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# A Biological Survey of the Blakeney Freshes: North Norfolk Report to the National Trust

B.J. Goldsmith, D.J. Hoare, J.I. Jones, G.N. Nobes and C.D.Sayer

**March 2004**

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# 1
# Introduction

## 1.1 Site Details

Blakeney Freshes in an area of low-lying grazing marsh on the North Norfolk coast, formed by the reclamation of salt marshes behind Blakeney spit (Figures 1 & 2). The area has long been recognised for its conservation value and was identified by Ratcliffe (1977) to be a Grade 1 site in the Nature Conservation Review. Reid *et al.* (1989) reiterated this describing the site as being of "key importance" due to it comprising of one of the most extensive areas of oligohaline-mesohaline grazing marsh in Norfolk. The marshes are particularly noted for a range of wintering and breeding birds, but also for the aquatic flora and fauna which inhabit the 25 km of drainage ditches that form a network across the site (Foster & Jackson 2000).

| | |
|---|---|
| **Location:** | Blakeney, Norfolk |
| **OS Grid Ref:** | TG 038447 |
| **Area:** | 165 ha |
| **Total ditch length** | c. 25 km |
| **Altitude:** | < 10 m |

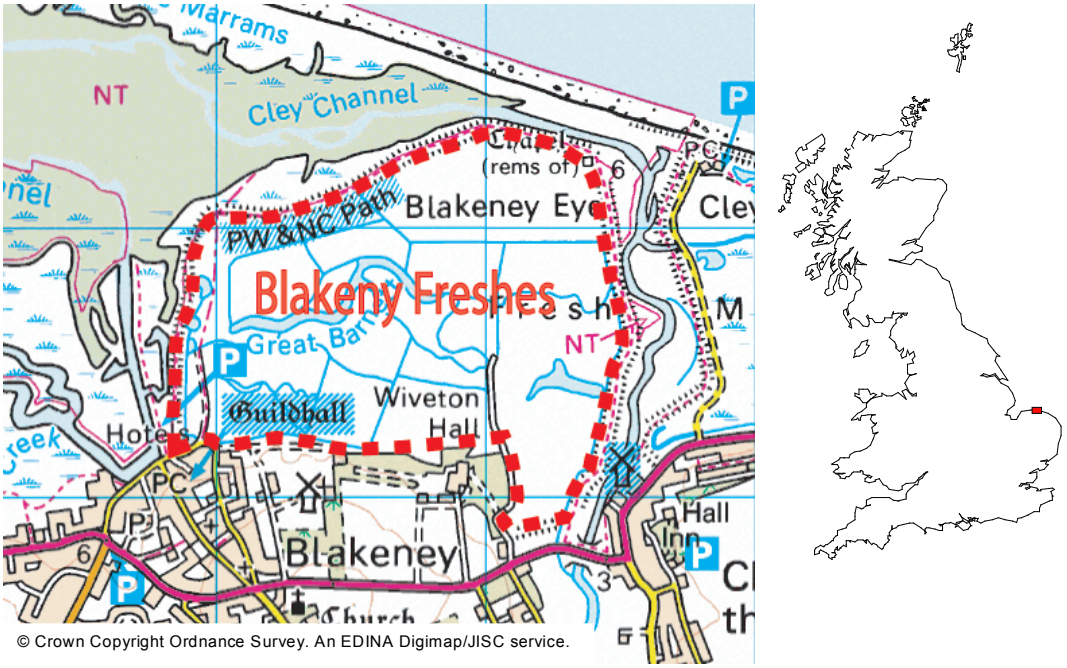


**Figure 1.** Location of Blakeney Freshes.

Blakeney Freshes is well recognised as an important component of what is one of the largest tracts of undeveloped coastal habitat of its type in Europe. It lies within 3 major statutory and non-statutory designations:

- a Ramsar site for wetlands of international importance, particulay for birds
- the North Norfolk Coast Site of Special Scientific Interest (SSSI)
- a Special Protection Area (SPA), under the EC Birds Directive.

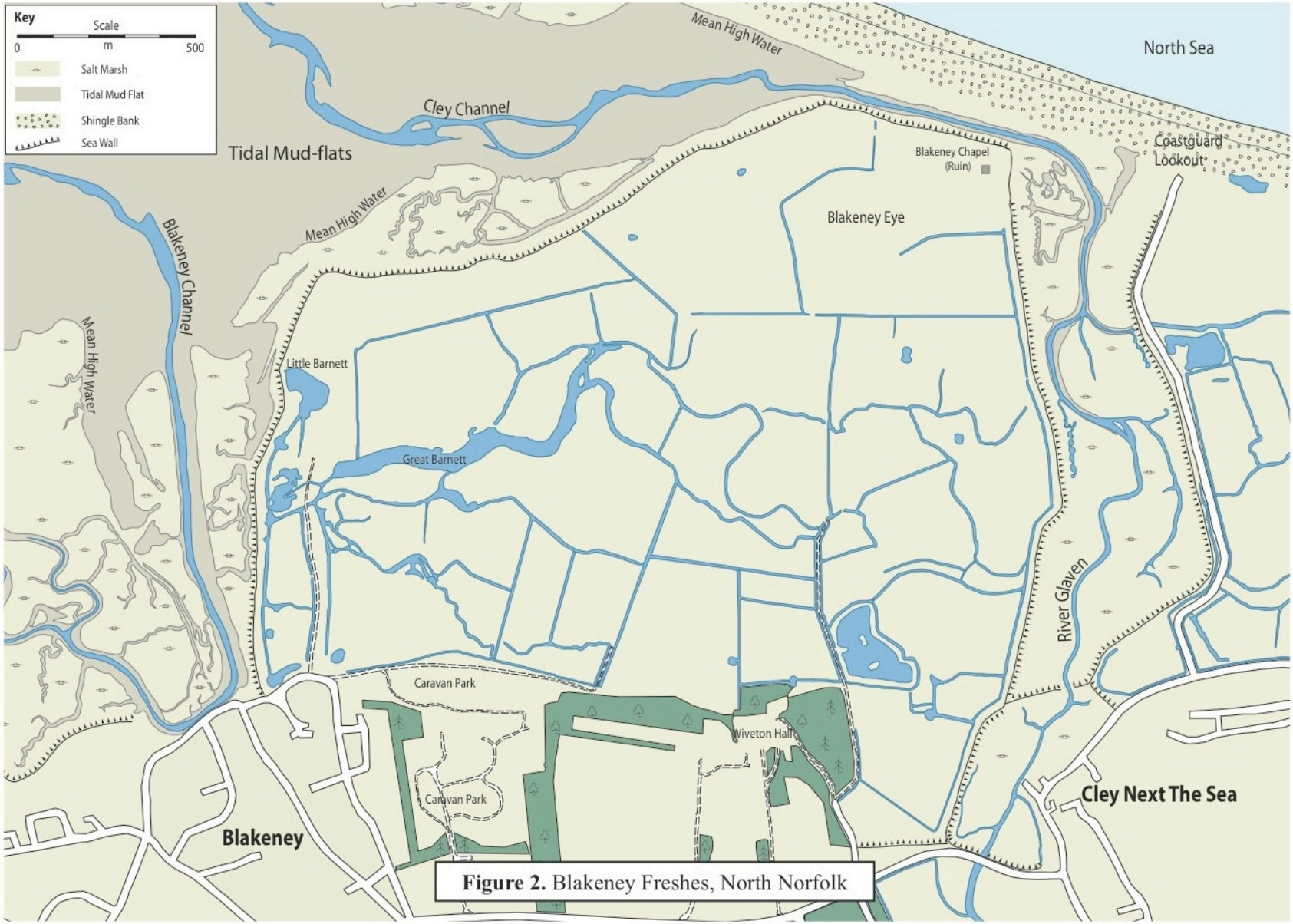


**Figure 2.** Blakeney Freshes, North Norfolk

## 1.2 Habitat Types

***Pasture***
The main area of the Blakeney Freshes is managed as semi improved pasture for grazing. The botanical interest of these areas was not investigated as part of this study but is reportedly low due to past agricultural improvement (Grove & Jackson 1991, Foster & Jackson 2000). Swards are dominated by common grasses interspersed with mainly common "weed" species e.g. ragwort and thistles. The elevated area to the NE of the site (Blakeney Eye) is more freely drained and was reported by Grove & Jackson (1991) to support gorse, in addition other common herb species. In 1997 these raised fields were reported as being not obviously different from the rest of the species poor enclosures (Foster & Jackson 2000). The north and north-westerly area of the marsh was generally more saline and the grass-dominated pastures appeared to be of lower productivity, with areas of bare mud exposed in the hollows where brackish water had collected

Although botanically of little interest, these pastures provide important feeding and roosting habitat for many bird species. In addition to the large numbers of geese and waders using the Freshes, marsh harriers were also seen hunting in the long grass during this survey.

***Reed-Beds***
The majority of common reed (*Phramites australis*) stands are concentrated around the larger areas of standing water to the west of the site. In particular Little and Great Barnett are dominated by reeds in large mono-specific stands. Access was very restricted to these areas making comprehensive surveys impossible. These large areas of reed-bed are of low floristic richness, but provide excellent cover for warblers, reed bunting and bearded tits (the latter seen and heard during surveying) as well as for larger birds including, it would be assumed, bittern.

Smaller stands of reeds associated with the ditch edges caused shading and generally resulted in low aquatic plant richness but higher numbers of different invertebrate species. Ditches fringed by reeds supported the highest aquatic beetle diversity and proved to be rich in mollusc species (see below). The value of reed-beds as good bird and invertebrate habitat makes then an important habitat type on the Freshes. They should however be managed to prevent further spreading which would determent other aspects of the aquatic flora.

***Drainage Ditches***
The ditches were the principal focus of this survey and the aquatic species are detailed below. In general the salinity gradient resulted in different species assemblages of both submerged and emergent vegetation. Many of the ditches were heavily clogged with *Enteromorpha* sp. resulting in dense shading of the water column. Common and ivy-leaved duck weed (*Lemna minor* and *L .trisulca*) also dominated many of the fresh-water ditches. A total of 15 species of submerged plant species were recorded, including two that are nationally rare; soft hornwort (*Ceratophyllum submersum*) and brackish water-crowfoot (*Ranunculus baudotii*).

Generally high plant biomass resulted in high numbers of invertebrates. This survey concentrated on molluscs (including bivalves) and beetles, finding 24 mollusc species and 36 beetle species.

Fish were also surveyed in the ditches using electrofishing techniques. Despite the apparent abundance of invertebrate food and good plant cover very few fish were captured or seen in

the ditches during the survey. Many water fowl and other birds were seen on or near the water demonstrating the value of the drainage ditches as important bird habitat.

***Open Water***
Very little of what appears to be open water from the map now remains due to the encroachment of the reed-beds. Access to Little and Great Barnett was restricted due to the reeds but it is assumed the extent of open water is now very limited, if any. The relatively new water body to the SE of the Freshes remains open with high submerged plant biomass; mainly of *Potamogeton berchtoldii.* Small areas of open water (ponds) can provide important habitat for plants, invertebrates, fish and birds and are of high conservation value when plant dominated with clear water and a balanced fish population, e.g. the "classic rudd pond".

## 1.3 Survey Aims

Due to the conservational importance of the Blakeney Freshes it is important to maintain comprehensive base-line data for the principal species groups that occur on the marshes. The focus of this survey was therefore on the aquatic habitats and concentrated of four major taxonomic groups:

- **Aquatic plants**
  - Submerged
  - Floating Leafed
  - Emergent
  - Marginal

- **Aquatic molluscs**
  - Snails
  - Bivalves

- **Aquatic Beetles**

- **Fish**

The principal objectives were:

- To determine the species composition and distribution of the aquatic plant communities.

- To compliment the 2002 aquatic macroinvertebrate survey (Harris & Driscoll 2002) with additional information on species of molluscs and beetles.

- To determine the species composition and biomass of the fish populations in the marsh ditches.

# 2
# Methods

## 2.1 Aquatic Macrophytes

A total of 99 survey points were sampled at approximately even intervals along the drainage ditches across the marsh (Figure 3). The area to the south-east was not surveyed due to restricted access from the land owner. The long ditch to the west of Blakeney Eye was dry and therefore not sampled. Dense reed stands also prevented access to Little and Great Barnet.

At each survey point marginal and emergent plant species were recorded and a grapnel trawl made across the width of the ditch was used to sample the submerged species. In addition to presence / absence data, species abundance was recorded at each site using a simple DAFOR scale with numeric codes assigned (Table 1). These data were combined to give a mean plant scores per ditch, to correspond with the 24 invertebrate sampling points. Field identification was used where possible with any uncertain or unidentified species placed in bags for laboratory identification. Iwan Jones and Carl Sayer were the principal plant analysts.

| DAFOR | Estimated abundance | Numeric code |
|---|---|---|
| D = Dominant | > 50% cover | 5 |
| A = Abundant | 10 - 50% cover | 4 |
| F = Frequent | 5 - 10% cover | 3 |
| O = Occasional | 2 -5% cover | 2 |
| R = Rare | < 1% cover - a trace | 1 |

**Table 1** DAFOR scale used to measure plant abundance at each sample point

## 2.2 Aquatic Invertebrates

A total of 24 sites were sampled across the study area from all available habitats at each site (Figure 3). Sites were chosen to give an even geographical coverage of the marsh and also to include a full range of aquatic habitats across the salinity gradient. Samples were collected with a standard 30 cm FBA invertebrate net with 1 mm mesh.

Where wading access was possible a one minute kick-netting techniques was employed alongside sweep-netting of the water column, plant beds and through emergent vegetation. Where access to the water was not possible sweep-netting only was employed but ensuring maximum agitation with the net in all sampled habitats. Netted material was transferred to a tray and large pieces of plant material discarded; making sure all invertebrates were first removed. The remaining samples were then placed into plastic bags and preserved with 50% alcohol.

In the laboratory the samples were sorted and all molluscs and beetles removed for identification to species level. Beetles were identified by Geoff Nobes, gastropods by Dan Hoare (with additional advice from Derek Howlett) and bivalves by Iwan Jones.


**Figure 3.** Blakeney freshes showing the 24 invertebrate and fish survey stations and the 99 plant sampling points

## 2.3 Fish Survey

Fish surveys were conducted, where appropriate, at the same sites used to sample invertebrates (Figure 3). No samples were taken at points 17 or 25. Site 17 was a very shallow pond area which periodically dries out and thus is unlikely to have fish. Site 25 is privately owned and permission was not granted for a fish survey.

Due to the high plant biomass in the ditches netting was not possible, and thus an electrofishing technique was used. Electrofishing works by passing an electric current through the water between two electrodes. This causes a muscular response from the fish, which results in temporary paralysis allowing them to be caught with a hand net. The fish can then be returned to the water where they quickly recover.

At each site fine mesh stop-nets were placed across the channel 25 m apart to isolate the site and prevent fish escaping beyond the nets. The section was then electrofished starting from one net and working towards the second net. Any fish seen were caught, identified, weighed, measured and then placed into a bucket of water to recover. The section was fished end to end until no more fish were caught. This method of depletion fishing allows for the total numbers and biomass of fish to be worked out for a given area. It is particularly effective where the water is clear with moderate plant cover.

## 2.4 Salinity

Water samples were taken from each invertebrate sampling station and analysed for conductivity. Samples ranged from 755 $\mu Scm^{-1}$ (fresh water) to 4660 $\mu Scm^{-1}$ (brackish). No sites were mesohaline (8000 - 14000 $\mu Scm^{-1}$), however.

# 3
# Results

## 3.1 Aquatic Macrophytes

A total of 45 species of aquatic plants were recorded, of which 40 were vascular plants, 4 were macro-algae (including one charophyte) and one an aquatic moss (Table 2).

| Scientific Name | Common Name | Site DAFOR |
|---|---|---|
| *Cladophora glomerata*. | Blanket weed | F |
| *Enteromorpha intestinalis* | Gut weed | A |
| *Hydrodictyon reticulatum* | Water net | O |
| *Chara vulgaris* var. *longibracteata* | Common stonewort | R |
| *Fontinalis squamosa* | Water moss | R |
| *Ranunculus sceleratus* . | Celery-leaved Buttercup | F |
| *Ranunculus circinatus* | Fan-leaved water-crowfoot | F |
| *Ranunculus baudottii* | Brackish water-crowfoot | O |
| *Ceratophyllum demersum* | Rigid hornwort | F |
| *Ceratophyllum submersum* | Soft hornwort | O |
| *Rorippa nasturtium-aquaticum* | Water-cress | O |
| *Epilobium hirsutum* | Great willowherb | O |
| *Oenanthe lachenalii* | Parsley water-dropwort | O |
| *Apium graveolens* . | Wild celery | R |
| *Apium nodiflorum* | Fool's-water-cress | O |
| *Solanum dulcamara* | Bittersweet | O |
| *Myosotis scorpioides* | Water forget-me-not | O |
| *Lycopus europaeus* | Gipsywort | O |
| *Callitriche stagnalis* | Common water-starwort | A |
| *Veronica anagallis-aquatica* | Blue water-speedwell | O |
| *Veronica catenata* | Pink water-speedwell | O |
| *Alisma plantago-aquatica* | Water-plantain | O |
| *Elodea canadensis* | Canadian waterweed | O |
| *Elodea nuttallii* | Nuttall's waterweed | O |
| *Triglochin maritimum* | Sea arrowgrass | R |
| *Potamogeton berchtoldii* | Small pondweed | A |
| *Potamogeton pectinatus* | Fennel pondweed | O |
| *Potamogeton crispus* | Curled pondweed | R |
| *Potamogeton trichoides* | Hairlike pondweed | R |
| *Zanichellia palustris* | Horned pondweed | O |
| *Lemna minor* | Common duckweed | D |
| *Lemna trisulca* | Ivy-leaved duckweed | A |
| *Juncus gerardii* | Saltmarsh rush | O |
| *Juncus maritimus* | Sea rush | O |
| *Juncus inflexus* | Hard rush | O |
| *Juncus effusus* | Soft rush | O |
| *Eleocharis palustris* | Common spike-rush | F |
| *Bulboschoenus maritimus* | Sea club-rush | A |
| *Schoenoplectus tabernaemontani* | Grey club-rush | A |
| *Carex otrubae* | False fox-sedge | O |
| *Phragmites australis* | Common reed | D |
| *Glyceria maxima* | Reed sweet-grass | F |
| *Sparganium erectum* | Branched bur-reed | F |
| *Typha latifolia* | Bulrush | O |
| *Iris pseudacorus* | Yellow flag | R |

**Table 2.** Aquatic plant species list for Blakeney Freshes ditch system

Many of the aquatic plant species recorded are typical of those found associated with the ditches of freshwater-brackish coastal grazing marshes (e.g. Driscoll 1986, Reid *et al.* 1989). The occurrence of two relatively uncommon species, soft hornwort (*Ceratophyllum submersum*) and brackish water-crowsfoot (*Ranunculus baudottii*), was also noted by Reid *et al.* (1989). These species were locally common but without more detailed information from the Reid *et al.* survey it is not possible to establish any change in the abundance of these species. See Appendix I for a full species list for all sites.

***Species Richness***

The number of aquatic plant species sampled at each the 99 sample sites ranged from 3 to 13, with a modal value of 7 (Figure 4).

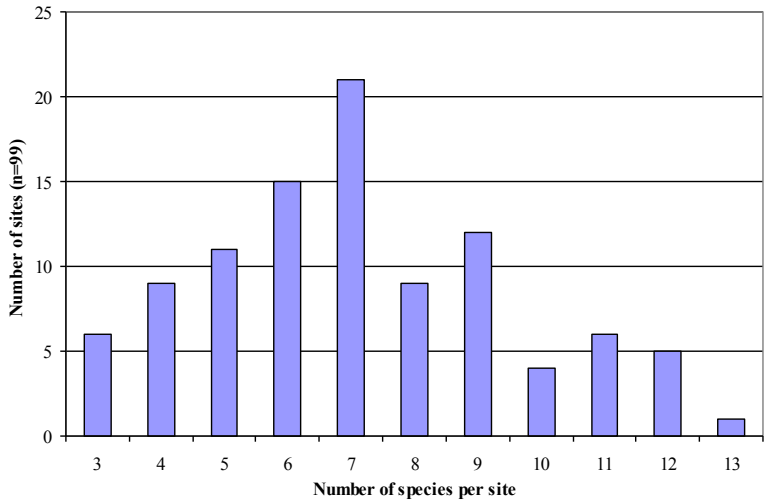


**Figure 4.** Aquatic plant richness from the 99 sampling sites

The patterns of species richness varied considerably over the marsh. The most species rich site was station 65, a small freshwater side channel off the east-west ditch, to the south of Blakeney Eye. This site was boggy in addition to having an area of deeper water and had many emergents in addition to submerged species. Stations 38, 39 and 40 were also relatively species rich as were 22 and 23. Sites of lower diversity mainly fell into two groups, those with brackish water and those shaded by dense reed-beds. Station 25 was heavily shaded by *Phragmites* reed and supported no other emergent plant species and only water starwort (*Callitriche stagnalis*) growing in the water. Similarly station 45 had a dense cover of *Phragmites* and grey club-rush (*Schoenoplectus tabernaemontani*) and only common duckweed (*Lemna minor*) on the water surface. The brackish sites contained very few submerged plant species and were generally of lower diversity, many of these were also reed fringed e.g. stations 51, 55 and 56.

In order to better understand the structure of the vegetation in the ditches the plant data were combined into groups to represent average scores for each ditch corresponding with the invertebrate and fish samples. Two sites were from standing water (invertebrate sites 17 and 24) and are thus not considered directly comparable with the ditch samples, but have been included to represent the standing waters. The structure of the vegetation is also more easily considered when split into truly “aquatic” species, i.e. those submerged under the water or living on the water surface and “emergent” species, i.e. those plants which are tolerant of inundation but have the majority of their structure out of the water.

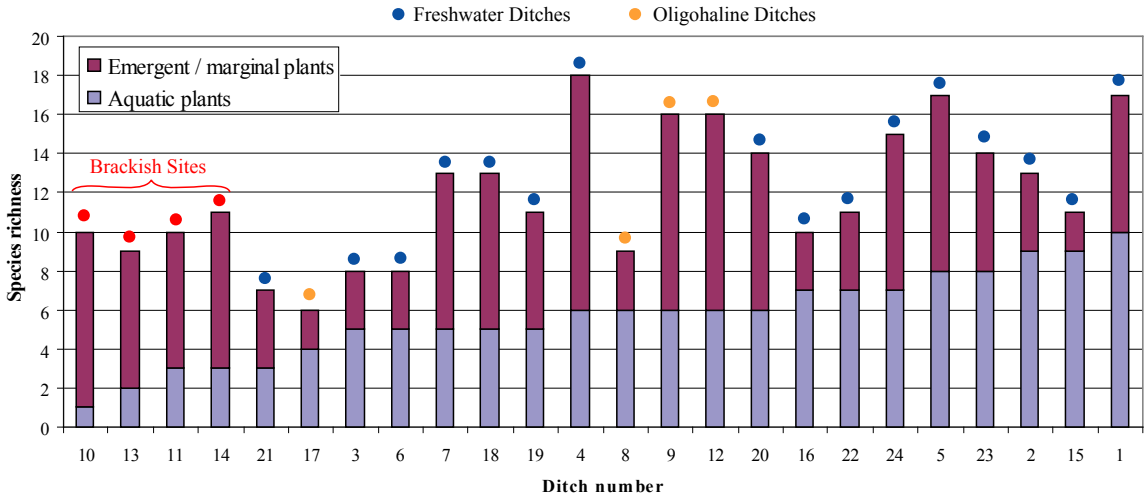


**Figure 5.** Aquatic plant richness from the 24 ditches sampled for invertebrates and fish - ordered by aquatic species richness

Figure 5 shows the combined species richness of the ditches where invertebrate and fish samples were collected. These data clearly demonstrate the most saline ditches to have low numbers of aquatic plant species. The distinction between the oligohaline and freshwater ditches if less clear from the species richness alone, there were however particular species which occurred at greater abundance at slightly elevated salinity e.g. *Ceratophyllum submersum* and *Potamogeton pectinatus.*

***Species Distribution***

In order to establish the shift in species composition between the ditches the technique of detrended correspondence analysis (DCA, Hill & Gauch 1980) was used. The results of DCA ordination can be represented as a bi-plot of the sites (Figure 6) whereby the ditches of similar species composition occur close together and those less similar far apart. The DCA was run both with and without the standing-water sites (17 and 24) included. Site 17 in particular had a strong influence on the ordination (see Figure 6 - inset) due to its somewhat unusual flora. The analysis was therefore re-run using only the ditch data. The DCA summary statistics are presented in Table 3.

| Axes | | 1 | 2 | 3 | 4 | Total inertia |
|---|---|---|---|---|---|---|
| Eigenvalues | : | 0.431 | 0.364 | 0.114 | 0.068 | 2.707 |
| Lengths of gradient | : | 3.098 | 3.967 | 1.574 | 1.473 | |
| Cumulative percentage variance of species data | : | 15.9 | 29.4 | 33.6 | 36.1 | |
| Sum of all eigenvalues | | | | | | 2.707 |

**Table 3.** DCA summary statistics for Blakeney Freshes plant data

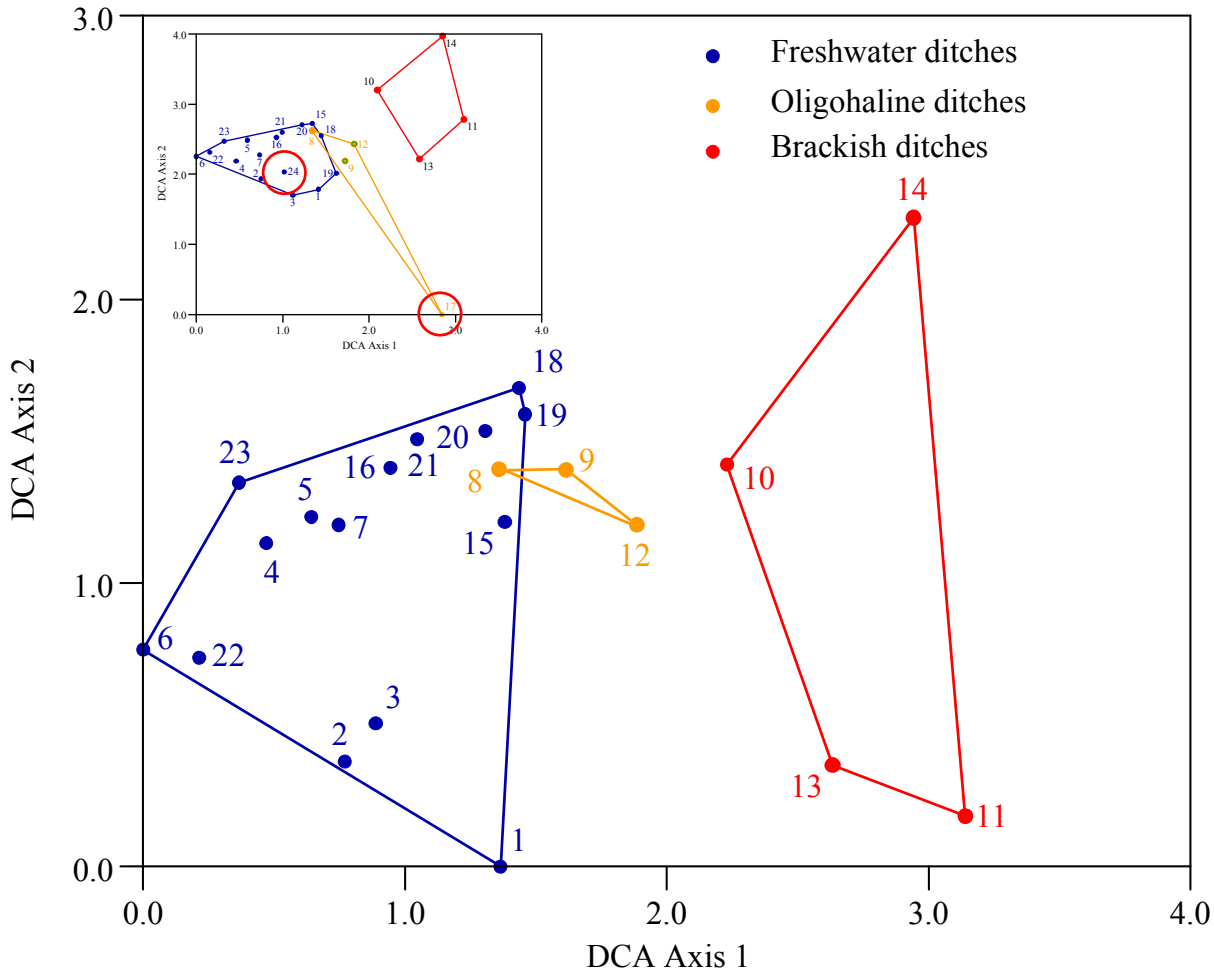


**Figure 6.** DCA ordination bi-plot with sites grouped by salinity - see text for explanation

**The DCA Bi-plot**

Detrended correspondence analysis (DCA) (Hill & Gauch 1980) is an indirect ordination method allowing for complex multivariate species data to be represented in two-dimensional space (bi-plots). An important feature of DCA is that the axes are scaled in units of average standard deviation of species turnover (Gauch 1982). A species can be seen to appear, rise to its mode and then disappear over a distance of just under 4 axis units (4 SD), thus complete species turnover is considered to have occurred over this range i.e. site of >4 axis units apart will have no species in common (Kent & Coker 1992). Conversely, two sites which plot close together will share many similar species.

The first DCA axis (Axis 1) appears to represent the salinity gradient with all four brackish sites plotting to the right of the bi-plot and freshwater sites to the left. These sites are characterised by low aquatic plant diversity and salt-tolerant marginal species e.g. *Juncus maritimus* and *Bulboschoenus maritimus*. The difference in salinity between the "fresh" sites and those falling into the "oligohaline" category was relatively small and this is reflected by the oligohaline sites plotting close to the freshwater sites. Many other factors also influence the distribution of the plant species and the relatively long length of DCA axis 2 reflects this. No single variable stands out as influencing the spread of DCA axis 2, but factors such as ditch structure and disturbance from livestock poaching are likely to be important.

The dominance of *Phragmites australis* at many sites from fresh to brackish makes it difficult to classify the ditch sites on the basis of their plant communities due to the problems discussed by Reid *et al*. (1989), whereby many different NVC communities become overlain, and thus no simple classification can be made. Despite the prevalence of common reed however this survey shows many different sub-communities to exist due to both changes in salinity and differences in ditch structure and management. Rather than attempting to classify these different communities here we will simply re-iterate the value of maintaining this ditch-type diversity.

- The gradient from fresh to brackish water[1] evidently results in an increase in the total number of species at Blakeney Freshes. In the brackish ditches the continued occurrence of soft hornwort (*Ceratophyllum submersum*) and brackish water-crowfoot (*Ranunculus baudottii*) provides considerable botanical value to the site. The maintenance of this salinity gradient is therefore strongly recommended.

- The diversity of ditch-types provides a broad range of different habitats which appear to suit different aquatic and emergent / marginal species. Fenced ditches were generally richer in herb species whereas grazed / poached areas favoured species tolerant of disturbance e.g. celery-leaved buttercup. The maintenance of ditch diversity through structured management should continue to enhance the botanical interest of the site.

- Habitat diversity is further enhanced by small ponds. Where these areas are remnants of the old salt-marsh channels (e.g. site 17) and have elevated salinity, they are a stronghold for brackish water-crowfoot (*Ranunculus baudottii*), and provide an important habitat for the nationally scarce water beetle *Hygrotus parallelogrammus* (see below).

***Problems***

One of the major problems encountered in the Blakeney Freshes ditch system was the high levels of gut weed (*Enteromorpha intestinalis*) and blanket weed (*Cladophora glomerata*) (and to a lesser extent, common duckweed (*Lemna minor*)). When occurring at very high concentrations these species are indicative of nutrient enrichment (eutrophication) and can cause a decline in the ditch quality due to a "choking" effect. The dense surface layers shade submerged plant species and greatly increasing the biological oxygen demand on the water, particularly at night and as the weed decays, thus reducing the water quality for invertebrates and fish. Gut weed is normally found in more saline areas but has been reported to thrive in freshwater at elevated nutrient concentrations (Kamer and Fong 2001) where the high nitrates were shown to ameliorate the effects of reduced salinity in fresh water.

Dense floating mats of gut weed where evident on the SW area of marsh, particularly ditches 4 and 5 and the surrounding ditches that were not surveyed. Without good water quality data, it is impossible to determine if this problem is due to high nutrients, but we would strongly recommend water quality surveys are conducted over the marsh and procedures implemented to reduce nutrient inputs where possible.

[1] Mesohaline conditions were also reported by Harris and Driscoll (2002) but were not measured during this survey.

### 3.2 Aquatic Beetles (*Coleoptera*)

A total of 914 specimens of water beetle were identified from the 24 sampling sites, comprising 36 different species (Table 4).

| Species | IUCN Status (Other status) | Total identified | Number of sites | Site DAFOR |
|---|---|---|---|---|
| ***GYRINIDAE*** | | | | |
| *Gyrinus caspius* | LRlc | 3 | 2 | R |
| *Gyrinus substriatus* | LRlc | 1 | 1 | R |
| ***HALIPLIDAE*** | | | | |
| *Peltodytes caesus* | LRnsB (Nb) | 5 | 3 | O |
| *Haliplus confinis* | LRlc | 3 | 3 | O |
| *Haliplus immaculatus* | LRlc | 7 | 4 | O |
| *Haliplus lineatocollis* | LRlc | 2 | 2 | R |
| *Haliplus ruficollis* | LRlc | 9 | 7 | O |
| *Haliplus ruficollis* group females | LRlc | 30 | 15 | F |
| *Haliplus wehnckei* | LRlc | 1 | 1 | R |
| ***HYGROBIIDAE*** | | | | |
| *Hygrobia hermanni* | LRlc | 44 | 9 | F |
| ***NOTERIDAE*** | | | | |
| *Noterus clavicornis* | LRlc | 348 | 23 | D |
| ***DYTISCIDAE*** | | | | |
| *Hygrotus impressopunctatus* | LRlc | 1 | 1 | R |
| *Hygrotus inaequalis* | LRlc | 61 | 13 | F |
| *Hygrotus parallelogrammus* | LRnsB (Nb) | 3 | 1 | R |
| *Hyphydrus ovatus* | LRlc | 200 | 15 | D |
| *Graptodytes pictus* | LRlc | 10 | 8 | O |
| *Nebrioporus elegans* | LRlc | 4 | 3 | O |
| *Agabus bipustulatus* | LRlc | 4 | 1 | R |
| *Agabus sturmii* | LRlc | 12 | 5 | O |
| *Ilybius ater* | LRlc | 1 | 1 | R |
| *Ilybius fuliginosus* | LRlc | 4 | 3 | O |
| *Ilybius quadriguttatus* | LRlc | 2 | 2 | R |
| *Rhantus suturalis* | LRnsB (Nb) | 1 | 1 | R |
| *Colymbetes fuscus* | LRlc | 1 | 1 | R |
| *Laccophilus hyalinus* | LRlc | 10 | 4 | O |
| *Laccophilus minutus* | LRlc | 12 | 5 | O |
| *Hydroporus palustris* | LRlc | 35 | 9 | F |
| ***HELOPHORIDAE*** | | | | |
| *Helophorus minutus* | LRlc | 7 | 5 | O |
| *Helophorus obscurus* | LRlc | 2 | 1 | R |
| ***HYDROPHILIDAE*** | | | | |
| *Anacaena globulus* | LRlc | 1 | 1 | R |
| *Anacaena limbata* | LRlc | 27 | 11 | F |
| *Laccobius bipunctatus* | LRlc | 15 | 5 | F |
| *Laccobius colon* | LRlc | 29 | 8 | F |
| *Laccobius striatulus* | LRlc | 2 | 2 | R |
| *Helochares lividus* | LRnsB (Nb) | 1 | 1 | R |
| *Enochrus testaceus* | LRlc | 10 | 7 | O |
| *Hydrobius fuscipes* | LRlc | 6 | 4 | O |

**Table 4**. Full species list of aquatic beetles sampled from Blakeney Freshes

### 3.2.1. Conservation Status[2]

No Red Data Book species were found on the Blakeney Freshes, but four Notable (Nb) species were identified:

- *Peltodytes caesus* in samples Ditch 4, 9 & 10.
- *Hygrotus parallelogrammus* Site 17.
- *Rhantus suturalis* Ditch 14.
- *Helochares lividus* Ditch 23.

***Species Notes***

***Peltodytes caesus*** **Family *Haliplidae***

**Distribution**
This species has been found as far north as Cheshire, but is predominantly found in southern England where it is a declining fenland species but locally common. Its distribution in Norfolk mainly centres around the north-west coast, but it has also been found at Winterton. A survey of the River Waveney dykes in 1997 found it to be widespread in the area (Nobes & Jackson 1997). It is also found occasionally in dykes in other areas of Broadland. It is usually found in slightly brackish water although records from freshwater exist from Breckland (west Norfolk) and it was found in this survey in ditch 4 (conductivity <1000 $\mu Scm^{-1}$).

**Habitat and ecology**
*P. caesus* is confined to low lowland slow-moving drains and ponds with permanent water, often brackish and always base-rich. Typically, these lie in areas of old grazing fen on coastal marshes although it does occur well inland. The larvae and adults feed on filamentous algae, and possibly also on stoneworts. Oviposition occurs in the spring on submerged vegetation. Fully grown larvae and teneral adults occur later in the summer.

**Status**
This species has been recorded from 35 hectads in England and Wales since 1990. *Peltodytes caesus* appears on many Red Lists in Europe (Foster 2000).

**Threats**
The decline in this species appears to be mainly due to habitat loss, but it is also sensitive to changes in water quality and land use. The conversion of grazing fen to arable land, which results in a reduction of dykes (Driscoll 1978, 1983, 1985), may therefore be an important threat.

**Management and conservation**
Most of the drainage systems on which it occurs are protected as SSSI under management agreements. In the absence of clear guidance on its habitat requirements, maintenance of traditional grazing fen must be considered appropriate (Foster 2000).

[2] Beetle identification and species notes by Geoff Nobes, Springside, Carbrooke. Thetford. Norfolk. IP256SQ. Tel : 01953-883859.

***Hygrotus parallelogrammus*** **Family *Dytiscidae***

**Distribution**
This species is widespread in coastal locations thrroughout Britain. Nobes has 8 locations for this species in Norfolk, from Snettisham in the west to Winterton in the east.

**Habitat and ecology**
Almost all records are for stagnant brackish water on the coast. There is one inland site in East Anglia, at Dogsthorpe Star Brickpit, Peterborough. This is consistent with the findings of this survey where it was only recorded at site 17, a shallow area of standing, oligohaline water which probably once formed part of a salt marsh channel.

**Status**
There have been 19 hectad records in Britain since 1990.

**Threats**
Coastal developments continue to result in a loss of habitats, in particular stagnant ditches and larger brackish pools.

**Management and conservation**
*Hygrotus parallelogrammus* occurs in mainly in sites receiving protection as SSSI or NNR and management of such sites should include the provision of open-bottomed pools (Foster 2000).

***Rhanthus suturalis*** **Family *Dytiscidae***

**Distribution**
This species occurs throughout Britain, but is more common in the south of England. It is common in fen sites in Norfolk. It also occurs in slightly brackish pools on the coast. In this survey it only occurred in one brackish ditch - 14 (2260 $\mu Scm^{-1}$).

**Habitat and ecology**
*Rhantus suturalis* occurs at the edges of exposed lowland pools and dykes amongst rich vegetation. It overwinters in the water as an adult. This species readily takes flight and is readily attracted to lights.

**Status**
*Rhanthus suturalis* has been recorded from 91 hectads in England and Wales since 1990.

**Threats**
This species is not considered to be under threat.

**Management and conservation**
Creation of new ponds and ditches will be beneficial to this species. It is not confined to primary fen conditions and does not require statutory protection (Foster 2000).

***Helochares lividus*** **Family *Hydrophilidae***

**Distribution**
This scavenger water beetle is relatively common throughout Britain including Norfolk

**Habitat and ecology**
This species is found in very shallow water amongst grass and mud at the edges stagnant ponds and dykes. A characteristic of *Helochares* is that the eggs are not placed in cocoons at the edges of the water, but are carried by the female in a bag on the ventral surface. Egg-carrying females are found mainly in May, small larvae at the end of May and the pupae in July (Hansen 1987). Only one specimen was found in this survey in ditch 23.

**Status**
*Helochares lividus* has been recorded from 174 hectads since 1990. These data indicate the need for this species to lose its "Nationally Scarce" status (Foster 2000).

**Threats**
This species is not under threat.

***Other species***
All of the other species of water beetles found in this survey are relatively common and widespread species found throughout Norfolk in a variety of habitats.

The whirligig beetle *Gyrinus caspius* is usually found in slightly brackish water dykes on the coast, but it is also common in some of the Broads. During this survey it was found in two brackish ditch sites: 11 & 13.

A remarkable 33 specimens of the screech beetle *Hygrobia hermanni* were found in the sample from the open water habitat at site 24. It is very unusual to get such a congregation, as normally only odd individuals are found.

Notable by its absence from the survey was the smaller *Noterus,* particularly *Noterus crassicornis.* This species is very common in The Broads and usually turns up in abundance in surveys there. This species was also not recorded at Blakeney Freshes by Harris and Driscoll (2002).

Other notable absentees were *Hydroporus* species other than *palustris.* Other very common species not found were *Ochthebius minimus* and *Hydraena riparia.* These are minute water beetles living in mud in very shallow water and are best caught using other sampling methods, e.g. a flour sieve. The commonest beetle

recorded was *Noterus clavicornis*. This species was found in all but one of the samples (ditch 7).

The assemblage of water beetles found in the survey was fairly ordinary, and apart from the brackish water species, would be found in most ponds and dykes throughout the county. The species list for beetles is very similar to that produced by Harris and Driscoll (2002), with three additional notable species found. One specimen of the notable brackish water species *Dytiscus circumflexus* was found by Harris and Driscoll, but was not found in this survey. A full list of species found at each site is given in Appendix II.

### 3.2.2 Species Distribution

With the exception of one common species, *Noterus clavicornis*, the distribution of beetles was very uneven across the marsh. A DCA plot of the sites demonstrates this with a wide spread of points on both the first and second axes (Figure 7). The length of the first two axes indicates high species variability. Salinity is obviously important on the first axis with the four most saline sites plotting to the right of the bi-plot. These brackish sites were relatively diverse (except 11) and had surprisingly high numbers of individuals. This is consistent with the findings of Drake (2003), who reported a decline in many of the invertebrate groups in the brackish areas of grazing marshes, but not coleopterans. The brackish and oligohaline sites accounted for three of the four notable beetle species.

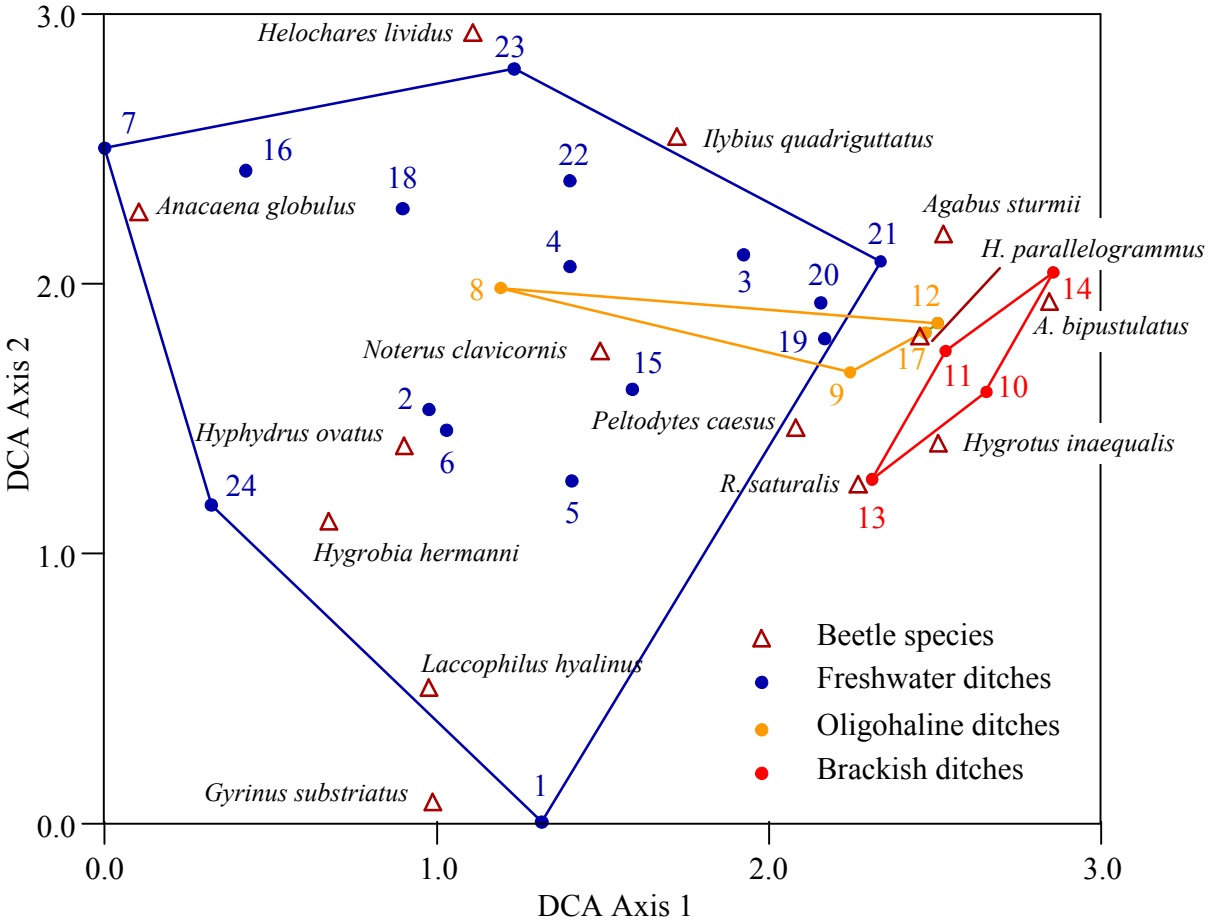


**Figure 7.** DCA ordination bi-plot of the beetle data with sites grouped by salinity - rare and indicative species are also plotted

The wide distribution of sites along DCA axis 2 appears to be habitat related. Site 1 was a deep, steep-sided ditch with emergent vegetation restricted mainly to one site. Sites 2, 5, 6 and 24 were also deeper ditches with open water. Sites with high DCA axis 2 scores were generally shallow with gently sloped margins and dense emergent and aquatic vegetation e.g. sites 7, 16, 18, 22 and 23. Habitat diversity is widely reported as being a key element in the maintenance of beetle diversity in grazing marsh ditches (Painter 1999, Harris & Driscoll 2002, Drake 2003).

***Factors affecting beetle diversity***

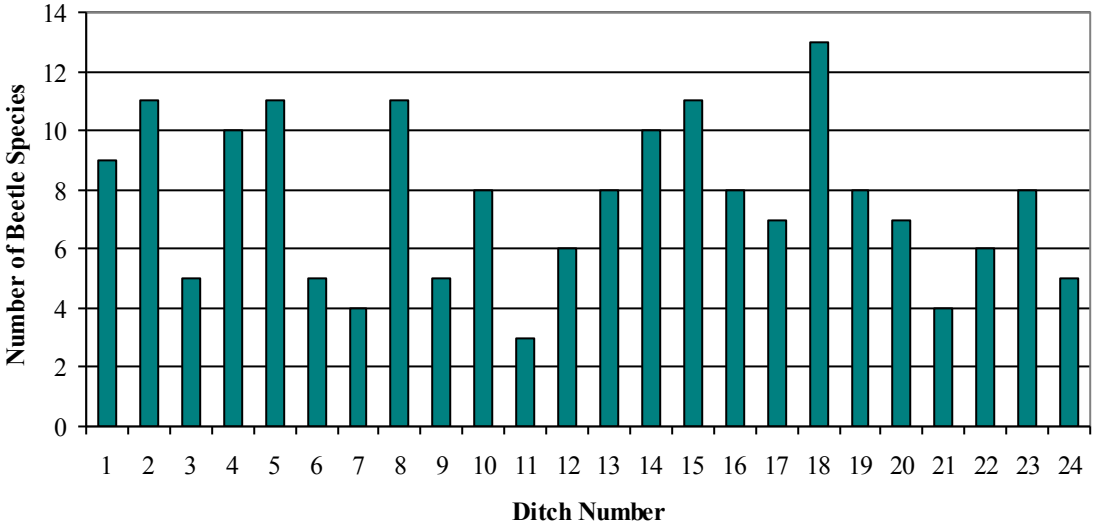


**Figure 8.** Number of aquatic beetle species in the 24 ditch sites sampled at Blakeney Freshes

There was considerable range in the species richness between the sites, ditch 18 having the most species with 13 and ditch 11 having the least with only 3 species (Figure 8). There was no apparent relationship between beetle diversity (measured as Hill's N2 (Hill 1973) and number of plant species (aquatic and emergent), but a significant relationship ($R^2 = 0.287$, P = 0.007) was seen between only the aquatic plant species and beetle diversity (Figure 9). No trend was observed between diversity and number of emergent species, however.

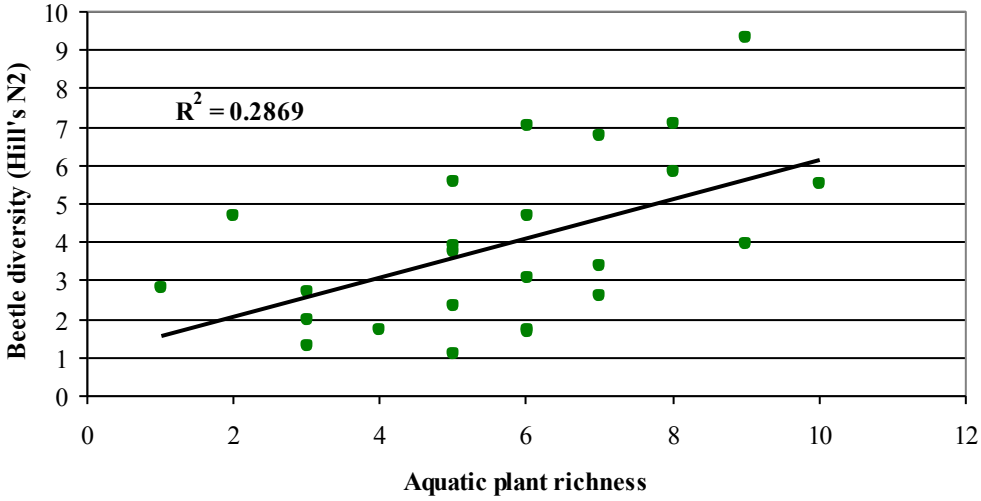


**Figure 9.** Relationship between beetle diversity and aquatic plant richness

Beetle diversity at the brackish sites appeared to be less affected by aquatic plant richness, no doubt due to the additional species present in these ditches which are salt tolerant. If the pattern between beetle diversity and aquatic plant species richness is considered without the brackish sites included, a stronger relationship is seen ($R^2$ 0.35, P = 0.006, Figure 10).

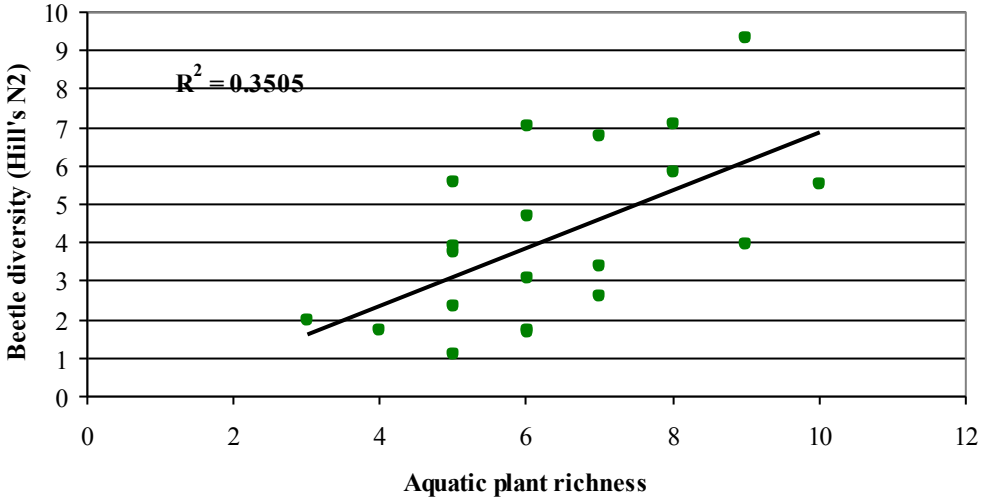


**Figure 10.** Relationship between beetle diversity and aquatic plant richness in the freshwater and oligohaline ditches (Brackish sites removed)

***Recommendations***

These data highlight two important management considerations for coleopteran conservation on the Blakeney Freshes:

- The salinity gradient provides a range of conditions which promotes the total number of beetle species present over the marsh. In addition the brackish sites provide an important refuge for nationally rare beetle taxa. Maintenance of this salinity gradient should be paramount in any future plans for the area, with particular attention paid to including brackish ponds.

- Beetle diversity is linked to habitat diversity and aquatic plant species richness. It is therefore important that the freshwater / oligohaline ditches and other wetland areas are managed to encourage the growth of aquatic plants to provide good beetle habitat. Marginal and emergent vegetation does not appear to be important for beetle diversity, but its importance as habitat for particular beetle species and for other species groups e.g. other invertebrates, birds and mammals, requires that a balance of marginal and aquatic habitats are maintained over the marsh.

### 3.3 Aquatic Molluscs (*Gastropoda and Bivalva*)

A total of 15 aquatic snail species and 6 bivalve species were found from the 24 sampled sites (Table 5). All of the species found are common to East Anglia. In addition to the truly aquatic snails, species of *Succinea* (amber snails) were also found. This genus is generally considered to be a terrestrial marsh dwelling snail, but often lives on emergent vegetation and is therefore knocked into the water during sampling. This group is not included in any analysis below. The most wide spread taxon, occurring at every sample site, was *Potamopyrgus antipodarum*, a small non-native mud-snail, thought to have been introduced from the Antipodes in the mid nineteenth century. This tiny snail is now reported to be the most commonly occurring snail species in the UK, being found in almost all brackish and coastal freshwater sites from Shetland to the Scilly Isles (Clare Eno *et al.* 1997). Despite its alien origin and widespread occurrence, no detrimental effects are reported from the presence of *Potamopyrgus antipodarum.*

| Species | Total Identified | Number of Sites | Site DAFOR |
|---|---|---|---|
| ***Gastropoda*** | | | |
| ***Bithyniidae*** | | | |
| *Bithynia tentaculata* | 47 | 14 | A |
| ***Hydrobiidae*** | | | |
| *Potamopyrgus antipodarum* | 80 | 24 | D |
| ***Lymnaeidae*** | | | |
| *Lymnaea auricularia* | 1 | 1 | R |
| *Lymnaea palustris* | 24 | 14 | A |
| *Lymnaea peregra* | 75 | 23 | D |
| *Lymnaea stagnalis* | 11 | 7 | F |
| ***Physidae*** | | | |
| *Physa fontanalis* | 62 | 20 | D |
| ***Planorbidae*** | | | |
| *Anisus vortex* | 85 | 23 | D |
| *Bathyomphalus contortus* | 1 | 1 | R |
| *Gyraulus albus* | 4 | 2 | O |
| *Gyraulus crista* | 21 | 12 | A |
| *Hippeutis complanatus* | 40 | 15 | A |
| *Planorbis carinatus* | 54 | 18 | A |
| ***Valvatidae*** | | | |
| *Valvata cristata* | 25 | 9 | F |
| *Valvata piscinalis* | 42 | 13 | A |
| ***Succineidae*** | | | |
| *Succinea* sp. | 6 | 5 | 0 |
| ***Bivalvia*** | | | |
| ***Sphaeriidae*** | | | |
| *Sphaerium corneum* | 2 | 1 | R |
| *Muculium lacustre* | 85 | 18 | A |
| *Pisidium subtruncatum* | 104 | 12 | A |
| *Pisidium personatum* | 21 | 3 | F |
| *Pisidium nitidum* | 19 | 6 | F |
| *Pisidium milium* | 3 | 3 | O |
| *Pisidium* sp. juvenile | 16 | 5 | N/A |

**Table 5.** Full species list of aquatic molluscs sampled from Blakeney Freshes

### 3.3.1 Mollusc Species Distribution

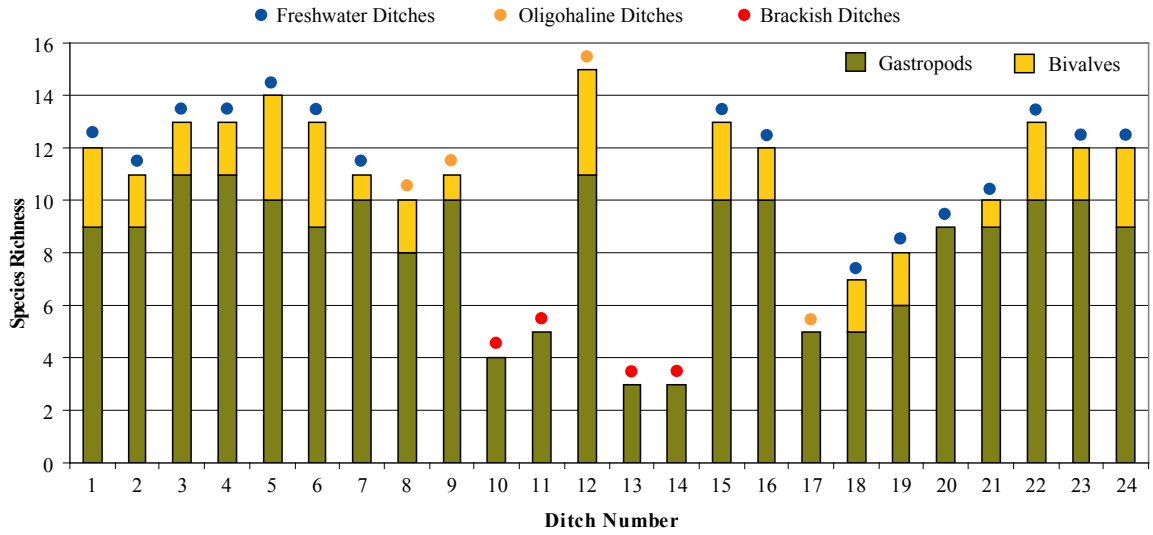


**Figure 11.** Number of mollusc species in the 24 ditch sites sampled at Blakeney Freshes

The total number of mollusc species at each site ranged from only 3 at sites 13 and 14 to 11 at site 12 (Figure 11). The brackish sites were the least diverse and had no bivalve species. A similar pattern was observed in the total number of molluscs sampled from each site (Figure 12).

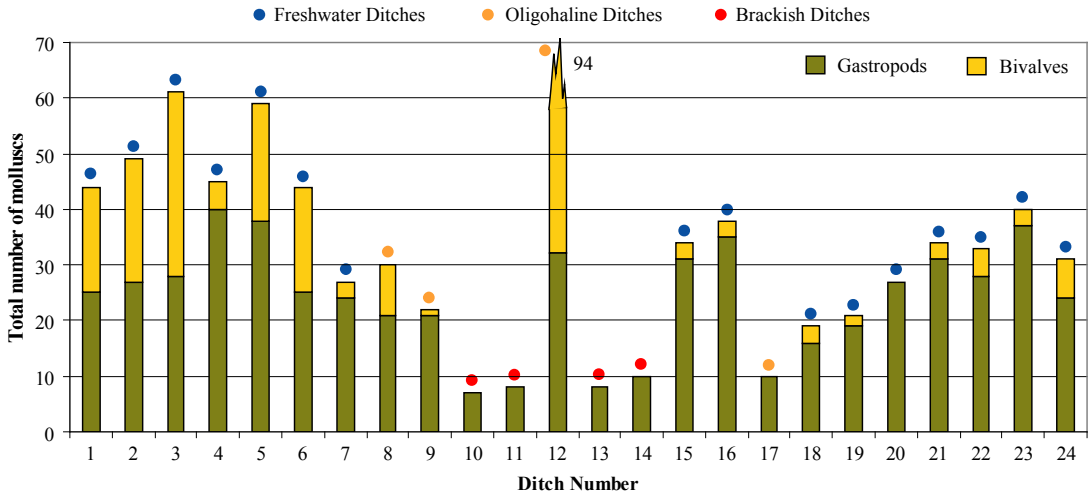


**Figure 12.** Total mollusc abundance in the 24 ditch sites sampled at Blakeney Freshes

These data show the freshwater and oligohaline ditches (with the exception of site 17) to support the highest numbers of molluscs and the most species. Only very low numbers of snails were in the samples from the more saline sites. Species tolerant of the brackish conditions were: *Lymnaea peregra, L. palustris, Anisus vortex, Physa fontinalis, Gyraulus crista* and *Potamopyrgus antipodarum*, with only the latter species being found in all four brackish ditches.

One of the primary reasons for the observed variation in mollusc diversity appears to be the availability of good habitat. The majority of aquatic snail species found in this survey live and feed within the submerged network of aquatic plants. No measure of the actual aquatic plant structure was taken, but it can be assumed that higher numbers of plant species will provide a greater range of habitat types than species poor sites. The data collected in this survey show a clear significant relationship ($R^2 = 0.547$, $P < 0.005$) between the number of mollusc species and the number of aquatic plant species (Figure 13).

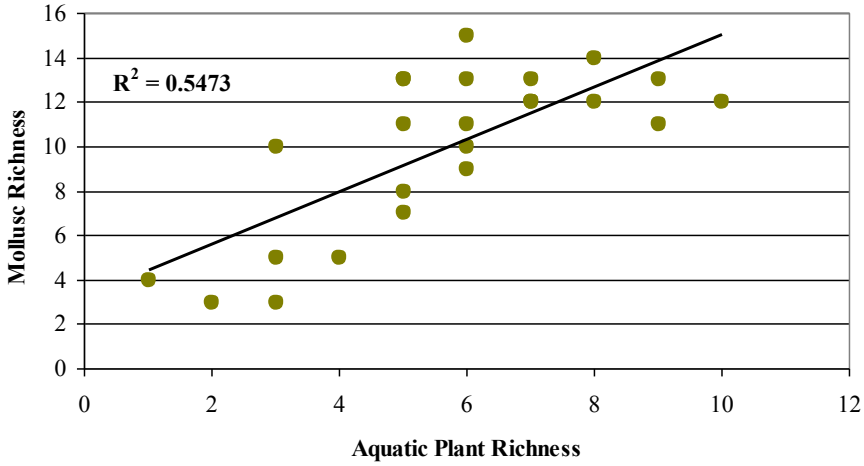


**Figure 13.** Relationship between mollusc richness and aquatic plant richness at Blakeney Freshes

This is perhaps an oversimplification of the reality, but it does highlight the importance of ensuring that some ditches are maintained to encourage a diverse aquatic flora for the benefit of the invertebrate fauna. Again it should be stressed that a range of ditch types is also important to provide different levels of vegetation structure and further increase overall habitat diversity across the marsh.

### 3.4 Fish

A total of six species of fish were recorded from eight of the 23 sample stations (site 24 was not fished). The number and mean weights / sizes (in parenthesis) of the fish recorded at each site are given below. Where fish did occur, the total numbers and biomass was low. Site 1and 2 supported the highest fish numbers with approximately one fish per 10 $m^2$ of surface area, accounting for 20.6 $g/m^2$ (±0.49) and 5.9 $g/m^2$ (±0.97) respectively.

| Common Name | Scientific name |
|---|---|
| Pike | *Esox lucius* |
| Roach | *Rutilus rutilus* |
| Rudd | *Scardinius erythrophthalmus* |
| Eel | *Anguilla anguilla* |
| 3 spined stickleback | *Gasterosteus aculeatus* |
| 9 spined stickleback | *Pungitius pungitius* |

**Table 6**. Fish species recorded from Blakeney Freshes

**Ditch 1** Fish seen shoaling
Pike 1 (1.6 kg) Poor condition
Roach 8 (46 g)
Rudd 2 (45 g)

**Ditch 2** Fish seen shoaling
Roach 6 (59 g)

**Ditch 3**
Pike 1 (1.5 kg) Poor condition

**Ditch 4** Eel seen but not caught
Eel 1 (<100 g))

**Ditch 10**
3-spine 5 (3 cm)

**Ditch 11**
9-spine 5 (3 cm)

**Ditch 15** Numerous fry seen and netted (<2.5 cm)
Rudd fry 50+ (1.5 cm)

**Ditch 21**
3-spine 1 (3 cm)

Despite the considerable length of ditch systems at Blakeney Fleshes, and abundant invertebrate population, very few fish were recorded. Pike, roach and rudd were restricted to the deeper ditches where open water occurred, but plant cover was plentiful, while the sticklebacks were found in shallower ditches with low submerged aquatic plant diversity. The two pike were both using dense emergent vegetation for cover. Both were in rather poor condition, no doubt as a result of low prey densities.

***Potential reasons for low fish stocks***

At the time of sampling the water level in many of the ditches was below normal and the overall flux of water across the marsh was low. Under these conditions there is a high risk of dissolved oxygen levels falling to critical levels for fish, particularly in the shallow ditches where thick reed-beds or dense coverings of *Enteromorpha* or *Lemna minor* restrict light penetration and place a high respiratory demand on the water during the night. Repeated periods of de-oxygenation render the ditches uninhabitable to many fish species and appear to restrict the majority of the very limited fish population to the few deeper ditches on the south-west side of the marsh. Nine-spine sticklebacks often favour dense, over-grown ditches and are tolerant of very low oxygen levels and slightly saline conditions. (Wheeler 1998).

Higher background salinity and periodic saline inundation, render the ditches on the north side of the marsh unsuitable for most freshwater fish species. The 3-spined stickleback is widely tolerant to salinity (up to sea water salinity) and is found in a wide range of habitats including small ponds and ditches without any plant cover (Wheeler 1998).

Theses findings suggest that the very low fish population in the freshwater ditches is most likely due to periods of low dissolved oxygen. Although de-oxygenation is a feature of many small, shallow water bodies during the warmer summer months, it is greatly exacerbated by nutrient enrichment where high algal (and *L. minor*) growth greatly increases the respiratory demand and results in more regular episodes of anoxia.

***Recommendations***

The problem of nutrient enrichment is common to the majority of agricultural lowlands in the UK and grazing marshes are no exception. If, as suspected, the Blakeney Freshes are receiving high nutrient inputs, the problems of increased algal and *L. minor* growth will be made worse, which in turn, is likely to result in increased periods of anoxia. The scope of this survey was insufficient to address these issues and it is therefore recommended that a detailed catchment level assessment is made of water quality in an attempt to identify the scale of the problem and allow for more informed management decisions to be made in light of the findings.

# 4
# Summary of Findings

The ditch structure varied greatly over the marsh in terms of salinity, channel form, disturbance, aquatic vegetation and emergent / marginal vegetation. This wide range of habitat types is of high conservation value in terms of both its flora and fauna. Two species of plant are particularly worthy of note: soft hornwort (*Ceratophyllum submersum*) and brackish water-crowfoot (*Ranunculus baudottii*) were both recorded as occasional and although not listed as nationally scarce are nonetheless only locally common. Both these species are tolerant of salinity. Three nationally scarce species of aquatic beetle were also recorded: *Peltodytes caesus, Rhantus suturalis* and *Hygrotus parallelogrammus*, the latter species favouring open-bottomed ponds with elevated salinity, an increasingly rare habitat. The marsh ditches also supported a diverse mollusc population although no rare taxa were recorded.

The fish population was recorded as being very low, with the majority of fish being found in the deeper more open ditches on the south west side of the marsh. The problems of prolific algal and duckweed growth are thought likely to restrict fish from many of the ditches due to periods of anoxia during summer. Eutrophication is suspected as the primary cause of these conditions. Typically, nutrient enrichment results in loss of aquatic diversity and is therefore likely to have a major effect on invertebrate communities and other species groups which rely on the invertebrates for food e.g. fish and birds.

### 4.1 Recommendations

**1.** Ensure ditch type diversity is maintained, focussing on four main issues:
- Maintain a salinity gradient from fresh to mesohaline. Two of the nationally scarce beetle taxa and both uncommon plants are most closely associated with the brackish environment.
- Maintain a range of disturbance regimes (livestock poaching/grazing) from complete exclusion to full access.
- Ensure a range of emergent and aquatic vegetation structures exist - i.e. 5-10 year cycles of ditch clearance promote aquatic plant diversity, but older ditches provide additional habitats often lost through regular maintenance (Painter1999).
- Maintain a variety of different water depths; deeper waters are less prone to anoxia and therefore favoured by fish. Shallow water has been shown to be important to some invertebrate species, particularly in brackish ditches (Drake 2003)
- Promote open water areas and small ponds across the salinity gradient. Such habitats are becoming increasingly rare at a national and regional level due to both drainage and natural infilling. Freshwater ponds can provide a valuable refuge to fish during low flow conditions when dissolved oxygen can drop to critical levels in the ditches. Open water also provides additional habitat for some of the more notable plant and invertebrates found during this survey, e.g. *Ceratophyllum submersum* and *Ranunculus baudottii* and the water beetle *Hygrotus parallelogrammus*.

2. Ensure regular (quarterly) water quality monitoring is implemented to inform future management of the ditches and ponds:
    - Determine nutrient (N and P) and salinity concentrations at a range of sites across the marsh.
    - Establish major nutrient sources by extending water quality surveys to a catchment level.

3. Ensure the biological monitoring of the aquatic environment (plants, invertebrates and fish) at Blakeney Freshes is maintained at a minimum of 5-6 year intervals.

# 5
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# Appendix I

## Full plant list for the 99 sampling points

| Site No | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Cladophora glomerata* | 3 | | | 5 | 4 | | | 2 | | | | | | | | |
| *Enteromorpha intestinalis* | | | | | | | | 1 | 2 | | 2 | 2 | 2 | 2 | | |
| *Hydrodictyon reticulatum* | | | | | | | | | | | | | | | | |
| *Chara vulgaris* var. *longibracteata* | | | | | | | | | | | | | | | | |
| *Fontinalis squamosa* | | | | | | | | | | | | | | | | |
| *Ranunculus sceleratus* | | | | | | | | | | | | | | | | |
| *Ranunculus circinatus* | | | | 4 | 5 | 5 | | | | 2 | 2 | 2 | 2 | 2 | | |
| *Ranunculus baudottii* | | | | | | | | | | | | | | | | |
| *Ceratophyllum demersum* | | | | | 1 | | | | | 1 | | | | | | |
| *Ceratophyllum submersum* | | | | | | | | | | | | | | | | |
| *Rorippa nasturtium-aquaticum* | | | | | | | | | | | | | | | | |
| *Epilobium hirsutum* | 3 | 3 | | | | | | 2 | | 1 | | 2 | 1 | 2 | | |
| *Oenanthe lachenalii* | | | | | | | | | | | | | | | | |
| *Apium graveolens* | 2 | | | | | | | | | | | | | | | |
| *Apium nodiflorum* | | | | | | | | | | | | | | | | |
| *Solanum dulcamara* | | | | | | | | | | | | | | | | |
| *Myosotis scorpioides* | | | | | | | | | | | | | | | 2 | |
| *Lycopus europaeus* | | | | | | | | | | | | | | | 2 | 1 |
| *Callitriche stagnalis* | 5 | 2 | 4 | 1 | | | 4 | 2 | 2 | 1 | 1 | 4 | 2 | 2 | 4 | 1 |
| *Veronica anagallis-aquatica* | | | | | | | | | | | | | | | | |
| *Veronica catenata* | | | | | | | | | | | | | | | | |
| *Alisma plantago-aquatica* | | | | | | | | | | | | | | | | |
| *Elodea canadensis* | | 2 | | | 1 | | 2 | | | 1 | 1 | | 1 | | | |
| *Elodea nuttallii* | | | | | | | | | | 1 | | | | | | |
| *Triglochin maritimum* | | | | | | | | | | | | | | | | |
| *Potamogeton berchtoldii* | | 2 | 5 | 1 | 2 | 1 | 2 | | 2 | 1 | 2 | | | | 1 | |
| *Potamogeton pectinatus* | | | 3 | | | | | | | | | | | | | |
| *Potamogeton crispus* | | | | | | | | | | | | | | | | |
| *Potamogeton trichoides* | | | | | | | | | | | | | | | | |
| *Zanichellia palustris* | | | | | | | | | | | | | | | | |
| *Lemna minor* | 4 | 3 | 3 | | 3 | | 4 | 2 | 4 | 1 | 2 | 3 | 1 | 1 | 2 | 1 |
| *Lemna trisulca* | 4 | 2 | 4 | | 3 | 4 | 2 | | | | | 2 | | | | |
| *Juncus gerardii* | | | | | | | | | | | | | | | | |
| *Juncus maritimus* | | | | | | | | | | | | | | | | |
| *Juncus inflexus* | | | | | | | | 1 | | | | | | | | |
| *Juncus effusus* | | | | | | | | | | | | | | | | |
| *Eleocharis palustris* | | | | | | | | | | | | | | | | |
| *Bulboschoenus maritimus* | 5 | 5 | 5 | 5 | 5 | 5 | | 3 | | | | | | 3 | 4 | |
| *Schoenoplectus tabernaemontani* | | 4 | 4 | 5 | 4 | 5 | | 2 | | | | | | | 4 | |
| *Carex otrubae* | | | | | | | | | | | | | | | | |
| *Phragmites australis* | | | | | 3 | 4 | 5 | 4 | 5 | 4 | 4 | 3 | 3 | 4 | 2 | 5 |
| *Glyceria maxima* | | | | | | | | 4 | 5 | | | | | | | |
| *Sparganium erectum* | | | | | | | | | | | | | | | 2 | |
| *Typha latifolia* | | | | | | | | | | | | | | | | |
| *Iris pseudacorus* | | | | | | | | | | | | | | | | |

| Site No | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Cladophora glomerata* | 5 | 4 | 5 | | | | | | 3 | | | | | | | |
| *Enteromorpha intestinalis* | 4 | | | | 5 | 5 | 5 | 5 | | 4 | 5 | 5 | 5 | 5 | 5 | 4 |
| *Hydrodictyon reticulatum* | | | | | | | | | | | | | | | | |
| *Chara vulgaris* var. *longibracteata* | | | | | | | | | | | | | | | | |
| *Fontinalis squamosa* | | | | | | | | | | | | | | | | |
| *Ranunculus sceleratus* | | | | | | | | | | | 1 | | 1 | | | |
| *Ranunculus circinatus* | | | | 1 | | | | | | | | | | | | |
| *Ranunculus baudottii* | | | | | | | | | | | | | | | | |
| *Ceratophyllum demersum* | | | | | | 1 | 1 | | | 1 | | | | | | |
| *Ceratophyllum submersum* | | | | | | | | | | | | | | | | |
| *Rorippa nasturtium-aquaticum* | | | | | | | 2 | | | | | | | | | |
| *Epilobium hirsutum* | | | | | | | 1 | | | | | | | | | |
| *Oenanthe lachenalii* | | | | | | | | | | | | | | | | |
| *Apium graveolens* | | | | | | | | | | | | | | | | |
| *Apium nodiflorum* | | | | | | 1 | | | | 2 | | | 2 | | | 2 |
| *Solanum dulcamara* | | | | | | | | | | | | | | | | |
| *Myosotis scorpioides* | | | | | | | 2 | | | 2 | | | | | | |
| *Lycopus europaeus* | | | | | 1 | | 2 | 3 | | | 3 | | | 2 | | |
| *Callitriche stagnalis* | 3 | 3 | 4 | 3 | 1 | 4 | | 2 | 5 | 1 | | | 2 | 5 | 4 | 5 |
| *Veronica anagallis-aquatica* | | | | | | | | | | | | | | 1 | | |
| *Veronica catenata* | | | | | | | | | | | | | | | | |
| *Alisma plantago-aquatica* | | | | | | 1 | | | | 2 | | | | | | |
| *Elodea canadensis* | | | | | | 3 | | | | | | | 1 | | | |
| *Elodea nuttallii* | | | | | | | | | | | | | | | | |
| *Triglochin maritimum* | | | | | | | | | | | | | | | | |
| *Potamogeton berchtoldii* | | | | 1 | 3 | 3 | 3 | 2 | | 4 | 4 | 4 | 2 | 4 | 4 | 3 |
| *Potamogeton pectinatus* | | | | | | | | | | | | | | | | |
| *Potamogeton crispus* | | | | | | | | | | | | | | | | |
| *Potamogeton trichoides* | | | | | | | | | | | | | | | | |
| *Zanichellia palustris* | | | | | | | | | | | | | | | | |
| *Lemna minor* | 2 | 1 | | 2 | | | 1 | | | 3 | 3 | 4 | 2 | 3 | 2 | 5 |
| *Lemna trisulca* | 2 | 2 | | 1 | | | | | | | | | 1 | 3 | 1 | 2 |
| *Juncus gerardii* | | | | | | | | | | | | | | | | |
| *Juncus maritimus* | | | | | | | | | | | | | | | | |
| *Juncus inflexus* | | | | 1 | | | 3 | | | | | | | | | |
| *Juncus effusus* | | | | | | | | | | | | | | | | |
| *Eleocharis palustris* | | | | | | 3 | 3 | | | | | 1 | | | | |
| *Bulboschoenus maritimus* | 2 | 2 | 1 | | 1 | 2 | | 1 | | | | | | | | |
| *Schoenoplectus tabernaemontani* | | | | | 1 | | | | | | 2 | | | | | |
| *Carex otrubae* | | | | | | 2 | 1 | | | | | 1 | | | | |
| *Phragmites australis* | 5 | 5 | 5 | 4 | | | | 5 | 5 | | | 4 | | | | 5 |
| *Glyceria maxima* | | | 1 | | 5 | | | | | 4 | 4 | 2 | 5 | 5 | 5 | 4 |
| *Sparganium erectum* | | | | | 2 | 3 | 3 | | | | | | | | | |
| *Typha latifolia* | | | | | | | | | | | | | | | | |
| *Iris pseudacorus* | | | | | | | | | | | | | | | | |

| Site No | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Cladophora glomerata* | | | | | | | | 2 | | | | | | | | |
| *Enteromorpha intestinalis* | | | | | | 3 | | | | | | | | | | |
| *Hydrodictyon reticulatum* | | | | | | | | | | | | | | | | |
| *Chara vulgaris* var. *longibracteata* | | | | | | | | | | | 3 | | | | | |
| *Fontinalis squamosa* | | | | | | | | | | | 2 | | | | | |
| *Ranunculus sceleratus* | | | | 2 | | | 3 | 2 | | 1 | 2 | | | | | |
| *Ranunculus circinatus* | | | | | | | | | | | | | | | | |
| *Ranunculus baudottii* | | | | | | | | | | | | | | | | |
| *Ceratophyllum demersum* | | | | 2 | 4 | 2 | 1 | | | | | | | | | |
| *Ceratophyllum submersum* | | | | | | | | | | | | | | | | 2 |
| *Rorippa nasturtium-aquaticum* | | | | | | | | | | 1 | | | | | | |
| *Epilobium hirsutum* | | | | 1 | | 3 | 1 | | 1 | | | | | | 1 | |
| *Oenanthe lachenalii* | | | | | | 2 | 1 | 1 | | 3 | | | | | | |
| *Apium graveolens* | | | | | | | | | | | | | | | | |
| *Apium nodiflorum* | 2 | | | | | | | | 2 | | 4 | | | 1 | | |
| *Solanum dulcamara* | | | | | | | | | | | | | | | 1 | |
| *Myosotis scorpioides* | | | | | | | | | | | | | | | | |
| *Lycopus europaeus* | 2 | | | | | | | 1 | | | | | | | | |
| *Callitriche stagnalis* | 4 | 1 | | 4 | | | 3 | 1 | | 2 | 2 | 5 | | | | |
| *Veronica anagallis-aquatica* | | | | | | | | | | | | | | | | |
| *Veronica catenata* | | | | | | | | | | | | | | | | |
| *Alisma plantago-aquatica* | | | | 3 | | 1 | 1 | | 1 | | | | | 1 | | |
| *Elodea canadensis* | | | | | | | | | | | | | | | | |
| *Elodea nuttallii* | | | | | | | | | | | | | | | | |
| *Triglochin maritimum* | | | | | | | | | | 2 | | | | | | |
| *Potamogeton berchtoldii* | 3 | 1 | | 3 | 4 | 2 | | | | | | | | | | 1 |
| *Potamogeton pectinatus* | | | | | | | | | | | | | | | | |
| *Potamogeton crispus* | | | | | | | | | | | | | | | | |
| *Potamogeton trichoides* | | | | | | | | | | | | | | | | |
| *Zanichellia palustris* | | | | | | | | 1 | | | | | | | | |
| *Lemna minor* | 5 | 5 | 4 | 4 | 3 | 4 | 2 | 2 | 4 | | | 4 | 3 | 5 | | |
| *Lemna trisulca* | 2 | | | 4 | 3 | | | | | 2 | | | | | | |
| *Juncus gerardii* | | | | | | | | | | | | | | | | |
| *Juncus maritimus* | | | | | | | | | | | | | | | 2 | 3 |
| *Juncus inflexus* | | | | | | | | | | | | | | | | |
| *Juncus effusus* | | | | | | 2 | | | | | | 1 | | | 1 | |
| *Eleocharis palustris* | 3 | | | | | | 3 | 2 | 4 | 3 | 3 | | | | | |
| *Bulboschoenus maritimus* | | 1 | 4 | | | 1 | 2 | 1 | 2 | | 3 | 2 | | | | 2 |
| *Schoenoplectus tabernaemontani* | | | | | | 3 | 2 | 2 | | 4 | | | 5 | | | 4 |
| *Carex otrubae* | 2 | | | | | 1 | | 1 | | | | | | | 1 | |
| *Phragmites australis* | 5 | 5 | 5 | 4 | 5 | 4 | 3 | 2 | 5 | 4 | 4 | 5 | 4 | 5 | 5 | |
| *Glyceria maxima* | | | | | | | | | | | | | | | | |
| *Sparganium erectum* | 3 | | | | | | | | | | | | | | | |
| *Typha latifolia* | | | | | | | | | | | | | | | 1 | |
| *Iris pseudacorus* | | | | | | | | | | | | | | | | |

| Site No | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Cladophora glomerata* | | | | | | | | | 1 | | | | | | 1 | |
| *Enteromorpha intestinalis* | | | | | | | | | | | 4 | 3 | 3 | | | |
| *Hydrodictyon reticulatum* | | | | | | | | | | | | | | | | |
| *Chara vulgaris* var. *longibracteata* | | | | | | | | | | | | | | | | |
| *Fontinalis squamosa* | | | | | | | | | | | | | | | | |
| *Ranunculus sceleratus* | | | | | | | | | | 1 | | | | | | 2 |
| *Ranunculus circinatus* | | | | | | | | | | | | | | | | |
| *Ranunculus baudottii* | | | | | | | | | | | | | | | | |
| *Ceratophyllum demersum* | | | | | | | | | 2 | | 3 | 3 | 4 | | | |
| *Ceratophyllum submersum* | 2 | 2 | | | | | 1 | | | | | | | 3 | 5 | 5 |
| *Rorippa nasturtium-aquaticum* | | | | | | | | | | | | | | | | |
| *Epilobium hirsutum* | | | | | | | | | | | | | | | | |
| *Oenanthe lachenalii* | | 1 | | 1 | | 1 | | | | | | | | | | |
| *Apium graveolens* | | 1 | | | | | | | | | | | | | | |
| *Apium nodiflorum* | | | | | | | | 1 | | 1 | | | | | | |
| *Solanum dulcamara* | | | | | | | | | | | | | | | | |
| *Myosotis scorpioides* | | | | | | | | | | | | | | | | |
| *Lycopus europaeus* | | | | | | | | | | | | | | | | |
| *Callitriche stagnalis* | | | | | | | | | 1 | 2 | 2 | 3 | 2 | | | |
| *Veronica anagallis-aquatica* | | | | | | | | | | | | | | | | |
| *Veronica catenata* | | | | | | | | | | | | | | | | |
| *Alisma plantago-aquatica* | | | | | | | | | 1 | 1 | | | | | | |
| *Elodea canadensis* | | | | | | | | | | | | | | | | |
| *Elodea nuttallii* | | | | | | | | | | | | 2 | 2 | | | |
| *Triglochin maritimum* | | | | | | | | | | | | | | | | |
| *Potamogeton berchtoldii* | | | | | | | | | | | 1 | 1 | | | | |
| *Potamogeton pectinatus* | 2 | 4 | 3 | | 5 | 5 | | | | | | | | | | |
| *Potamogeton crispus* | | | | | | | | | | | | | | | | |
| *Potamogeton trichoides* | | | | | | | | | | | | | | | | |
| *Zanichellia palustris* | | | | | | | | | | | | | | | | |
| *Lemna minor* | | | | | 1 | | | | 3 | 4 | 4 | 4 | 4 | 4 | | 4 |
| *Lemna trisulca* | | | | | | | | | 3 | | 3 | 3 | 3 | 3 | 2 | 3 |
| *Juncus gerardii* | | | | | 4 | | | | | | | | | | | |
| *Juncus maritimus* | 3 | 3 | | 1 | | 1 | | | | | | | | | | |
| *Juncus inflexus* | | | | | | | | | | | | | | | | |
| *Juncus effusus* | | | | | 1 | | | | 1 | | | | | | | |
| *Eleocharis palustris* | | | | | | | | | | | 3 | | | | | |
| *Bulboschoenus maritimus* | 3 | 4 | 4 | 1 | 1 | 4 | | | 1 | 4 | | | | | | |
| *Schoenoplectus tabernaemontani* | 4 | 2 | | | | | 1 | | | | 3 | | | | | 4 |
| *Carex otrubae* | | 1 | | | | 1 | | | | | | | | | | |
| *Phragmites australis* | | | 5 | 5 | | 5 | 5 | 5 | 5 | 5 | 3 | 5 | 5 | 5 | 5 | 4 |
| *Glyceria maxima* | | | | | | | | | | | | | | | | |
| *Sparganium erectum* | | | | | | | | | | | | | | | | |
| *Typha latifolia* | 3 | | | | | | | | | | | | | | | |
| *Iris pseudacorus* | | | | | | | | | | | | | | | | |

| Site No | 65 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Cladophora glomerata* | 3 | 4 | | | | | 3 | | | | | | | | | |
| *Enteromorpha intestinalis* | | | | | | | | 3 | | | | | | | | |
| *Hydrodictyon reticulatum* | | | | | | | | | | | | | 3 | 3 | | |
| *Chara vulgaris* var. *longibracteata* | | | | | | | | | | | | | | | | |
| *Fontinalis squamosa* | | | | | | | | | | | | | | | | |
| *Ranunculus sceleratus* | 3 | 1 | 1 | | 3 | | 2 | | 2 | | 3 | 3 | 2 | 1 | 2 | |
| *Ranunculus circinatus* | | | | | | | | | | | | | | | | |
| *Ranunculus baudottii* | | 4 | | | | | | | | | | | | | 2 | 2 |
| *Ceratophyllum demersum* | | | | | | 2 | | | 4 | 2 | | | | | | |
| *Ceratophyllum submersum* | 1 | | | | | | | | | | | | | | | |
| *Rorippa nasturtium-aquaticum* | | | | | | | | | | | | | | | 1 | |
| *Epilobium hirsutum* | | | | | | | | | | | | | | | | |
| *Oenanthe lachenalii* | | | | | | | | | | | | | | | | |
| *Apium graveolens* | | | | | | | | | | | | | | | | |
| *Apium nodiflorum* | 1 | | | | | | | | | | | | | | | |
| *Solanum dulcamara* | | | 1 | | | | | | | | | | | | | |
| *Myosotis scorpioides* | | | | | | | | | | | | | | | | |
| *Lycopus europaeus* | | | | | | | | | | | | | | | | |
| *Callitriche stagnalis* | 2 | | | 1 | | 2 | | 2 | | 1 | | | | | 2 | |
| *Veronica anagallis-aquatica* | | | | | | | | | | | | | | | | |
| *Veronica catenata* | | | | | 2 | | | | | | | | | | 2 | |
| *Alisma plantago-aquatica* | 3 | | 3 | 3 | 1 | | | | 1 | 3 | | | | | | |
| *Elodea canadensis* | | | | | | | | | | | | | | | | |
| *Elodea nuttallii* | | | | | | | | | | | | | | | | |
| *Triglochin maritimum* | | | | | | | | | | | | | | | | |
| *Potamogeton berchtoldii* | 3 | | | | | | | | 2 | 3 | | | 5 | | | |
| *Potamogeton pectinatus* | | | | | | | | | | | | | | | | |
| *Potamogeton crispus* | 2 | | | | | | | | | | | | | | | |
| *Potamogeton trichoides* | | | | | | | | | | | | | | | | |
| *Zanichellia palustris* | | 3 | | | | | | | | | | | | | | |
| *Lemna minor* | 3 | | 3 | 2 | 4 | 5 | 3 | 4 | 5 | 4 | | 4 | 2 | 3 | 3 | 3 |
| *Lemna trisulca* | 2 | | | | | 2 | | | 5 | 4 | | | | | 5 | 5 |
| *Juncus gerardii* | | | | 4 | 1 | | | | | | | | | | | |
| *Juncus maritimus* | | | 5 | 3 | | | | | | | | | | | | |
| *Juncus inflexus* | | | | | | | | | | | | | | | | |
| *Juncus effusus* | | | | | | | | | | | | | | | | |
| *Eleocharis palustris* | 3 | 1 | | | 4 | | 4 | | | | 1 | | | 3 | 4 | |
| *Bulboschoenus maritimus* | 3 | 5 | 1 | | 2 | | 3 | | | 4 | 2 | 5 | 3 | 2 | 4 | 3 |
| *Schoenoplectus tabernaemontani* | 3 | | 1 | | 4 | | 5 | | | 3 | 2 | 4 | 3 | 5 | 2 | 3 |
| *Carex otrubae* | | | 1 | | | | 1 | | | | | | | | | |
| *Phragmites australis* | | | | | | 5 | | 5 | 4 | 3 | | | | 3 | 4 | 4 |
| *Glyceria maxima* | | | | | | | | | | | | | | | | |
| *Sparganium erectum* | | | | | | | | | | | | | | | | |
| *Typha latifolia* | | | | | | | | | | | | | | | | |
| *Iris pseudacorus* | | | | | | | | | | | | | | | | |

| Site No | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 | 95 | 96 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Cladophora glomerata* | | | | | | | | | | | | | | | | |
| *Enteromorpha intestinalis* | | | | | | | 3 | | | | | | | 2 | 3 | 3 |
| *Hydrodictyon reticulatum* | | | | | | | | | | | | | | | | |
| *Chara vulgaris* var. *longibracteata* | | | | | | | | | | | | | | | | |
| *Fontinalis squamosa* | | | | | | | | | | | | | | | | |
| *Ranunculus sceleratus* | | 2 | 2 | | | | 2 | 2 | | 2 | | | | | | |
| *Ranunculus circinatus* | | | | | | | | | | | | | | | | |
| *Ranunculus baudottii* | 1 | | | | | | | | | | | | | | | |
| *Ceratophyllum demersum* | | | | | 1 | 1 | 2 | | | | 3 | | | | | 2 |
| *Ceratophyllum submersum* | | | | | | | | | | | | | | | | |
| *Rorippa nasturtium-aquaticum* | | | | | | | | | | | | | | | | |
| *Epilobium hirsutum* | | | | | | | | | | | 2 | | | | | 1 |
| *Oenanthe lachenalii* | | | | | | | | | | | | | | | | |
| *Apium graveolens* | | | | | | | | | | | | | | | | |
| *Apium nodiflorum* | | 2 | 2 | | | | | 1 | | | | | | | | |
| *Solanum dulcamara* | | | | | | | | | | | | | | | | |
| *Myosotis scorpioides* | | | | | | | | | | | 1 | | | | 1 | 2 |
| *Lycopus europaeus* | | | | | | | | | | 2 | | | | | | |
| *Callitriche stagnalis* | 1 | 3 | 3 | 2 | 2 | 3 | 4 | 2 | 2 | 1 | | 3 | 2 | 3 | 2 | 3 |
| *Veronica anagallis-aquatica* | | | | | | | | | | | | | | 2 | | |
| *Veronica catenata* | | 2 | | | | | | | | | | | | | | |
| *Alisma plantago-aquatica* | | 2 | | | | | | | | | | | | | | |
| *Elodea canadensis* | | | | | | | | | | | 2 | | | 2 | | 3 |
| *Elodea nuttallii* | | | | | | | | | | | 2 | 2 | | | | |
| *Triglochin maritimum* | | | | | | | | | | | | | | | | |
| *Potamogeton berchtoldii* | | | 3 | 2 | 4 | 3 | 3 | | | | 4 | 2 | 2 | | 4 | 4 |
| *Potamogeton pectinatus* | | | | | | | | | | | | | | | | |
| *Potamogeton crispus* | | | | | | | | | | | | | | | | |
| *Potamogeton trichoides* | | | | | | | | | | | 1 | | | | | |
| *Zanichellia palustris* | | | | | | | | | | | | | | | | |
| *Lemna minor* | 4 | 5 | 4 | 5 | 3 | 3 | 5 | 5 | 5 | 3 | 5 | 5 | 5 | 5 | 5 | 4 |
| *Lemna trisulca* | 2 | | | | 3 | 2 | 4 | | | | | 1 | | | 2 | 2 |
| *Juncus gerardii* | | | | | | | | | | | | | | | | |
| *Juncus maritimus* | | | | | | | | | | | | | | | | |
| *Juncus inflexus* | | | | | | | | | | | | | 2 | | | |
| *Juncus effusus* | | | | | | | | | | | | | | | | |
| *Eleocharis palustris* | | | | | | | | | | | | | | | 3 | |
| *Bulboschoenus maritimus* | 3 | 2 | 1 | | | | | | | | | | | | | |
| *Schoenoplectus tabernaemontani* | | 3 | 4 | 4 | 4 | 3 | 3 | | | | | | | | | |
| *Carex otrubae* | | 1 | 1 | | | | 1 | | | | | | | | | |
| *Phragmites australis* | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 4 | 4 | 4 | 2 |
| *Glyceria maxima* | | | | | | | | | 1 | | | 4 | 4 | 4 | | |
| *Sparganium erectum* | | 3 | | | | | 3 | | | | | | | | 4 | 5 |
| *Typha latifolia* | | | | | | | | | | | | | | | | |
| *Iris pseudacorus* | | | | | | | | | | | | | | | 1 | |

| Site No | 97 | 98 | 99 |
|---|---|---|---|
| *Cladophora glomerata* | | | 4 |
| *Enteromorpha intestinalis* | | 4 | 4 |
| *Hydrodictyon reticulatum* | | | 1 |
| *Chara vulgaris* var. *longibracteata* | | | |
| *Fontinalis squamosa* | | | |
| *Ranunculus sceleratus* | 1 | | |
| *Ranunculus circinatus* | | | |
| *Ranunculus baudottii* | | | |
| *Ceratophyllum demersum* | 1 | | |
| *Ceratophyllum submersum* | | | |
| *Rorippa nasturtium-aquaticum* | | | |
| *Epilobium hirsutum* | | | 2 |
| *Oenanthe lachenalii* | | | |
| *Apium graveolens* | | | |
| *Apium nodiflorum* | 2 | | |
| *Solanum dulcamara* | | | |
| *Myosotis scorpioides* | 1 | 2 | |
| *Lycopus europaeus* | | | 1 |
| *Callitriche stagnalis* | 2 | 3 | |
| *Veronica anagallis-aquatica* | 1 | | |
| *Veronica catenata* | | 1 | |
| *Alisma plantago-aquatica* | | | |
| *Elodea canadensis* | 2 | | 1 |
| *Elodea nuttallii* | | | |
| *Triglochin maritimum* | | | |
| *Potamogeton berchtoldii* | 5 | 3 | 5 |
| *Potamogeton pectinatus* | | | |
| *Potamogeton crispus* | | | |
| *Potamogeton trichoides* | | | |
| *Zanichellia palustris* | | | |
| *Lemna minor* | 5 | 4 | 3 |
| *Lemna trisulca* | 3 | 3 | 1 |
| *Juncus gerardii* | | | |
| *Juncus maritimus* | | | |
| *Juncus inflexus* | | | |
| *Juncus effusus* | | | |
| *Eleocharis palustris* | | | |
| *Bulboschoenus maritimus* | | | |
| *Schoenoplectus tabernaemontani* | | | 3 |
| *Carex otrubae* | | | 1 |
| *Phragmites australis* | 3 | 3 | 5 |
| *Glyceria maxima* | | | |
| *Sparganium erectum* | 5 | 4 | |
| *Typha latifolia* | | | |
| *Iris pseudacorus* | | | |

# Appendix II

## Full beetle list for the sample stations 1-12

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Gyrinus caspius* | | | | | | | | | | | 1 | |
| *Gyrinus substriatus* | 1 | | | | | | | | | | | |
| *Peltodytes caesus* | | | | 2 | | | | | 2 | 1 | | |
| *Haliplus confinis* | | | | 1 | | | 1 | | | 1 | | |
| *Haliplus immaculatus* | | 1 | | | | | | 1 | | | | |
| *Haliplus lineatocollis* | | | | 1 | | | | | | | | 1 |
| *Haliplus ruficollis* | | 1 | | 1 | | 1 | | | | 1 | | |
| *Haliplus ruficollis* (females) | 1 | 2 | 1 | 3 | 3 | 2 | 1 | 2 | | 1 | | |
| *Haliplus wehnckei* | | 1 | | | | | | | | | | |
| *Hygrobia hermanni* | 1 | 2 | | | | 2 | | 1 | 1 | | | |
| *Noterus clavicornis* | 2 | 3 | 12 | 1 | 8 | 2 | | 16 | 7 | 24 | 13 | 56 |
| *Hygrotus impressopunctatus* | | | | | | | | | | | | |
| *Hygrotus inaequalis* | | 1 | | 1 | | | | 1 | 3 | 20 | 1 | 7 |
| *Hygrotus parallelogrammus* | | | | | | | | | | | | |
| *Hyphydrus ovatus* | | 4 | | 1 | 3 | 2 | 82 | 14 | | | | |
| *Hydroporus palustris* | | | | | 1 | 1 | | | | 3 | | 7 |
| *Graptodytes pictus* | | 1 | | 1 | 1 | | 1 | 1 | | | | |
| *Nebrioporus elegans* | 1 | | | 1 | 2 | | | | | | | |
| *Agabus bipustulatus* | | | | | | | | | | | | |
| *Agabus sturmii* | | | | | | | | | | | | |
| *Ilybius ater* | | | | | | | | | | | | |
| *Ilybius fuliginosus* | 1 | | | | | | | 2 | | 1 | | |
| *Ilybius quadriguttatus* | | | | | | | | | | | | |
| *Rhantus suturalis* | | | | | | | | | | | | |
| *Colymbetes fuscus* | | | | | | | | | | | | 1 |
| *Laccophilus hyalinus* | 4 | 1 | | | 2 | | | | | | | |
| *Laccophilus minutus* | 1 | | | | 4 | | | 1 | | | | |
| *Helophorus minutus* | | | 1 | | | | | | | | | |
| *Helophorus obscurus* | | | | | | | | | | | | |
| *Anacaena globulus* | | | | | | | | | | | | |
| *Anacaena limbata* | | 3 | 1 | | 3 | | | 5 | 1 | | | |
| *Laccobius bipunctatus* | | | | | | | | 5 | | | | |
| *Laccobius colon* | | | 5 | 5 | 1 | | | | | | | |
| *Laccobius striatulus* | | | | | | | | | | 1 | | |
| *Helochares lividus* | | | | | | | | | | | | |
| *Enochrus testaceus* | | 2 | | | 1 | | | | | | | |
| *Hydrobius fuscipes* | | | | | | | | | | | | 1 |

## Full beetle list for the sample stations 13-24

| | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Gyrinus caspius* | 2 | | | | | | | | | | | |
| *Gyrinus substriatus* | | | | | | | | | | | | |
| *Peltodytes caesus* | | | | | | | | | | | | |
| *Haliplus confinis* | | | | | | | | | | | | |
| *Haliplus immaculatus* | | | 1 | | | 4 | | | | | | |
| *Haliplus lineatocollis* | | | | | | | | | | | | |
| *Haliplus ruficollis* | | | 2 | 1 | | 2 | | | | | | |
| *Haliplus ruficollis* (females) | 2 | | 2 | | 1 | 3 | 4 | 2 | | | | |
| *Haliplus wehnckei* | | | | | | | | | | | | |
| *Hygrobia hermanni* | | | 1 | 2 | 1 | | | | | | | 33 |
| *Noterus clavicornis* | 1 | 25 | 23 | 1 | 50 | 16 | 22 | 28 | 12 | 13 | 4 | 9 |
| *Hygrotus impressopunctatus* | | | | | 1 | | | | | | | |
| *Hygrotus inaequalis* | 7 | 1 | 1 | | 7 | 5 | 6 | | | | | |
| *Hygrotus parallelogrammus* | | | | | 3 | | | | | | | |
| *Hyphydrus ovatus* | 1 | | 7 | 1 | | 48 | 4 | 3 | | 12 | 2 | 16 |
| *Hydroporus palustris* | | 1 | 1 | | | 3 | 15 | | | 3 | | |
| *Graptodytes pictus* | | | | 3 | | 1 | | | | | 1 | |
| *Nebrioporus elegans* | | | | | | | | | | | | |
| *Agabus bipustulatus* | | 4 | | | | | | | | | | |
| *Agabus sturmii* | 1 | 5 | | | | | | 1 | 4 | 1 | | |
| *Ilybius ater* | 1 | | | | | | | | | | | |
| *Ilybius fuliginosus* | | | | | | | | | | | | |
| *Ilybius quadriguttatus* | | 1 | | | | | | | | 1 | | |
| *Rhantus suturalis* | | 1 | | | | | | | | | | |
| *Colymbetes fuscus* | | | | | | | | | | | | |
| *Laccophilus hyalinus* | | | 3 | | | | | | | | | |
| *Laccophilus minutus* | | | 5 | | | | | | | | | 1 |
| *Helophorus minutus* | | | | | | 3 | | 1 | 1 | | 1 | |
| *Helophorus obscurus* | | | | 2 | | | | | | | | |
| *Anacaena globulus* | | | | 1 | | | | | | | | |
| *Anacaena limbata* | 4 | 1 | | 2 | | 5 | 1 | | 1 | | | |
| *Laccobius bipunctatus* | | 1 | | | | 4 | | | | 4 | 1 | |
| *Laccobius colon* | | | 3 | | 3 | 6 | | | | | 4 | 2 |
| *Laccobius striatulus* | | | | | | | 1 | | | | | |
| *Helochares lividus* | | | | | | | | | | | 1 | |
| *Enochrus testaceus* | | | 1 | | | 2 | 1 | 1 | | | 2 | |
| *Hydrobius fuscipes* | | 3 | | | | 1 | | 1 | | | | |

# Appendix III

## Full mollusc list for the sample stations 1-12

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Valvata piscinalis* | | 3 | 3 | 4 | 5 | 3 | 2 | | | | | |
| *Valvata cristata* | | | 1 | 4 | 4 | 3 | 2 | | 1 | | | 3 |
| *Potamopyrgus antipodarum* | 3 | 4 | 5 | 4 | 4 | 1 | 3 | 3 | 3 | 4 | 3 | 4 |
| *Bithynia tentaculata* | | | | 5 | 4 | 4 | 3 | 3 | 3 | | | 1 |
| *Lymnaea peregra* | 4 | 3 | 3 | 4 | 3 | 3 | 3 | 1 | 3 | 1 | 1 | 3 |
| *Lymnaea palustris* | 1 | 2 | 1 | 2 | 2 | | | 2 | 1 | 1 | | 3 |
| *Lymnaea stagnalis* | | | 1 | | | | | 1 | | | | 3 |
| *Physa fontanalis* | 4 | 3 | 2 | 4 | 4 | 3 | 2 | 3 | 3 | | 1 | 3 |
| *Anisus vortex* | 4 | 5 | 4 | 5 | 5 | 4 | 3 | 5 | 3 | 1 | 2 | 4 |
| *Segmentina complanata* | 3 | 2 | 2 | 3 | 4 | | 2 | | 1 | | | 3 |
| *Planorbis carinatus* | 4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | | | 3 |
| *Gyraulus crista* | 1 | 2 | | 2 | | | | | 1 | | 1 | 2 |
| *Gyraulus albus* | 1 | | 3 | | | | | | | | | |
| *Bathyomphalus contortus* | | | | | | 1 | | | | | | |
| *Lymnaea auricularia* | | | | | | | 1 | | | | | |
| *Succinea sp.* | | | 1 | | 1 | | | | | | | 2 |
| *Sphaerium corneum* | | | | | | 2 | | | | | | |
| *Muculium lacustre* | 12 | 4 | 1 | 4 | 5 | 6 | 3 | 6 | 1 | | | 31 |
| *Pisidium subtruncatum* | 6 | 18 | 32 | 1 | 6 | 10 | | 3 | | | | 5 |
| *Pisidium personatum* | | | | | 1 | 1 | | | | | | 19 |
| *Pisidium nitidum* | | | | | 9 | | | | | | | 7 |
| *Pisidium milium* | 1 | | | | | | | | | | | |

**Appendix II (cont.)**

## Full mollusc list for the sample stations 13-24

| | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Valvata piscinalis* | | | 3 | 4 | | | | 3 | 3 | 3 | 3 | 3 |
| *Valvata cristata* | | | | | | | | | | 3 | 4 | |
| *Potamopyrgus antipodarum* | 4 | 3 | 5 | 5 | 1 | 3 | 3 | 4 | 3 | 3 | 4 | 1 |
| *Bithynia tentaculata* | | | 2 | 4 | | 3 | | | 4 | 4 | 4 | 3 |
| *Lymnaea peregra* | | 3 | 4 | 5 | 3 | 4 | 5 | 5 | 4 | 2 | 5 | 3 |
| *Lymnaea palustris* | | 4 | 1 | 2 | | | | | 1 | 1 | | |
| *Lymnaea stagnalis* | | | | 2 | | | 2 | 1 | | | | 1 |
| *Physa fontanalis* | | | 4 | 3 | 2 | | 3 | 4 | 4 | 3 | 4 | 3 |
| *Anisus vortex* | 2 | | 4 | 4 | 2 | 4 | 3 | 4 | 5 | 4 | 4 | 4 |
| *Segmentina complanata* | | | 3 | 3 | | | | 3 | 3 | 2 | 3 | 3 |
| *Planorbis carinatus* | | | 3 | 3 | | 2 | | 2 | 4 | 3 | 4 | 3 |
| *Gyraulus crista* | 2 | | 2 | | 2 | | 3 | 1 | | | 2 | |
| *Gyraulus albus* | | | | | | | | | | | | |
| *Bathyomphalus contortus* | | | | | | | | | | | | |
| *Lymnaea auricularia* | | | | | | | | | | | | |
| *Succinea sp.* | | | | | | | 1 | | | 1 | | |
| *Sphaerium corneum* | | | | | | | | | | | | |
| *Muculium lacustre* | | | 1 | 1 | | 1 | 1 | | 3 | 3 | 2 | 1 |
| *Pisidium subtruncatum* | | | 1 | 2 | | 2 | | | | | | 3 |
| *Pisidium personatum* | | | | | | | | | | | | |
| *Pisidium nitidum* | | | | | | | 1 | | | 1 | 1 | 3 |
| *Pisidium milium* | | | 1 | | | | | | | 1 | | |