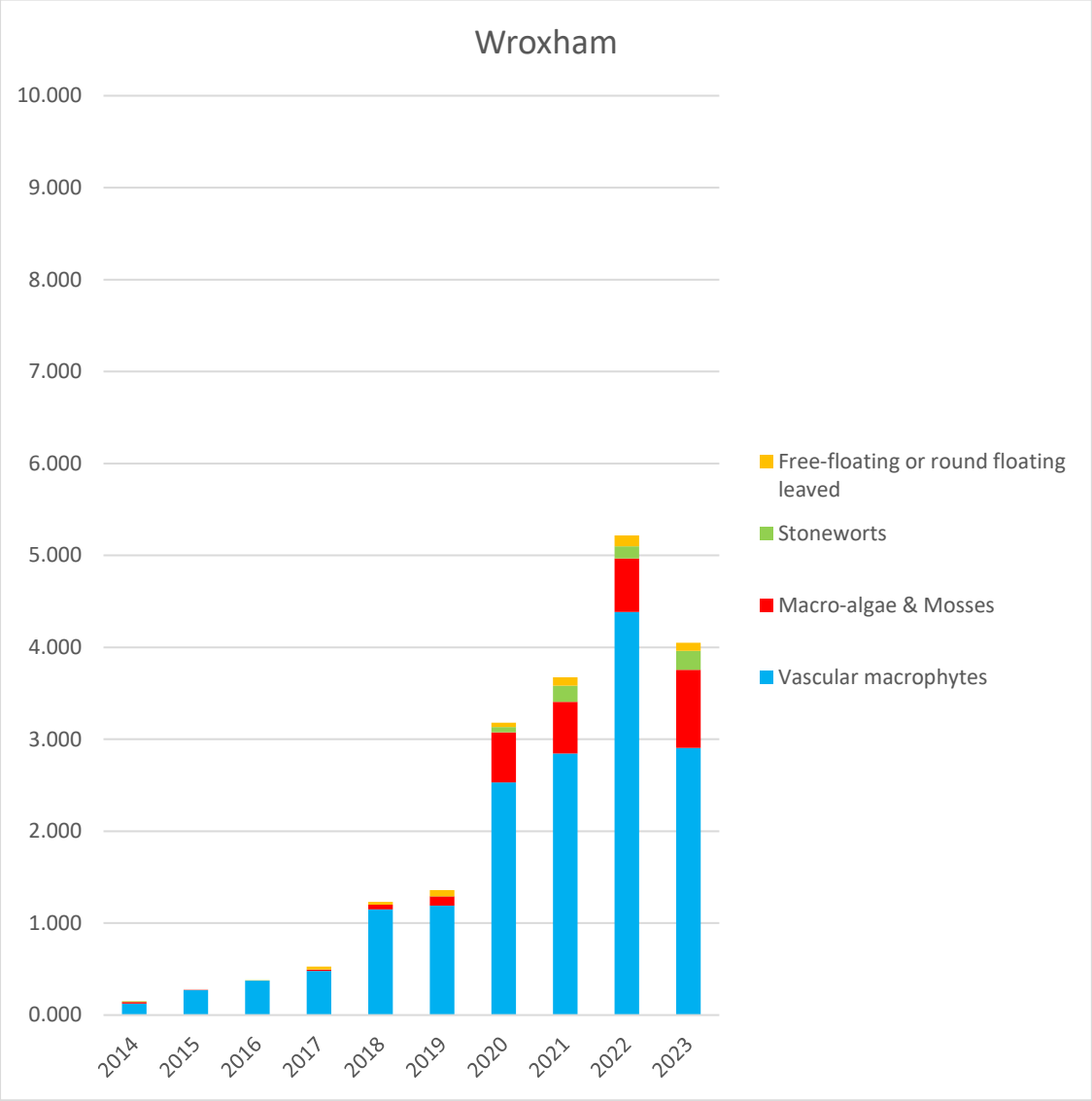
Table 21

Common Name	Scientific Name	Summary Abundance	Occurrences
Rigid hornwort	*Ceratophyllum demersum*	1.547	58
Nuttall's waterweed	*Elodea nuttallii*	0.932	45
Filamentous algae	*Zygnematales*	0.849	61
Fennel-leaved pondweed	*Potamogeton pectinatus*	0.310	17
Pointed stonewort	*Nitella mucronata*	0.191	13
Yellow water lily	*Nuphar lutea*	0.088	4
Spiked water milfoil	*Myriophyllum spicatum*	0.074	5
Starwort species	*Callitriche sp*	0.029	2
Stonewort (Nitella) species	*Nitella sp.*	0.015	1
Unbranched bur-reed	*Sparganium emersum*	0.015	1
Total number of species recorded		**12**	**Total samples taken: 68**

The water was clear during the survey in 2023 and the overall water plant abundance is high even though abundance has decreased from last year. The species number found in Wroxham Broad this year was the same as 2022. The only increases were seen in Filamentous algae (0.582 to 0.849) and Pointed stone wort (0.132 to 0.191). Three mussels were found including Duck, Painters, Zebra and an Asiatic clam.

Graph 18

Wroxham Broad summary abundance shown in plant groups (see Appendix 1 for more detail)



Yare Valley

The majority of the broads within the Yare valley are isolated from the main river, with only Bargate, Rockland and Wheatfen having a direct hydrological connection. The Yare valley survey also includes two water bodies which are not a true 'broad'; a manmade lake created from flooded peat diggings, or 'decoy', a lake created for wildfowl shooting. Whitlingham Great and Little are created from gravel extraction and are quite young compared to other open water bodies.

2022 Summary

There were four broads surveyed this year in this river valley, they are Bargate Broad, Buckenham Broad, Hassingham Broad and Rockland Broad.

Bargate Broad

Table 22

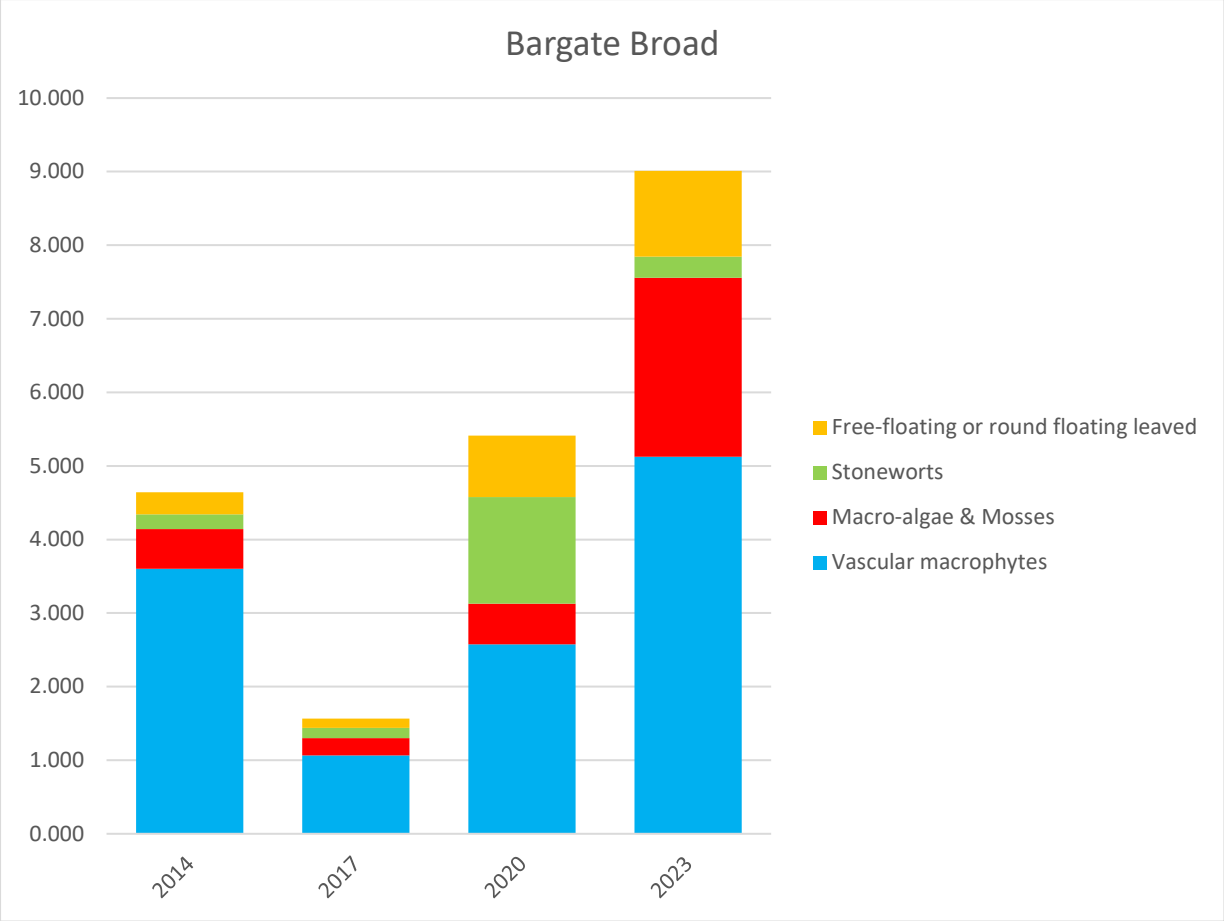
Common Name	Scientific Name	Summary Abundance	Occurrences
Filamentous algae	*Zygnematales*	2.029	35
Rigid hornwort	*Ceratophyllum demersum*	1.976	27
Nuttall's waterweed	*Elodea nuttallii*	1.883	36
Unbranched bur-reed	*Sparganium emersum*	0.643	13
Yellow water lily	*Nuphar lutea*	0.548	9
Common duckweed	*Lemna minor*	0.286	12
Pointed stonewort	*Nitella mucronata*	0.286	11
Enteromorpha	*Enteromorpha*	0.238	2
Arrowhead	*Saggitaria sagittifolia*	0.190	6
Starwort species	*Callitriche sp*	0.145	7
Water net	*Hydrodictyon*	0.143	4
Frogbit	*Hydrocharis morsus-ranae*	0.119	2
Whorled water milfoil	*Myriophyllum verticillatum*	0.119	3
Least duckweed	*Lemna minuta*	0.095	4
Greater duckweed	*Spirodela polyrhiza*	0.095	4
Fresh water sponge	*Spongillidae*	0.071	3
Flat-stalked pondweed	*Potamogeton friesii*	0.071	2
Spiked water milfoil	*Myriophyllum spicatum*	0.048	2
Common water moss	*Fontinalis antipyretica*	0.024	1
Inflated duckweed	*Lemna gibba*	0.024	1
Fennel-leaved pondweed	*Potamogeton pectinatus*	0.024	1
Water Soldier	*Stratiotes aloides*	0.024	1
Total number of species recorded		**22**	**Total samples taken: 42**

There has been a marked increase in species number in this Broad since 2020. There were 11 species in 2020 and in 2023, 22 species were recorded. The top three species saw increases from 2020, Filamentous algae (0.264 to 2.029), Rigid hornwort (0.071 to 1.976) and Nuttal's waterweed (1.002 to 1.883). Decreases have occurred in Pointed stonewort

(0.836 to 0.548) and Yellow water lily (1.452 to 0.286). The waters were very clear when sampling.

Graph 19

Bridge Broad summary abundance shown in plant groups (see Appendix 1 for more detail)



Buckenham Broad

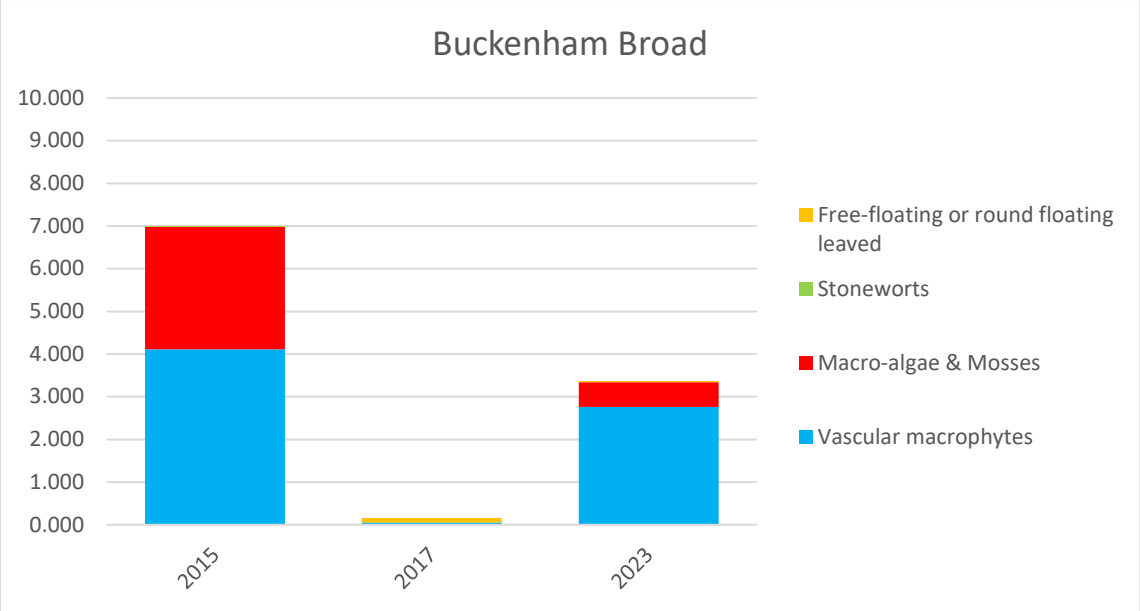
Table 23

Common Name	Scientific Name	Summary Abundance	Occurrences
Whorled water milfoil	*Myriophyllum verticillatum*	1.000	19
Rigid hornwort	*Ceratophyllum demersum*	0.947	15
Filamentous algae	*Zygnematales*	0.553	18
Curled pondweed	*Potamogeton crispus*	0.526	20
Fennel-leaved pondweed	*Potamogeton pectinatus*	0.211	8
Spiked water milfoil	*Myriophyllum spicatum*	0.053	2
Nuttall's waterweed	*Elodea nuttallii*	0.026	1
Common water moss	*Fontinalis antipyretica*	0.026	1
Frogbit	*Hydrocharis morsus-ranae*	0.026	1
Total number of species recorded		**10**	**Total samples taken: 38**

This Broad has seen a bounce back from 2017, not to levels seen in 2015 but vascular plants are recovering in terms of summary abundance. Filamentous has decreased since 2015 from 2.871 to 0.553 in 2023. Whorled water milfoil was not present in 2015 and was found in 19 points out of 38.

Graph 20

Buckenham Broad summary abundance shown in plant groups (see Appendix 1 for more detail)


Buckenham Broad
10.000
9.000
8.000
7.000
6.000
5.000
4.000
3.000
2.000
1.000
0.000
2015
2017
2023
Free-floating or round floating leaved
Stoneworts
Macro-algae & Mosses
Vascular macrophytes

Hassingham Broad

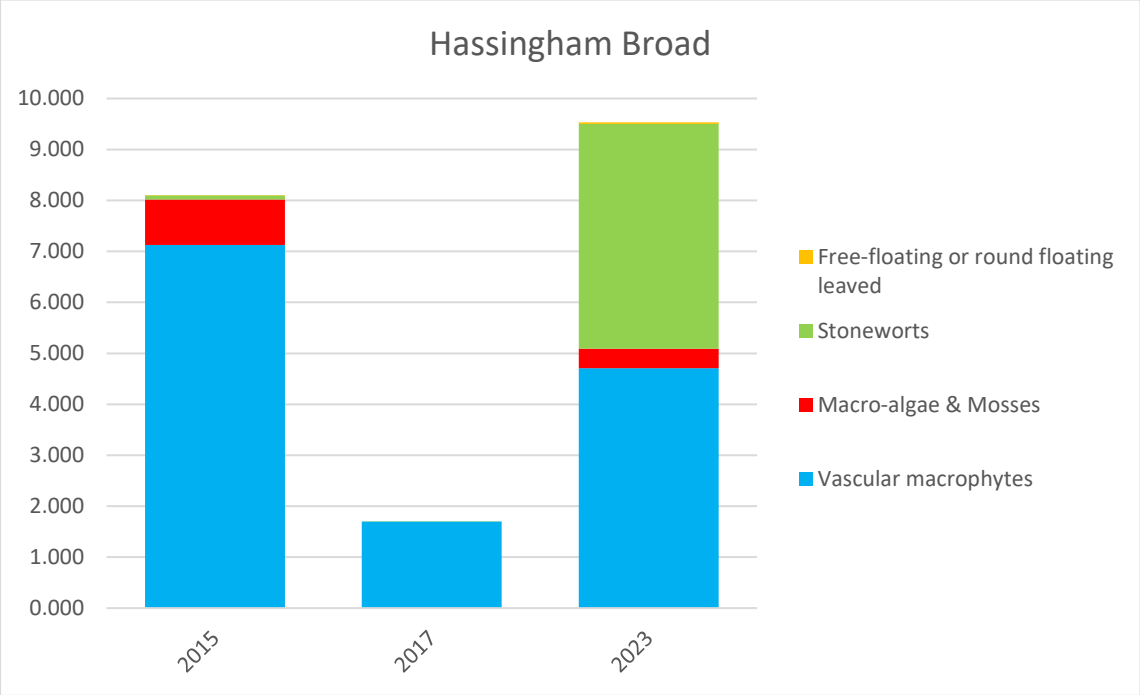
Table 24

Common Name	Scientific Name	Summary Abundance	Occurrences
Fragile/convergent stonewort	*Chara globularis/connivens*	3.882	26
Rigid hornwort	*Ceratophyllum demersum*	3.176	24
Holly-leaved naiad	*Najas marina*	1.118	15
Fragile stonewort	*Chara globularis*	0.529	5
Filamentous algae	*Zygnematales*	0.353	11
Curled pondweed	*Potamogeton crispus*	0.324	9
Nuttall's waterweed	*Elodea nuttallii*	0.059	1
Ivy-leaved duckweed	*Lemna trisulca*	0.029	1
Jelly algae	*Nostoc*	0.029	1
Fennel-leaved pondweed	*Potamogeton pectinatus*	0.029	1
Fresh water sponge	*Spongillidae*	0.029	1
Total number of species recorded		**10**	**Total samples taken: 34**

Stoneworts have increased significantly since the last survey with Fragile/convergent stonewort from 0.006 to 3.882. Rigid hornwort has also seen an increase from 1.268 to 3.176 along with Holly-leaved naiad from 0.603 to 1.118. The waters were very clear when sampling and Fresh water sponge was recorded.

Graph 21

Hassingham Broad summary abundance shown in plant groups (see Appendix 1 for more detail)



Rockland Broad

Table 25

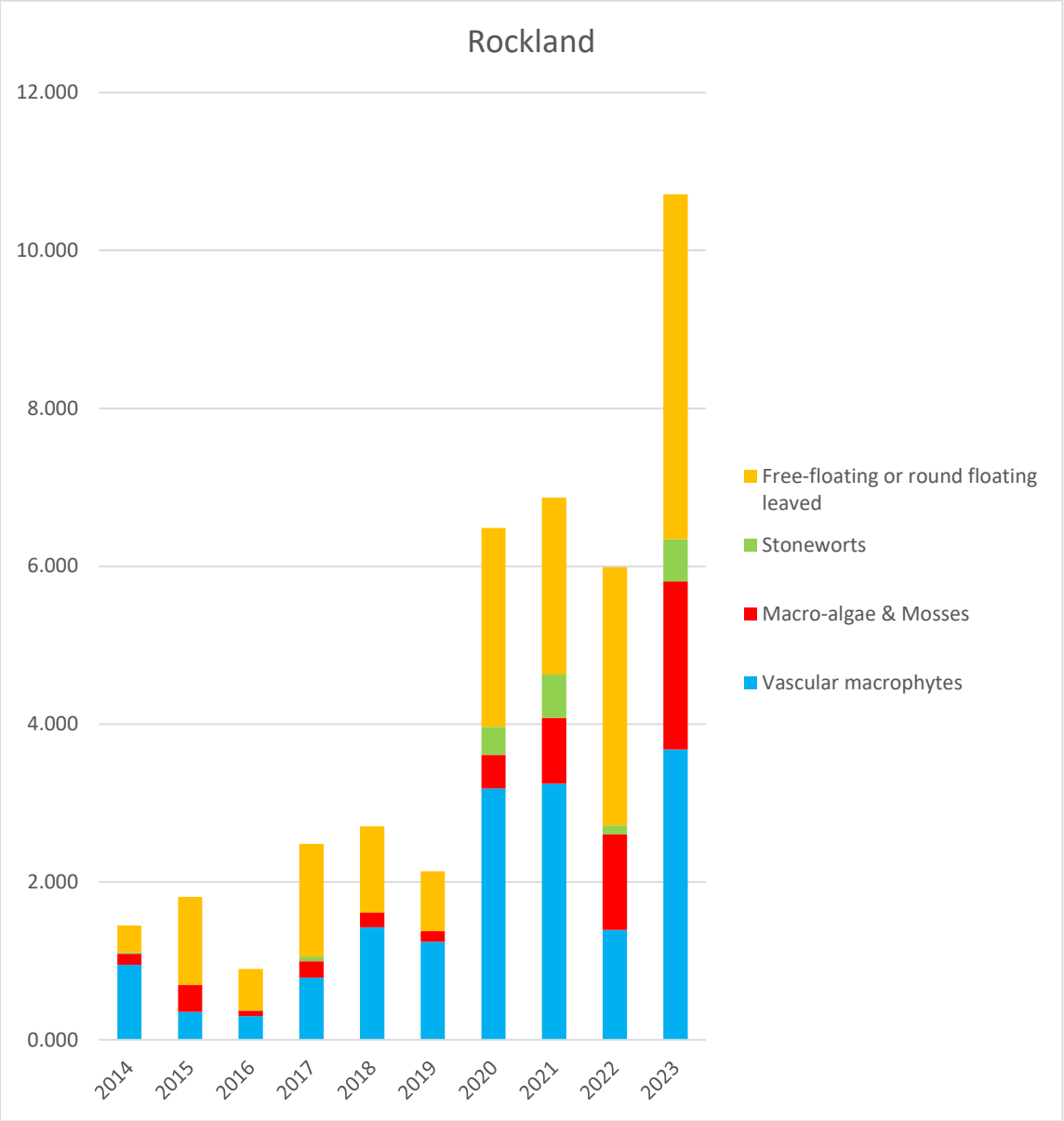
Common Name	Scientific Name	Summary Abundance	Occurrences
Yellow water lily	*Nuphar lutea*	3.274	36
Filamentous algae	*Zygnematales*	1.598	47
Nuttall's waterweed	*Elodea nuttallii*	1.032	44
Spiked water milfoil	*Myriophyllum spicatum*	0.645	31
Starwort species	*Callitriche sp*	0.597	29
Unbranched bur-reed	*Sparganium emersum*	0.565	23
Pointed stonewort	*Nitella mucronata*	0.532	15
Common water moss	*Fontinalis antipyretica*	0.452	18
Common duckweed	*Lemna minor*	0.452	27
Rigid hornwort	*Ceratophyllum demersum*	0.435	27
Least duckweed	*Lemna minuta*	0.210	13
Whorled water milfoil	*Myriophyllum verticillatum*	0.210	10
Frogbit	*Hydrocharis morsus-ranae*	0.161	5
Inflated duckweed	*Lemna gibba*	0.129	8
Fennel-leaved pondweed	*Potamogeton pectinatus*	0.113	7
Greater duckweed	*Spirodela polyrhiza*	0.113	7
Jelly algae	*Nostoc*	0.065	4
Ivy-leaved duckweed	*Lemna trisulca*	0.032	2
Lesser pondweed	*Potamogeton pusillus*	0.032	2
Arrowhead	*Saggitaria sagittifolia*	0.032	2
Enteromorpha	*Enteromorpha*	0.016	1
Small pondweed	*Potamogeton berchtoldii*	0.016	1
Total number of species recorded		**22**	**Total samples taken: 62**

Rockland Broad has seen a large increase this year. Vascular plants have more than doubled in summary abundance (1.390 to 3.677) and floating leaved or round floating leaved have

increased along with macro-algae and mosses. There are increases in all the groups of water plants and some additional species this year to last. A Duck mussel along with an Asiatic clam were found. Freshwater sponge was also found during the survey. The increased plant growth seen in Rockland this year has meant that the summary abundance is over 10.00 which has not been recorded on a survey before.

Graph 22

Rockland Broad summary abundance shown in plant groups (see Appendix 1 for more detail)



Broads River Plant Monitoring: 2023 Annual Report

River Plant Survey Methodology

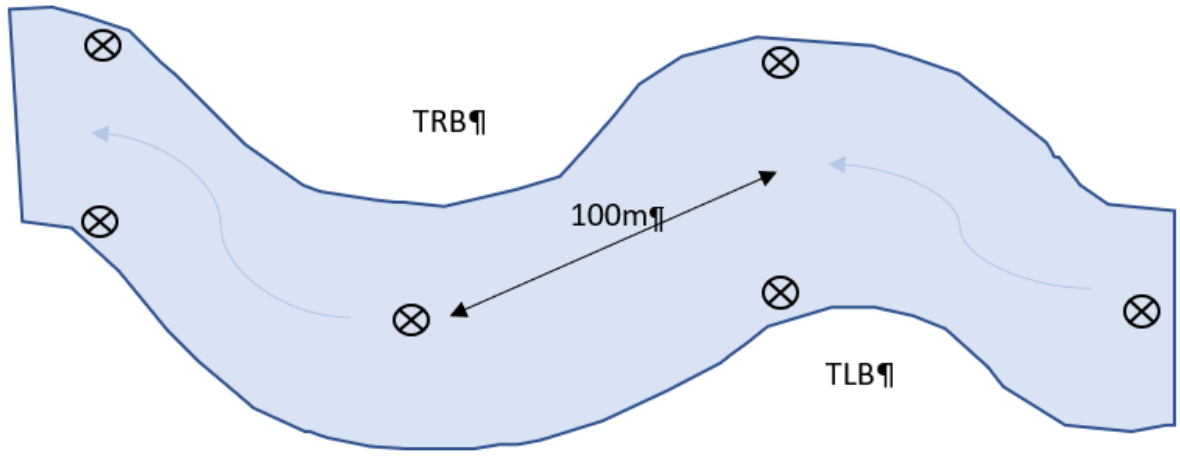
Point sample survey technique

The new survey design has developed upon groundwork laid by earlier surveys of the Broads' river systems. Stretches where routine water plant cutting takes place annually were identified and the surveys have focused exclusively on these reaches (see Appendix 1).

Survey points were placed in a diamond formation along the reach to be surveyed, to account for differing plant communities at the margins compared to the centre of the channel (see figure 3). A sampling point was taken in the middle of the channel and then 100m downstream two sampling points were taken at the true left and true right banks. The maps and sample point co-ordinates were loaded onto a Samsung tablet for the survey teams to use.

Along each reach to be surveyed, the survey team used the maps and grid references, loaded onto the Samsung tablet, and GPS to navigate by boat to each sample point. Once within 5m of the plotted grid reference, mud weights were deployed to keep the boat in the correct location. At the sample point a double headed survey rake is thrown at a distance of 5m from the edge of the boat. In contrast to the broads' water plant survey, only one downstream throw is made at each point to mitigate against downstream drift of plant material. The rake is left for 10 seconds to allow it to sink to the bottom, after which it is pulled steadily back towards the boat.

Figure 3:
Diagram illustrating river survey methodology



The plants accumulated on the rake head are collected in a white survey tray and washed to remove any excess sediment, as required. All live plant material is identified to species level wherever possible. However, some particularly difficult groups, such as the non-flowering

starworts *Callitriche sp.*, can only be identified to genus level. Specimens that remain unidentified in the field, or where identification was uncertain, are collected in labelled plastic bags and taken for closer inspection under a microscope or sent for expert identification. Specimens of interest are pressed and dried using standard herbarium techniques.

A level of abundance for each species is assigned based on the total volume of live water plant material, accounting for maximum trap-ability on the rake. Scores give each species present a range from 10% (low abundance) to 100% (the maximum trappable) in increments of 10%, with scores of 1% given to trace, or very small amounts, of identifiable plant material. A score of 100% represents the maximum amount trappable on the rake, to control for the 'trap-ability' of a given species. For instance, fine leaved species such as unbranched bur-reed, *Sparganium emersum,* are not as trappable with the rake as more structured species such as spiked water milfoil, *Myriophyllum spicatum.* This has the potential to result in under-recording of high abundances of less readily trapped species. Consequently, surveyor experience and judgement are important for scoring these less trappable species, such as duckweeds, *Lemna sp.* and water lilies. Scoring should consider the likelihood of a given species being retrieved on the rake and other visual indications of abundance.

The maximum total of all species abundance scores on an individual rake sample cannot really be more than 100%, although ± 10% is considered acceptable to account for the varying trap-ability of different species.

On the Thurne, a preliminary survey is undertaken in April/May time, before the water plant harvester is mobilised, and where prioritised, a secondary survey is undertaken later in the season, in June or July. Due to the constraints introduced by the coronavirus pandemic in 2020, the river survey was confined to the River Thurne. In 2021, lifting restrictions allowed the survey to be extended to the other Broads river systems. However, in 2021 the River Ant was excluded from the survey programme due to an infestation of floating pennywort which is currently under management. In 2022 the river plant survey was extended to all survey reaches of all river systems in the Broads for the first time since 2014 and this has continued into 2023. However, due to time and resource constraints, a single survey is completed in the middle of the growing season on all river systems, except the Thurne where an early and late survey is still undertaken annually.

River Plant 2023 Survey Results

The data collected from each river transect is presented as abundance (the amounts of each species recorded) based on the Braun-Blanquet Scale, as outlined in the river survey methodology. The results tables illustrate the number of points at which each species was recorded to indicate frequency of occurrence. Historical records from past surveys are not presented here, different survey methodologies were used and therefore the results are not directly comparable.

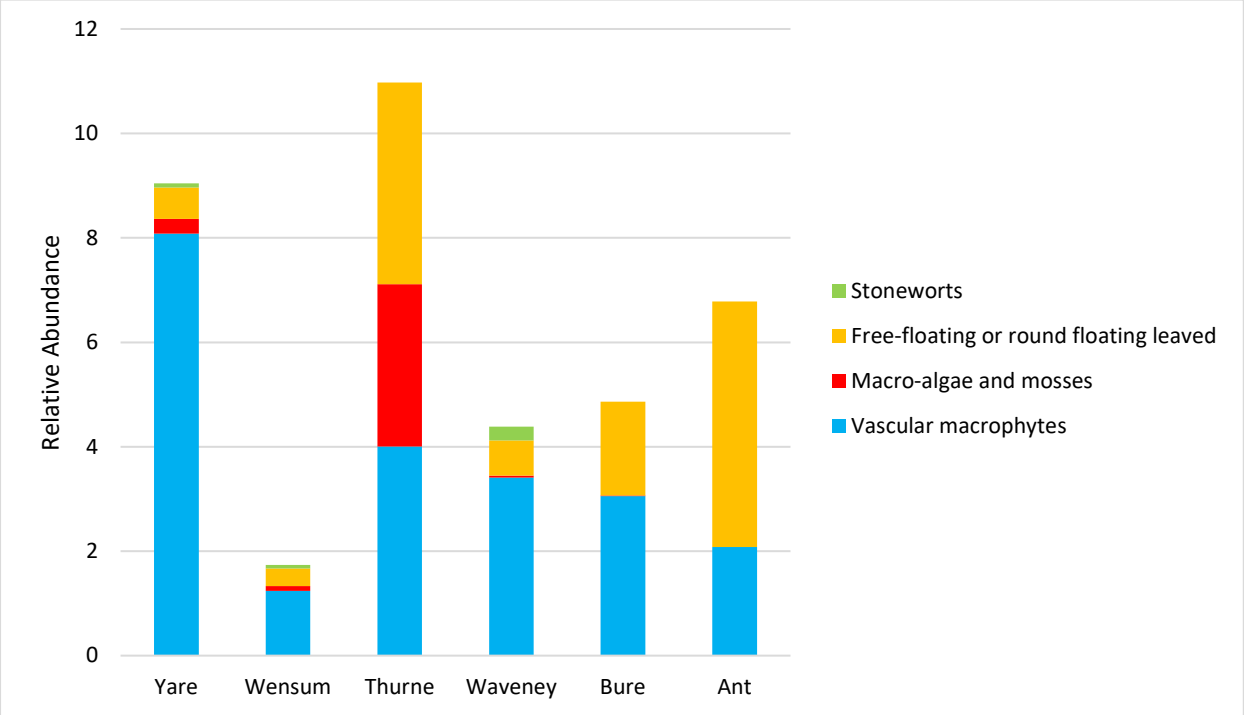
Summary

Vascular plants were the most common group of plants recorded on most river systems, followed by floating plants, whereas on the Ant there were greater abundances of floating than vascular plants this year. Pointed stonewort, *Nitella mucronata,* was recorded at fifteen separate points across the Waveney, the Wensum and through the Thorpe Green reach of the Yare, in significant abundance. Otherwise, stoneworts were not well represented in the river systems. The Yare and the Thurne were the most species rich river systems and carried the greatest abundance of plants, with the Thurne ultimately having the greatest species richness and abundance. Greater levels of macro-algae and mosses were recorded on the Thurne compared to the other river systems. Holly-leaved naiad, *Najas marina,* which is a Section 41 priority species, was only recorded on the Thurne.

The Wensum had the lowest species richness and abundance, as also observed in 2022. The dominant species was arrowhead, *Sagittaria sagittifolia,* across both of the surveyed stretches of the Yare and Wensum through Norwich. However, species richness on the Yare was augmented by good plant growth through the Thorpe Green reach.

Graph 23

Broads rivers summary abundance shown in plant groups (see Appendix 1 for more detail)



Ant

Table 26

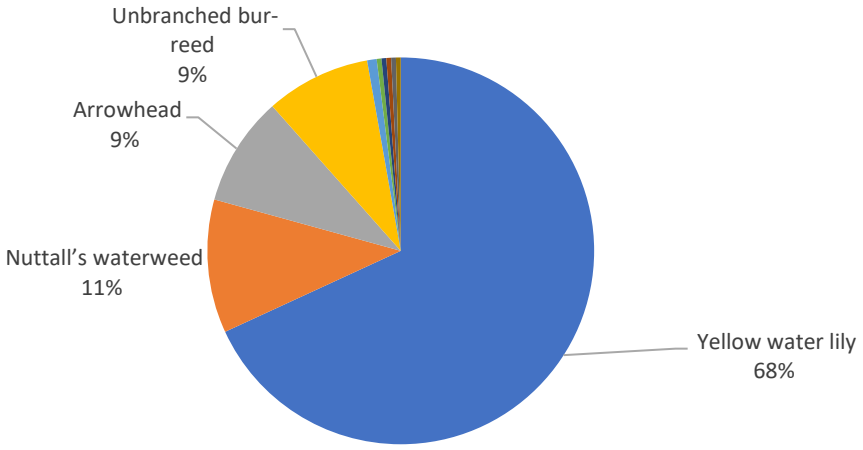
Common name	Scientific name	Abundance	Occurrence
Yellow water lily	Nuphar lutea	4.62	1
Nuttall's waterweed	Elodea nuttallii	0.76	1
Arrowhead	Saggitaria sagittifolia	0.62	1
Unbranched bur-reed	Sparganium emersum	0.59	19
Starwort species	Callitriche sp	0.05	1
Rigid hornwort	Ceratophyllum demersum	0.03	1
Frogbit	Hydrocharis morsus-ranae	0.03	16
Fennel-leaves pondweed	Potamogeton pectinatus	0.03	26
Fan-leaved water crowfoot	Ranunculus circinatus	0.03	1
Water Soldier	Stratiotes aloides	0.03	16
Total number of species recorded		**10**	**Total number of samples taken: 37**

The Ant was found to have average species abundance, although species richness was relatively high, with 17 species recorded across 37 survey points over both surveys. Yellow water lily *Nuphar lutea* was the most dominant species. Nuttall's waterweed *Elodea nuttallii*

was the second most commonly recorded species. One point was recorded as having no plants. Water soldier is rare and classified as near-threatened in the UK, it was found at one point on the Ant, at the bottom of the North Walsham and Dilham Canal. It has not been recorded here previously.

Graph 24

Pie chart showing Ant species diversity



Bure

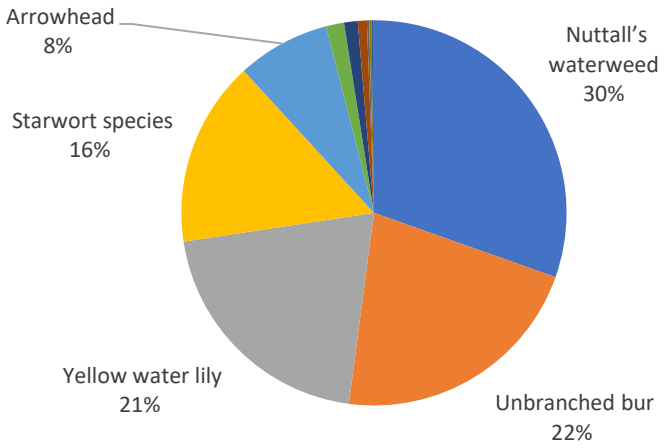
Table 27

Common Name	Scientific Name	Abundance	Occurrence
Nuttall's waterweed	Elodea nuttallii	1.48	87
Unbranched bur-reed	Sparganium emersum	1.06	64
Yellow water lily	Nuphar lutea	1.00	29
Starwort species	Callitriche sp	0.76	59
Arrowhead	Saggitaria sagittifolia	0.38	32
Long-stalked pondweed	Potamogeton praelongus	0.07	4
Lesser water-parsnip	Berula erecra	0.06	4
Ivy-leaved duckweed	Lemna trisulca	0.04	4
Canadian waterweed	Elodea canadensis	0.01	1
Common water moss	Fontinalis antipyretica	0.01	1
Fan-leaved water crowfoot	Ranunculus circinatus	0.01	1
River water crowfoot	Ranunculus fluitans	0.00	1
Total number of species recorded		**12**	**Total number of samples taken: 108**

Moderate species abundance and diversity were recorded on the Bure, the survey was extended to cover the increased spatial spread of water plants requiring cutting for navigational access. The most dominant species was Nuttall's waterweed, *Elodea nuttallii,* followed by unbranched bur-reed, *Sparganium emersum* and yellow water lily *Nuphar lutea.* Although the species recorded had good abundance, there was lower species richness recorded on the Bure compared to the Thurne. Eight points were recorded as having no plants, this is approximately 7.4% of points.

Graph 25

Pie chart showing Bure species diversity


Arrowhead
8%
Nuttall's
waterweed
30%
Starwort species
16%
Yellow water lily
21%
Unbranched bur
22%

Thurne

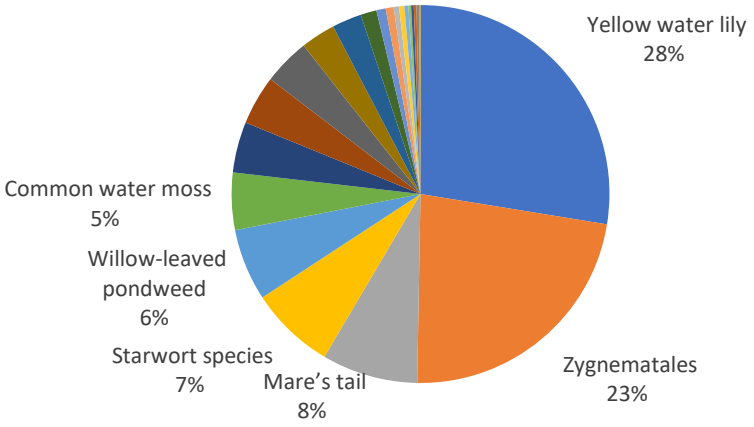
Table 27

Common Name	Scientific Name	Abundance	Occurrences
Yellow water lily	Nuphar lutea	1.96	30.5
Zygnematales	Filamentous algae	0.54	16
Mare's tail	Hippuris vulgaris	0.48	9.5
Starwort species	Callitriche sp	0.38	19
Willow-leaved pondweed	Potamogeton x salicifolius	0.36	15.5
Common water moss	Fontinalis antipyretica	0.35	14
Whorled water milfoil	Myriophyllum verticillatum	0.34	7.5
Canadian waterweed	Elodea canadensis	0.33	7.5
Spiked water milfoil	Myriophyllum spicatum	0.29	17
Arrowhead	Saggitaria sagittifolia	0.25	5.5
Curled pondweed	Potamogeton crispus	0.25	10
Nuttall's waterweed	Elodea nuttallii	0.19	8.5
Fennel-leaved pondweed	Potamogeton pectinatus	0.08	1
Enteromorpha	Enteromorpha	0.05	4
Shining pondweed	Potamogeton lucens	0.03	0.5
Fan-leaved water crowfoot	Ranunculus circinatus	0.01	0.5
Ivy-leaved duckweed	Lemna trisulca	0.01	0.5
Rigid hornwort	Ceratophyllum demersum	0.01	0.5
Holly-leaved naiad	Najas marina	0.025	2
Perfoliate pondweed	Potamogeton perfoliatus	0.025	6
Long-stalked pondweed	Potamogeton praelongus	0.025	12
Unbranched bur-reed	Sparganium emersum	0.0125	3
Total number of species recorded		**22**	**Total samples taken: 40**

Yellow water lily, *Nuphar lutea,* was the most dominant species on the Thurne system followed filamentous algae, *Zygnematales.* Filamentous algae, *Zygnematales,* was abundant on the Thurne compared to the other river systems. Although in low abundance, there was greater species richness recorded on the Thurne than on any of the other surveyed river systems. No points were recorded as having no plants. Slightly higher diversity and abundance was recorded in the April survey than the August survey, but differences between the two surveys were minor.

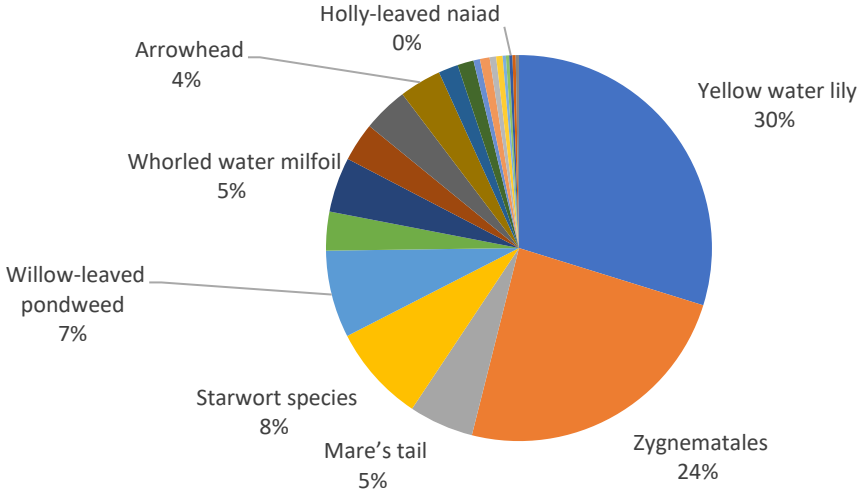
Graph 26

Pie chart showing April & August Survey Results



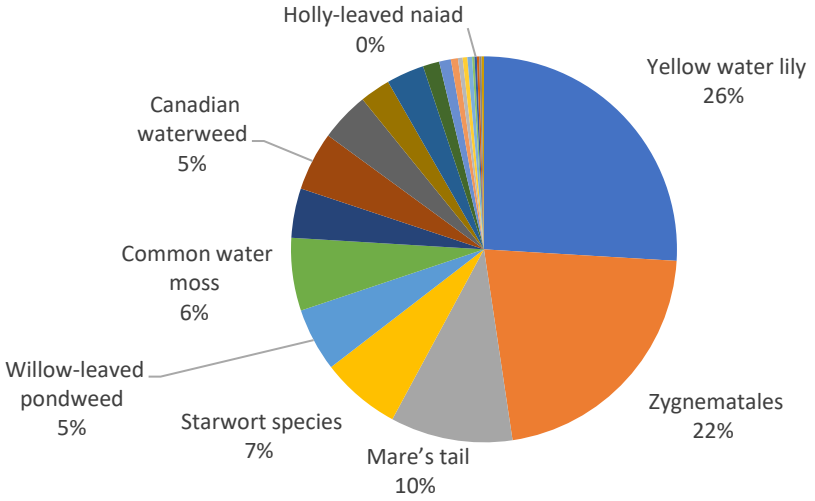
Graph 27

Pie chart showing April Survey Results



Graph 28

Pie chart showing August Survey Results



Waveney

Table 28

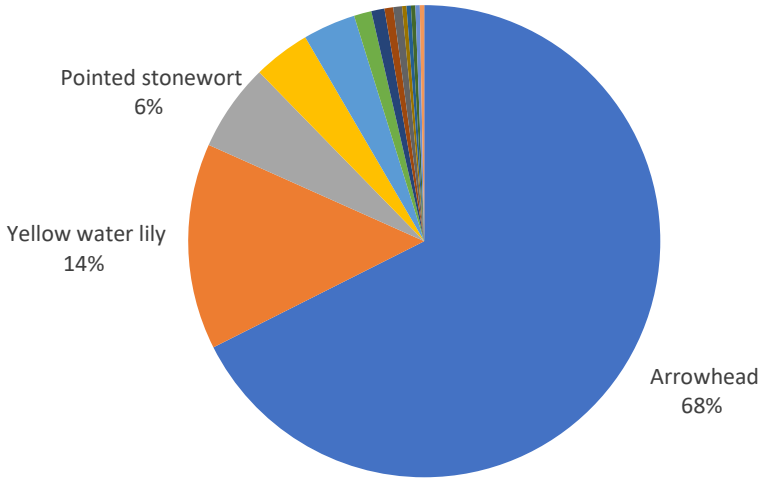
Common Name	Scientific Name	Abundance	Occurrence
Arrowhead	Saggitaria sagittifolia	2.96	59
Yellow water lily	Nuphar lutea	0.62	9
Pointed stonewort	Nitella mucronata	0.26	10
Nuttall's waterweed	Elodea nuttallii	0.17	13
Unbranched bur-reed	Sparganium emersum	0.16	11
Starwort species	Callitriche sp	0.05	4
Whorled water milfoil	Myriophyllum verticillatum	0.04	3
Rigid hornwort	Ceratophyllum demersum	0.03	2
Common water moss	Fontinalis antipyretica	0.03	2
Canadian waterweed	Elodea canadensis	0.01	1
Zygnematales	Filamentous algae	0.01	1
Fan-leaved water crowfoot	Ranunculus circinatus	0.01	1
Lesser water-parsnip	Berula erecta	0.01	1
Bladderwort	Utricularia vulgaris	0.01	1
Total number of species recorded		**14**	**Total number of samples taken: 76**

Species abundance and diversity had improved on the Waveney. Arrowhead *Saggitaria sagittifolia* was the most abundant species, followed by yellow water lily *Nuphar lutea.* Bladderwort was found for the first time this year, at the top of the navigation in Geldeston. *Nitella mucronata* was found in patches throughout the survey area, though concentrated

towards the Geldeston area. No plants were recorded on 13 points, accounting for approximately 16% of points.

Graph 29

Pie chart showing Waveney species diversity



Wensum

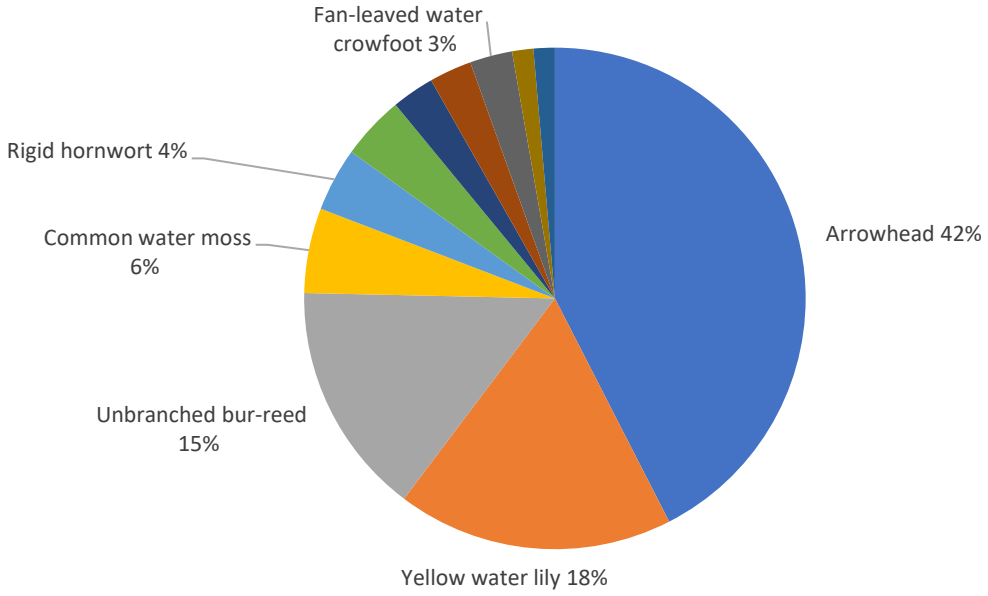
Table 30

Common name	Scientific name	Abundance	Occurrences
Arrowhead	Saggitaria sagittifolia	0.74	2
Yellow water lily	Nuphar lutea	0.31	17
Unbranched bur-reed	Sparganium emersum	0.26	17
Common water moss	Fontinalis antipyretica	0.10	4
Rigid hornwort	Ceratophyllum demersum	0.07	3
Pointed stonewort	Nitella mucronata	0.07	3
Nuttall's waterweed	Elodea nuttallii	0.05	2
Spiked water milfoil	Myriophyllum spicatum	0.05	2
Fan-leaved water crowfoot	Ranunculus circinatus	0.05	1
Starwort species	Callitriche sp	0.02	1
Flat-stalked pondweed	Potamogeton friesii	0.02	3
Total number of species recorded		**14**	**Total number of samples taken: 42**

Arrowhead, *Saggitaria sagittifolia,* was the most dominant species on the Wensum. The species richness was similar to that recorded on the Ant and Bure but overall abundance was lower on the Wensum than any other river system. No plants were recorded on 17 points, approximately 40% of the surveyed points.

Graph 30

Pie chart showing Wensum species diversity



Yare

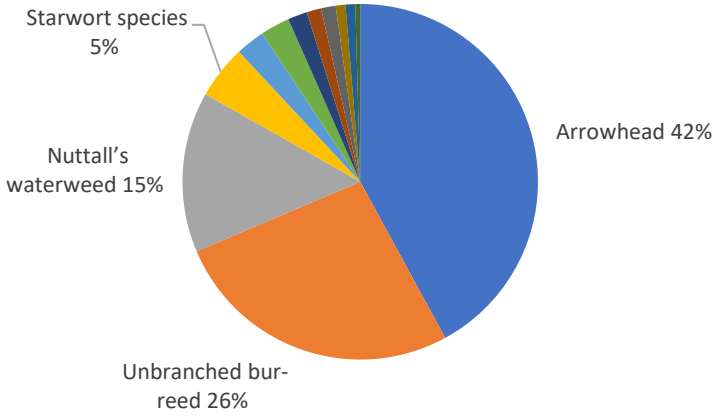
Table 31

Common Name	Scientific Name	Abundance	Occurrences
Arrowhead	Saggitaria sagittifolia	3.804	2
Unbranched bur-reed	Sparganium emersum	2.4	24
Nuttall's waterweed	Elodea nuttallii	1.32	19
Starwort species	Callitriche sp	0.44	9
Filamentous algae	Zygnamatales	0.24	3
Flat-stalked pondweed	Potamogeton friesii	0.24	3
Yellow water lily	Nuphar lutea	0.16	2
Rigid hornwort	Ceratophyllum demersum	0.12	3
River water-dropwort	Oenanthe fluviatilis	0.12	18
Pointed stonewort	Nitella mucronata	0.08	2
Fennel-leaved pondweed	Potamogeton pectinatus	0.08	6
Common water moss	Fontinalis antipyretica	0.04	1
Total number of species recorded		**12**	**Total number of samples taken: 25**

Arrowhead, *Saggitaria sagittifolia,* was the most dominant species on the section of the Yare surveyed, followed by unbranched bur-reed, *Sparganium emersum.* River water-dropwort *Oenanthe fluviatilis* was found at one location through Thorpe Green. There was a good species richness in the stretch surveyed, with a total of 12 separate species recorded. Species richness and abundance was particularly good through the Thorpe Green reach. Only two plants had no plants recorded, approximately 0.13% of points.

Graph 31

Pie chart showing Yare species diversity

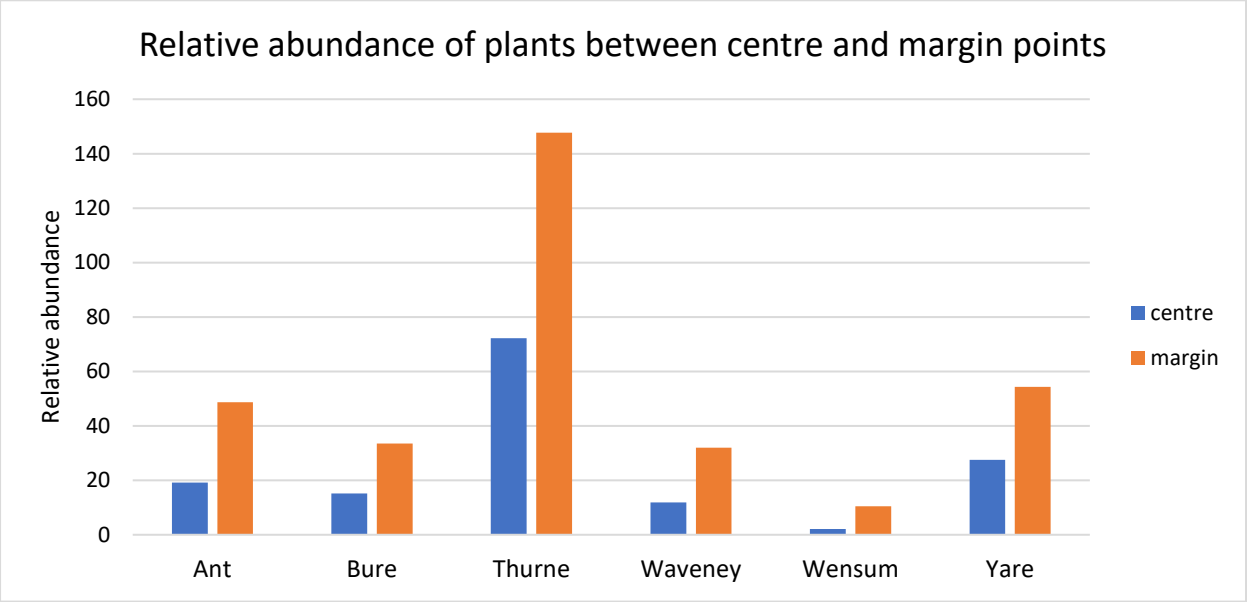


Variation in centre and margin points

It was hypothesised that plants would have a greater abundance at the river channel margins than in the centre. In the 2023 survey, abundance was consistently higher in the marginal points over the centre points. Significant differences in plant abundances were observed between the centre and marginal points on all the rivers. The Thurne had the greatest overall abundance on both the central and marginal points.

Graph 32

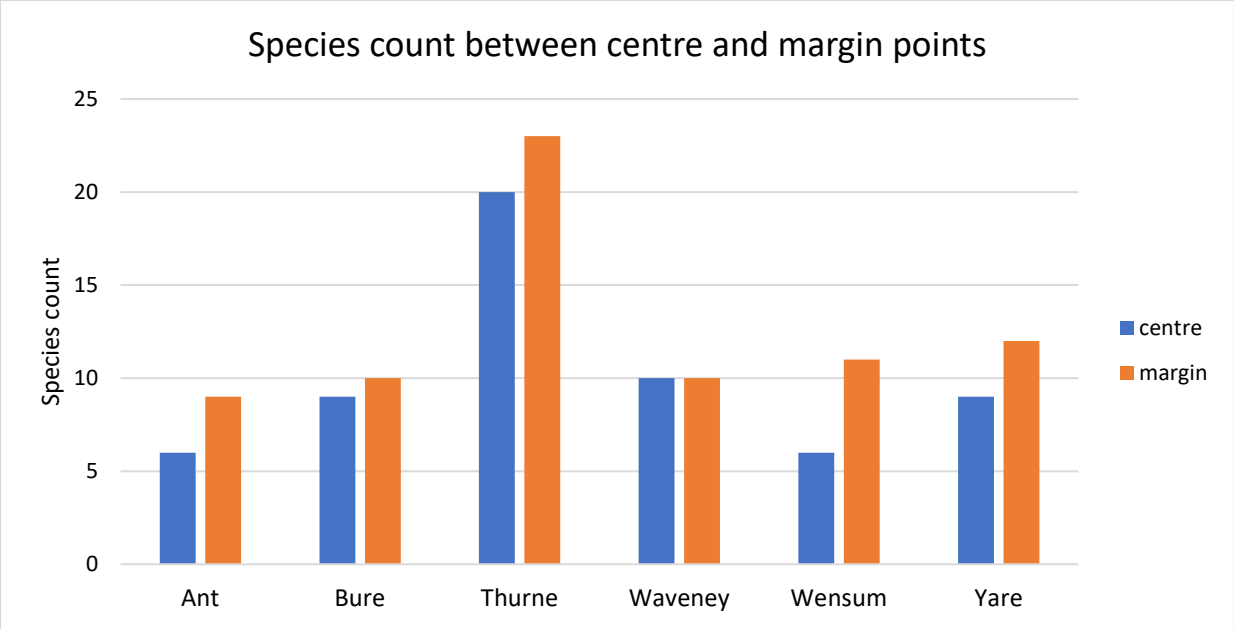
Relative abundance of plants between centre and margin points



The Thurne also had greater overall species richness, though the differences in species richness are less pronounced than the difference in abundance between the centre and marginal points. The Bure and Waveney show only small differences in species richness between central and marginal points. The Yare, Ant and Wensum again have greater differences in species richness between central and marginal points, with species richness on marginal points consistently greater than in the centre of the channel.

Graph 33

Species count between centre and margin points



Annual comparison across all surveyed stretches

There was a slight decrease in the number of vascular plants recorded in 2022 compared to 2021 but this had recovered by 2023. The slight decrease in the number of macro-algae and mosses recorded between 2021 and 2022 had also shown recovery into 2023. A decrease was seen in the abundance of stonewort (primarily *Nitella mucronata)* recorded between 2022 and 2023. However, a strong increase in abundance of free floating or round floating leaved plants was recorded in the 2023 survey.

Graph 34

Relative abundance across plant families over three years

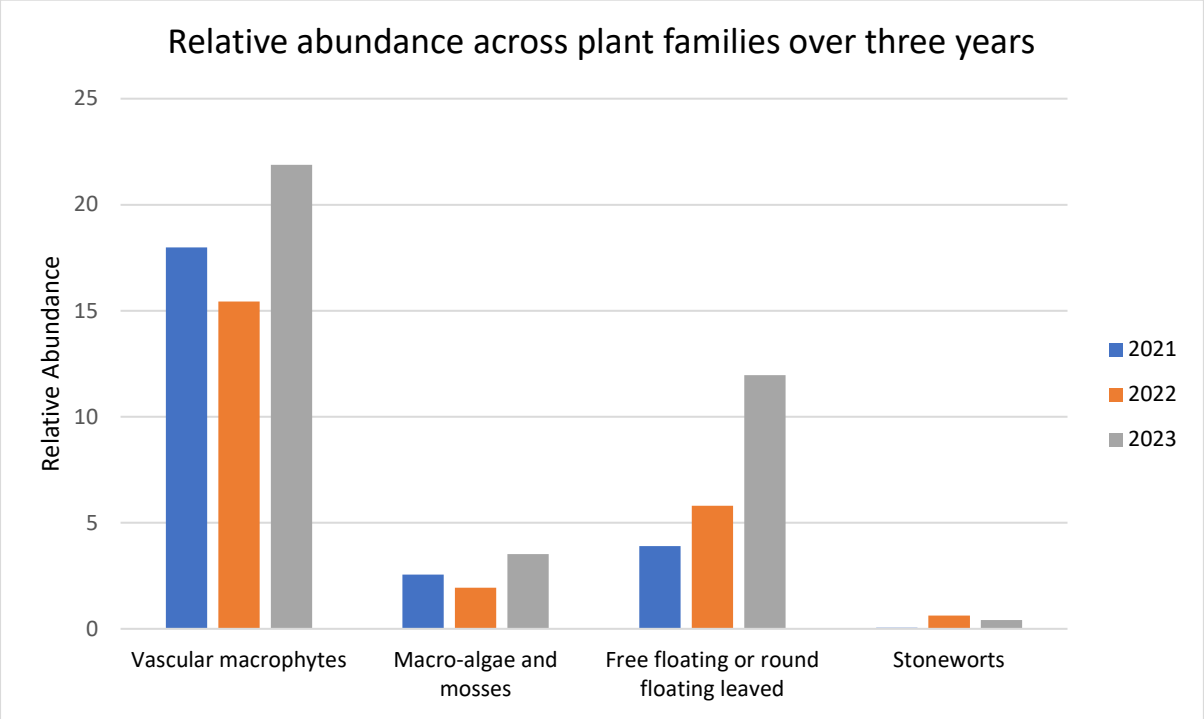
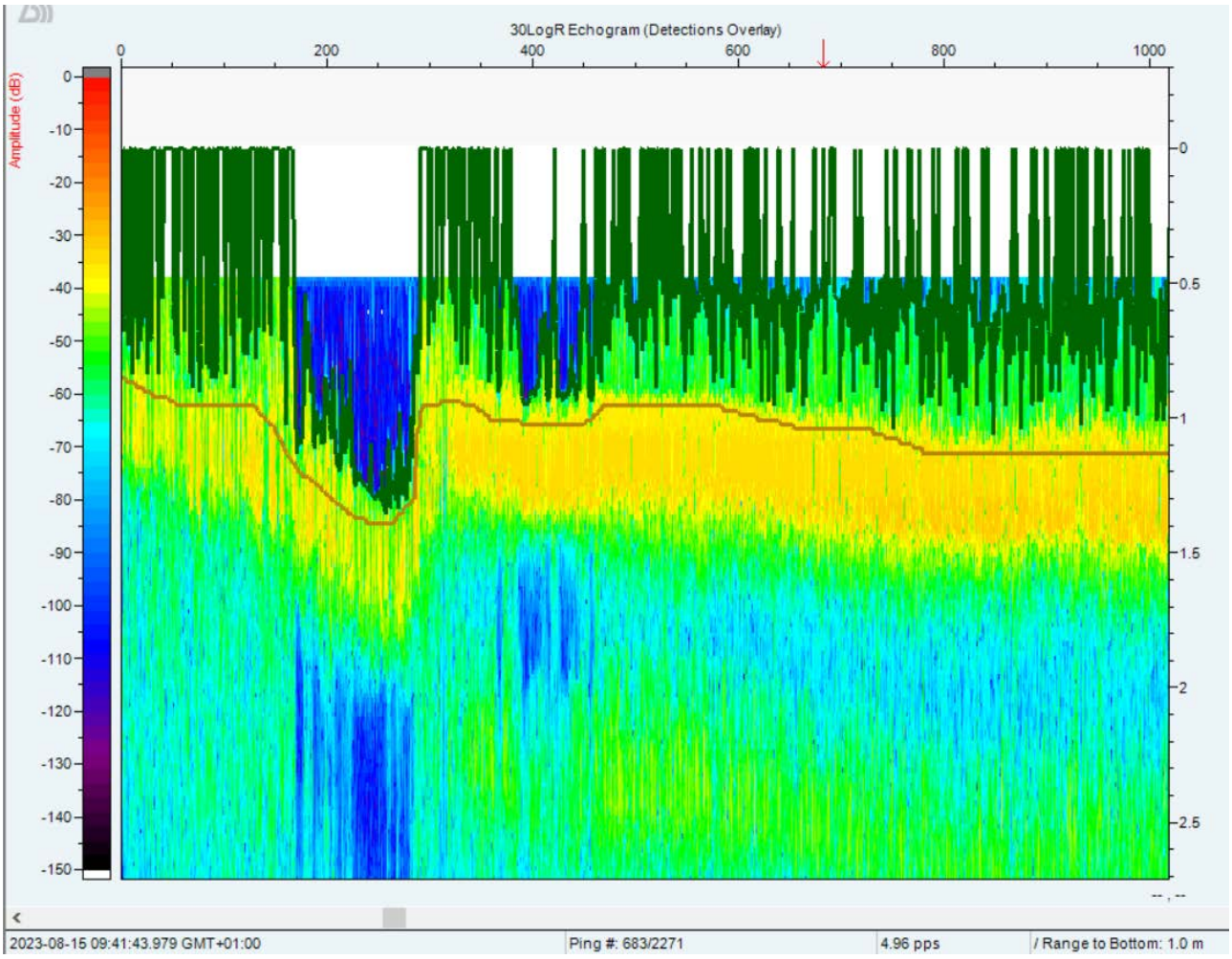


Figure 1

Hydroacoustic map of Hickling Broad



Background Information

Hickling Broad

Hickling Broad (Figure 2) is the largest body of water within the Norfolk & Suffolk Broads, comprising 128 hectares (ha) of open water. The broad has an average depth of between 0.68m to 1.86m and the bed is mostly comprised of soft mud with a layer of fluidised sediment on top. Hickling Broad contains species and habitats of high conservation importance, and is also a key navigation waterbody within the Broads executive area.

Figure 2
Aerial image of Hickling Broad from 2022

As the navigation authority, the Broads Authority (BA hereafter) is obliged to maintain navigable access within the Broads Executive Area. Water plants, especially during the summer when growth can be prolific, can reduce accessibility for boats. For Hickling Broad, waterways specifications are assessed with consideration to the presence of protected water plant communities. Given the good water plant growth in Hickling Broad and the importance of the broad to navigation and recreation in the Norfolk Broads, the main channel has undergone management in the form of dredging during the winter months that were completed in February 2021 and water plant cutting in the summer (assent from Natural England is currently in place) to cut the submerged water plants within the marked channel to enable boat access to continue.

Hydroacoustic Survey

Hickling Broad is monitored by the BA to assess the condition and status of the water plant community and provide useful information to inform management decisions. Two complimentary survey techniques are conducted at Hickling Broad. Hydroacoustic surveys provide a measure of the height, cover and volume of water plants across the broad. Standard water plant surveys identify the species present at 39 sampling points and provide a score of their abundance. The purpose of this report is to present the findings of the hydroacoustic surveys of Hickling Broad.

Hydroacoustic surveys have been conducted annually at Hickling Broad since 2012 (Table 1). In 2016, the survey design was updated to incorporate the water plant survey points (see below), with the frequency of surveys also increased. In 2017, an additional 18 transects, running parallel to the main transects were surveyed in June, August and October, to increase the coverage of the western section of the broad. The increased survey effort was in response to the expansion of water plants in 2016 with the aim of monitoring the growth of plants over the growing season. The schedule returned to the original number of surveys and transects in 2018.

Table 1

Details of the hydroacoustic survey conducted at Hickling Broad

Year	Survey date	No. of transects	Distance surveyed (m)
2013	October	14	4,746
2014	August	26	8,120
2015	August	18	6,585
2016	June	19	12,468
	October	19	10,565
2017	May	19	12,204
	June	37	21,238
	August	37	22,148
	October	37	22,673
2018	May	19	11,943
	August	19	11,761

Year	Survey date	No. of transects	Distance surveyed (m)
	October	19	11,975
2019	May	19	11,704
	August	19	11,981
	October	19	12,242
2020	June	19	10,092
	August	19	11,796
	October	19	11,964
2021	May	19	11,897
	August	19	11,717
	October	19	11,692
2022	May	19	11,496
	August	19	10,799
	October	19	11,290
2023	May	19	11,981
	August	19	11,823
	October	19	12,970

Methodology

Hydroacoustic survey equipment, utilising sonar technology, is commonly used for detection, assessment, and monitoring of underwater physical and biological objects. Boat-mounted hydro-acoustic equipment can be utilised to detect the depth of a water body (bathymetry), as well as the presence or absence, distribution and size of underwater plants.

Such survey equipment measures the range to an object and its relative size by producing a pulse of sound and measuring the time it takes for an echo to return from the object and

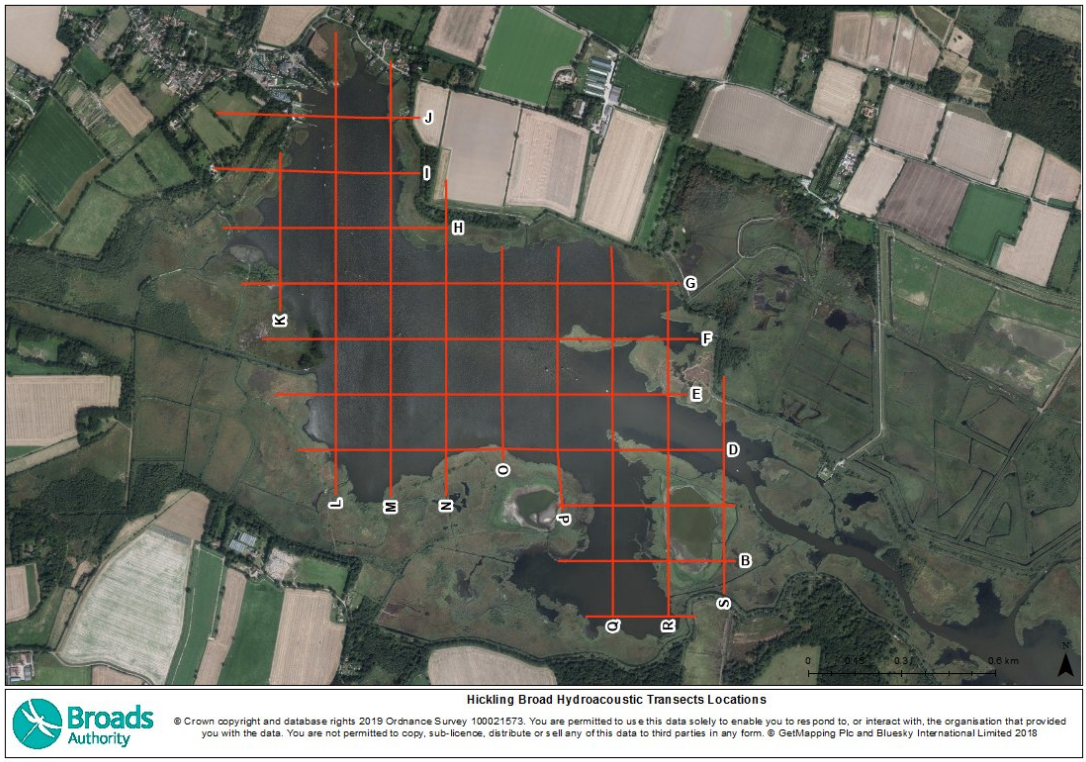
the amplitude of the returned echo. The range is calculated as a function of the speed of sound and the time it takes for the echo to return.

The surveys were completed with updated hardware (BioSonics DT-X scientific echosounder) and software which was first used in the August 2021 survey. The older equipment (DTX biosonics) was replaced as the software was no longer being supported.

Survey design and programme

From 2018 onwards, the survey design reverted to the 19 transects (A to S) first surveyed in 2016. The length of the programmed transects are between 150 to 1020m and the survey consists of ten transects on an east – west axis and nine on a north – south axis (Figure 2). These parallel transects are 177 m apart and the location where transects intersect corresponds to the sample points for the annual water plant survey.

Figure 2
Location of the 19 hydroacoustic survey transects covering Hickling Broad



Three surveys were programmed for 2023, in May, August and October. The programme was devised following the assessment of previous hydroacoustic surveys (see 1.2 above).

Survey Methodology

The hydroacoustic surveys were conducted by navigating a survey boat along the transects (see Figure 2), maintaining a constant speed of approximately 5 miles per hour (mph). The equipment used in this survey included a BioSonics DT-X, single beam (10°), 420 KHz transducer, with an on-board control unit and operating laptop. All data recorded was geo-referenced through connection to an internal GPS receiver. This allowed subsequent

quantitative analysis of the data using Visual Aquatic post-processing software, developed specifically with a vegetation analysis component (see below).

The surveys were conducted by trained BA staff on 16 May, 15 August and 17 October 2023. Table 2 presents the total length of transects surveyed in each of the surveys conducted in 2023.

Table 2
Sampling details

Survey	Dates	Number of transects	Distance surveyed (m)
May	16th 2023	19	11,981
August	15th 2023	19	11,823
October	17th 2023	19	12,970

Data analysis

Using the Visual Aquatic software, the sediment surface of each transect file was identified, as well as the less intense return derived from the upper surface of the water plants. The sonar produces 5 pings per second and the transects were analysed every 10 pings. The programme produces a report on those 10 pings to get an average on depth, plant height and percentage cover.

The results derived from the processing of the hydroacoustic data were then used to calculate plant height, mean area of lake bed covered by water plants (PAI) and mean percent volume of the water column inhabited by water plants (PVI). Overall means were calculated for each survey for the entire broad and the individual transects (A to S). Water depth on the date of the survey is recorded and variability between surveys should be considered when interpreting results. Water depths are noted with the result tables and accompanying maps. The results of the three surveys of Hickling Broad are presented in Table 3, figures 1 to 3 are the mean results of the surveys since 2013.

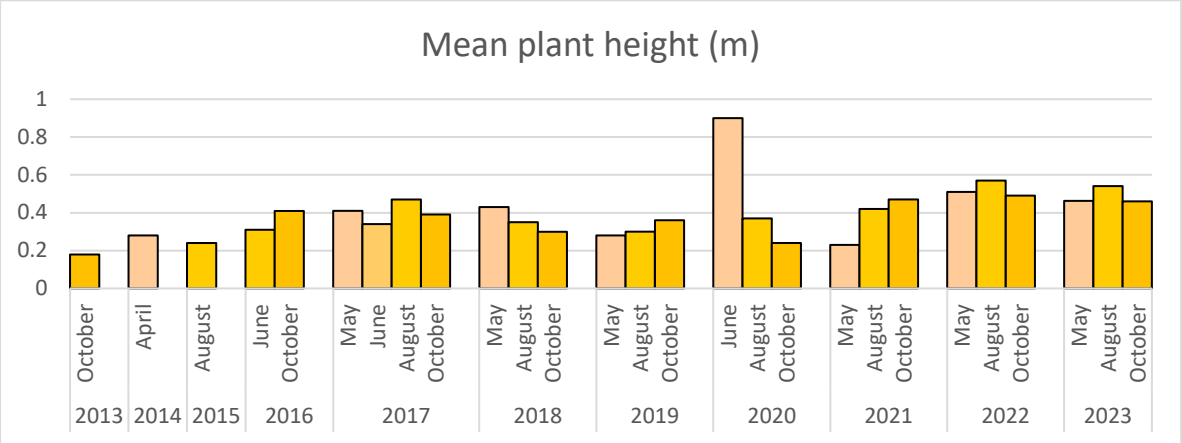
Table 3

Results of the hydroacoustic surveys of Hickling Broad in 2023

Metric	May 2023	August 2023	October 2023
Metres Above Ordnance Datum (mAOD)	0.49m	0.43m	0.67m
Maximum water depth (m)	1.93m	1.92m	2.23m
Mean water depth (m)	1.28 m	1.28m	1.53m
Maximum water plant height (m)	1.26m	1.42m	1.34m
Mean water plant height (m)	0.46m	0.54m	0.46m
PAI (%)	83.97	89.65	89.10
PVI (%)	33.36	41.05	28.97

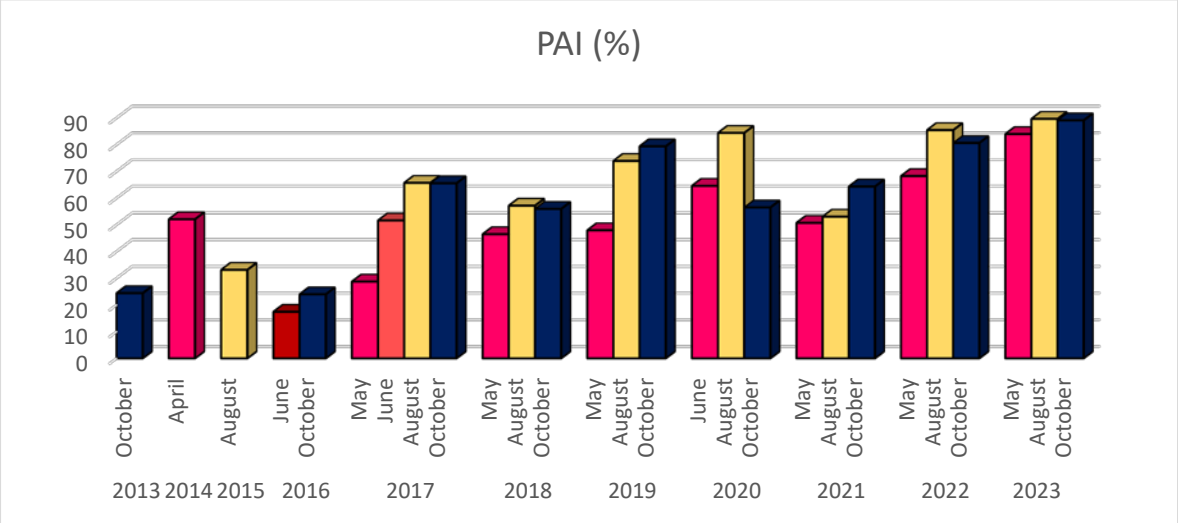
Graph 1

Mean Plant Height in metres. Results of the hydroacoustic surveys conducted at Hickling Broad between 2013 and 2023.



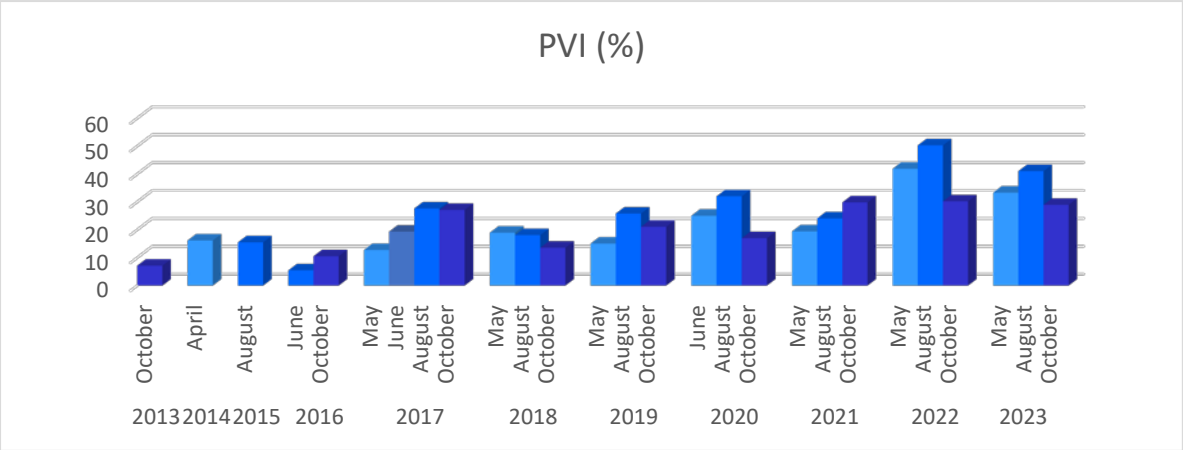
Graph 2

Mean PAI (plant area over bed). Results of the hydroacoustic surveys conducted at Hickling Broad between 2013 and 2023.



Graph 3

Mean PVI (Plants in water column). Results of the hydroacoustic surveys conducted at Hickling Broad between 2013 and 2023.



The annual mean water level for Hickling Broad is 0.35m *Meters above ordnance datum* (mAOD). At the time of the survey in May 2023 the mAOD was 0.49m, during August, the mAOD during the survey was 0.43m and in October 0.67m. These are high compared to previous years, which coincide with 2023 being a very wet year. These considerable variations in actual water levels through from May to October must be considered when interpreting the results as the percentage volume of plants in the water column (PVI) will read higher when water levels are low and lower when water levels are high.

In May, water plants reached a maximum height of 128cm in transect N and an overall mean height of 46cm. Eleven transects recorded plants reaching a maximum height of 102cm plus and twelve transects had mean heights of at least between 47cm and 58cm. Transect A and K had the greatest mean cover of water plants (PAI) with 96%, which are some of the shortest transects. The second highest transect (J) containing 94% PAI and the lowest cover at just 78% PAI was transect M. Overall PVI was estimated at 33.36%, with values ranging from 21.83% (G) to 50.13% (K); all together seven transects displayed a mean PVI figure of over 37%.

The maximum plant height recorded in August was 142cm, with ten transects containing water plants in excess of 105cm in height and all the transects had a max plant height above 0.79cm. The mean heights ranged from 44cm to 70cm, with thirteen transects with a mean of at least 50cm in height. Overall, mean plant cover (PAI) was estimated at 90%, with a range of values from 82% (transect H) to 97% (transect A), with all nineteen transects containing a minimum of 82% cover and eleven greater than 91%. The mean PVI ranged from 33% (transect S) to 65% (transect K), resulting in an overall mean of 41%. In total, fourteen transects contained PVI minimum values of 50% (transects A, B, C, E, F, G, I, J, K, L, N, 0, P & Q).

The maximum height of the water plants in Hickling Broad decreased by 8cm to 134cm in October, with nine transects containing plants greater than 100cm in height (transects B, D, E, F, G, H, L, M, N, O, P, Q & R). The mean height of water plants by transect ranged from 30cm (S) to 86cm (K), resulting in an overall mean of 46cm for the broad as a whole. Cover of plants ranged from 78% (R) to 98% (C), resulting in an overall mean cover for the broad of 89%. The mean PVI percentages ranged from 11% (N) to 42% (K), with an overall mean of 29%.

The result shows that transect K to the west contained highest plant cover from 95% to 97% over the duration of the survey period. The Southern transects A, B & C through the survey period ranged from 91% to 98% plant cover. There was an average increase of just 2% cover from May to August for the three transects. There was a 17% increase of cover in transect F from May to August; this was the largest increase in all the transects. Transect G had the second largest increase of 11% in cover over the period. Transect R indicates a decline of plant cover from May to October by 12%. Transect P & F had the lowest percentage cover over the 3 surveys both having an average 83%, while in comparison, transect K averaged 96%. Transects A, B and c are all particularly high varying from 91% to 96%.

In May, transect K had a percentage of plants in water column (PVI) greater than 50%; in August that increased to three transects (A, C, K) then by October no transects were greater than 50%; K had declined to 42%. Transect K had the highest PVI over the year with 65% recorded in August and nine transects had a minimum of 40% in that month. Transect A increased 21% from May (37%) to August (58%). Over the three surveys, transect K was the highest averaging 41% with transect N being the lowest at 11% PVI. Over the three surveys, 1 transect averaged a minimum of 42%, 7 transects an average of 30% or greater.

In Figure 3, the maps show the water depths of Hickling along the transects during the survey; in all three, the navigation channel can be identified from the dark blue points. It is also notable in October where the map shows deeper water over the broad which coincides with the highest water levels recorded during the survey period. During the survey, the depth gauge averaged 1.53m mAOD compared to 1.28m in May and August.

The average plant heights in August mapped in Figure 4 show that the plant growth was at its peak which also coincides with a PVI of 41cm. The southeast corner of the broad had the

most growth; this was also represented in the data from the PVI of transects A, B and C, these transects having some of the highest PVI, all between 47cm and 58cm.

The August map from Figure 5 shows the highest PAI which correlates with the 89.65% plant cover figures obtained from the data. The southeast corner again indicates vigorous growth which is represented from the data in those transects (A, B & C); 91% to 97% PAI. All the maps show the abundance of plant growth across all of the broad, with PAI between 84% to 89% from May to October. Throughout the year all transects recorded a PAI above 69% and at the height of the growing season (August) all 19 transects had a PAI of 82% or greater.

Figure 3

Water depths

May

August

October

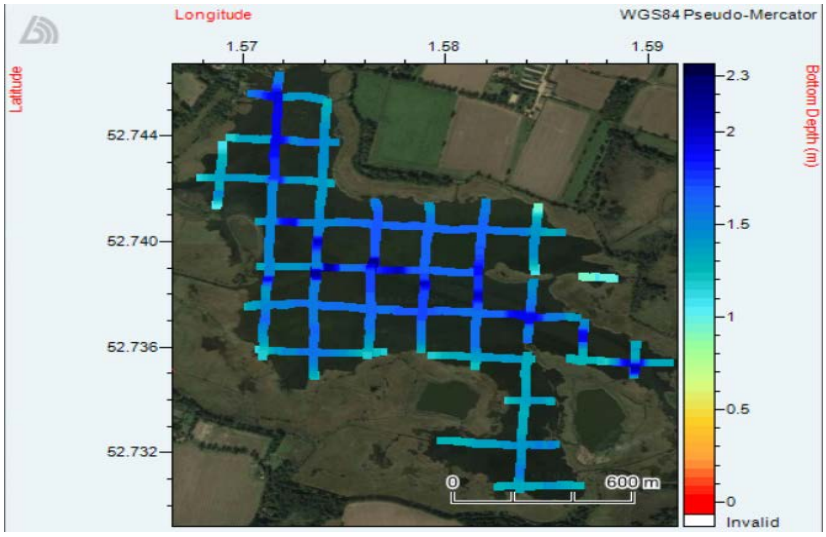
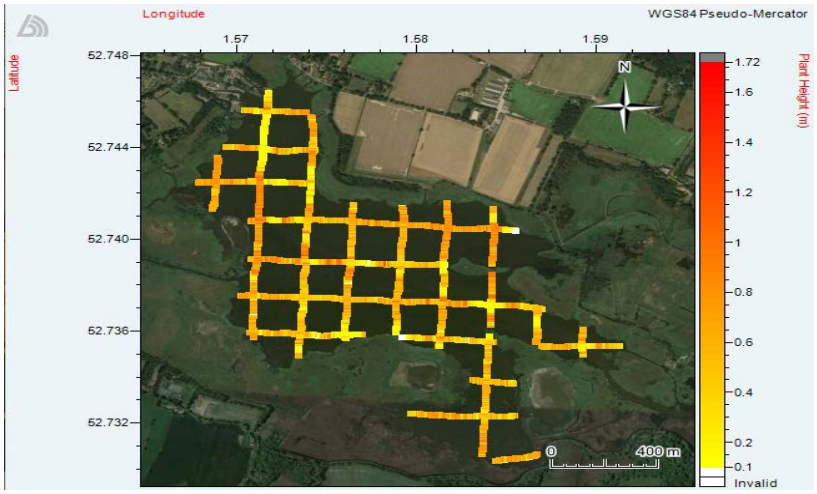


Figure 4

Average plant height

May

August



October

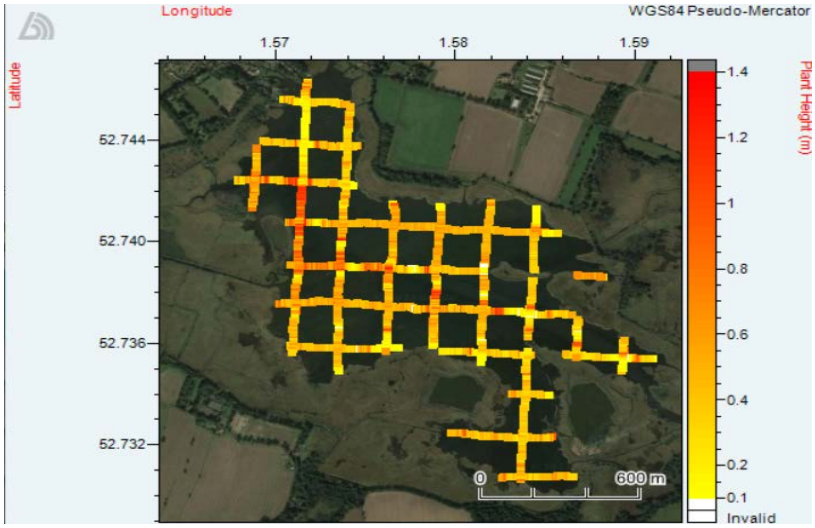


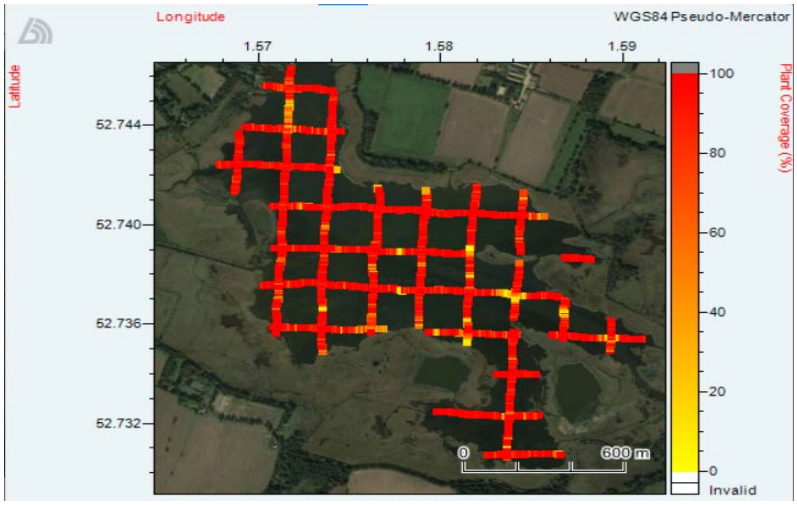
Figure 5

Average plant cover

May

August

October



Conclusions & Recommendations

- The hydroacoustic surveys of Hickling Broad reveal that water plant cover reached its highest value in August (90%) with lowest levels being measured in May, though this was very high at 84% compared to previous years.

- The higher than usual plant cover in May is likely due to a couple of factors, a good growing season in the previous year and the mild winter, reducing the natural die back of macrophytes. So, at the commencement of the growing season the was a good establishment of plants in the broad.

- The greatest value for mean plant height was recorded in August at 54cm compared to 57 cm the previous year, and the highest percentage volume of water plants was also recorded in August at 41% down from 50% recorded in 2022.

- Throughout the season, transects A, B & C had a minimum of 90%, an increase of 15% from 2022; in October they were all above 91%, identical to the previous year.

- Transect K had a high density of macrophytes throughout the year, with a minimum of 96% plant cover. It is one of the shallower and sheltered parts of the broad, with a good a stonewort population. Taking these factors into consideration, it provides favourable conditions for macrophytes to grow and become established. Stoneworts also retain a core structure if not disturbed or over-grazed, therefore due to the sheltered conditions, the plant bed is likely to retain its biomass through the seasons.

- All transects in august had plant cover above 82% with ten of them greater than 91%. The highest being 97% in transect A & K, which are locating in the shallow and sheltered edges of the broad. This is compared to sixteen transects in the previous year with plant cover greater than 81%.

- Transect F recorded the lowest plant cover of 69%, though still high compared to previous years. This is most likely due to a significant proportion of the transect dissecting the navigation channel.

- Mean PVI was highest in August at 41% at the peak of the growing season; it was lowest in October at 29%. October's results are likely to be skewed owing to particularly high water levels, 25cm higher compared to the May and August average depth.

- The new sonar equipment does seem to provide higher percentage results in comparison to the previous DTX biosonics sonar. Alterations to the software and the analysis criteria means that a direct comparison to previous survey data cannot be made. It should also be noted that changing weather patterns may continue to affect survey results by widening the variations of water levels throughout the survey season.

Acknowledgements

The Broads Authority would like to thank all those individuals and organisations who assisted during the 2022 survey season by providing their time, boats, identification skills or permissions.

Many thanks must be expressed to the landowners who kindly granted permission to access the privately owned & managed broads: Norfolk Wildlife Trust, Natural England, the Horsey Estate and the National Trust, RSPB, Fairhaven Garden.

Many thanks to those individuals who facilitated access to the broads this year; John Blackburn, Steve Collin, Adam Houlgate, Rick Southwood, Robin Buxton, Steve Prowse, Richard Starling, Simon Partridge and Chris Tubby from How Hill Trust, Tim Strudwick, Louise Rout.

Most of all many thanks all those who gave up their time to collect and assist with analysing the water plant data; Erin Holroyd, Abigail Leach, Wyn Purdy, Merlyn Purdy, Kylie Moos, Adam Hillburn, Georgina Lake, Elaine Green and Lorraine Taylor.

Work experience Rowan Senior, Hermione Chapman and Florence Adams.

A special thanks to Vicky Short for all the GIS work involved and Tom Waterfall for formatting and publishing the report.

Appendix I: Common water plants in the Broads

Table 27

Details of Broads water plants

Group	Scientific name	Common name	Section 41
Stoneworts	*Chara aspera*	Rough stonewort	
	C. baltica	Baltic stonewort	Y
	C. connivens	Convergent stonewort	Y
	C. contraria	Opposite stonewort	
	C. curta	Lesser bearded stonewort	
	C. globularis	Fragile stonewort	
	C. hispida	Bristly stonewort	
	C. intermedia	Intermediate stonewort	Y
	C. pedunculata	Hedgehog stonewort	
	C. virgata	Delicate stonewort	
	C. vulgaris	Common stonewort	
	Nitella flexilis	Starry stonewort	Y
	N. mucronata	Pointed stonewort	
	N. translucens	Translucent stonewort	
Vascular macrophytes	*Acorus calamus*	Sweet flag	
	Crassula helmsii	Australian swamp stonecrop	
	Callitriche sp.	Starwort sp.	
	Ceratophyllum demersum	Rigid hornwort	
	Elodea canadensis	Canadian waterweed	
	E. nuttallii	Nuttall's waterweed	
	Eleogiton fluitans	Floating club-rush	
	Glyceria maxima	Reed sweet grass	
	Hippuris vulgaris	Mare's tail	
	Myriophyllum spicatum	Spiked water milfoil	
	M. verticillatum	Whorled water milfoil	
	Najas marina	Holly-leaved naiad	Y
	Persicaria amphibia	Amphibious bistort	
	Potamogeton acutifolius	Sharp-leaved pondweed	
	P. berchtoldii	Small pondweed	
	P. crispus	Curled pondweed	
	P. friesii	Flat-stalked pondweed	
	P. lucens	Shining Pondweed	
	P. natans	Broad –leaved pondweed	
	P. obtusifolius	Blunt-leaved pondweed	
	P. pectinatus	Fennel-leaved pondweed	
	P. perfoliatus	Perfoliate pondweed	
	P. pusillus	Lesser pondweed	
	P. trichoides	Hair like pondweed	
	Potamogeton x Salicifolius	Willow-leaved pondweed	
	Ranunculus circinatus	Fan-leaved water crowfoot	
	Rorippa nasturtium-aquaticum	Water cress	
	Saggitaria sagittifolia	Arrowhead	
	Sparganium erectum	Branched bur-reed	

	S. emersum	Unbranched bur-reed	
	Stratiotes aloides	Water-soldier	
	Utricularia vulgaris	Greater bladderwort	
	Zannichellia palustris	Horned pondweed	
Free-floating or Round floating leaved macrophytes	*Hydrocharis morsus-ranae*	Frogbit	
	Lemna gibba	Inflated duckweed	
	L. minor	Common duckweed	
	L. minuta	Least duckweed	
	L. trisulca	Ivy-leaved duckweed	
	Nuphar lutea	Yellow water lily	
	Nymphaea alba	White water lily	
	Spirodela polyrhiza	Greater duckweed	
Macro-algae & Mosses	*Enteromorpha*		
	Fontinalis antipyretica	Common water moss	
	Hydrodictyon	Water net	
	Leptodictyum riparium	Stringy moss	
	Zygnematales	Filamentous algae	

For more information about Stoneworts please see:
https://www.yumpu.com/en/document/view/31414379/important-stonewort-areas-plantlife