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Working Papers

No. 13

OCCURRENCE OF *SPHAGNUM* MOSS IN THE SUBLITTORAL OF SEVERAL GALLOWAY LOCHS, WITH PARTICULAR REFERENCE TO LOCH FLEET

P. J. Raven

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Palaeoecology Research Unit
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Occurrence of *Sphagnum* moss in the sublittoral of several Galloway lochs, with particular reference to Loch Fleet.

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Abstract

A survey of the sublittoral vegetation of eight Galloway lochs in 1985 showed that *Sphagnum* was abundant in L. Fleet. It was found in four other lochs, being particularly abundant in Loch Stroan and Loch Trool. Reference to historical data suggests that *Sphagnum* established after 1905, while evidence from sediment cores indicates a very recent appearance (post-1960) in Loch Fleet. These changes may be a floristic response to water acidification in Galloway.

CONTENTS

INTRODUCTION

An exploratory study involving comparison between contemporary field surveys and historical aquatic macrophyte data concluded that the nutrient status in 8 out of 23 Galloway lochs had declined between 1905 and 1983-84. Moreover, the loss of calcicole species (e.g. *Potamogeton lucens*) from a number of these sites implied a floristic change in response to water acidification (Raven 1985). These conclusions were tempered by the fact that only macrophytes in the littoral region of each loch was sampled in 1983-84, and that floristic change in response to acidification and/or oligotrophication in previously oligo-dystrophic lochs could not be satisfactorily assessed.

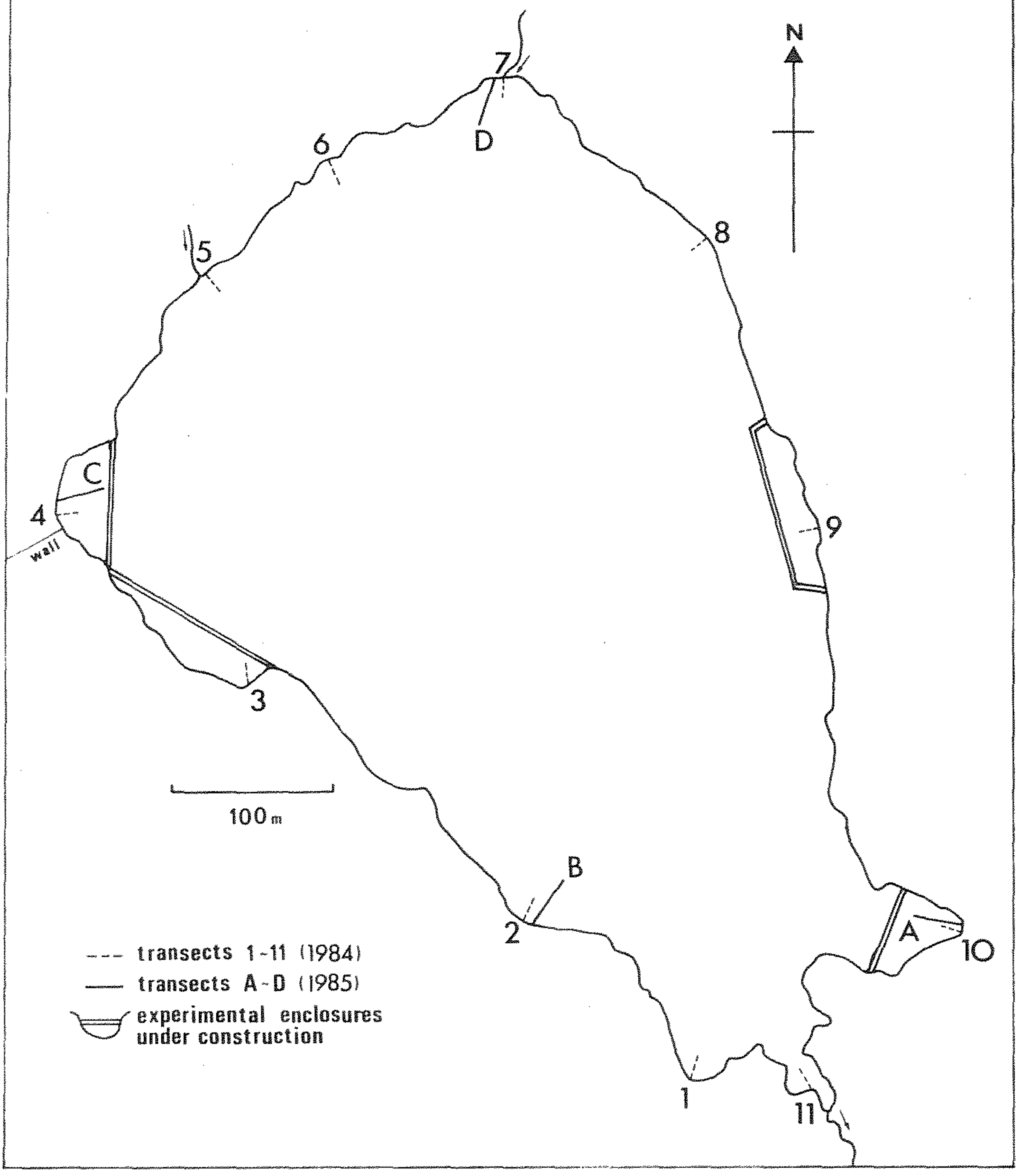
It has been suggested that the recent phenomenon of increased *Sphagnum* growth in some acidified lakes represents a floristic change in response to water acidification (Roelofs *et al*. 1984). Since a number of lochs in Galloway are known to have been acidified (Flower & Battarbee 1983; Batttarbee & Flower 1985), it is appropriate to assess if *Sphagnum* has increased in this part of Scotland. With the exception of Loch Grannoch, no sublittoral growth of *Sphagnum* was reported during an extensive floristic survey of Galloway lochs in 1905 (West 1910). The presence of sublittoral *Sphagnum* in 1985 would therefore represent a similar floristic trend which has been reported in recently acidified lakes in Sweden (Grähn *et al*. 1974; Grähn 1977), the Netherlands (Roelofs 1983) and the United States (Hendrey &

Vertucci 1980).

Sublittoral macrophyte data from 8 Galloway lochs are presented in this paper. With the exception of Loch Fleet, the sampling was rudimentary because macrophytes represented a minor component of a research programme which focused on limnological and diatom data collection and analysis (Flower et al. 1986). At Loch Fleet, however, a comprehensive data-base describing the distribution of aquatic macrophytes has now been established. Sampling will be replicated in 1986-87 to assess floristic changes caused by experimental manipulation of sub-catchments involving liming and heather burning.

Since nearly all the 31 lochs sampled in 1983-84 were re-visited in 1985, data which amend those found in the initial report (Raven 1985) can be found in Appendix 4. Details of site location and limnological data for each loch mentioned in this paper are presented in Flower et al. (1986).

Figure 1 The location of the 1984 and 1985 transects in Loch Fleet



2. METHODS

2.1. Loch Fleet

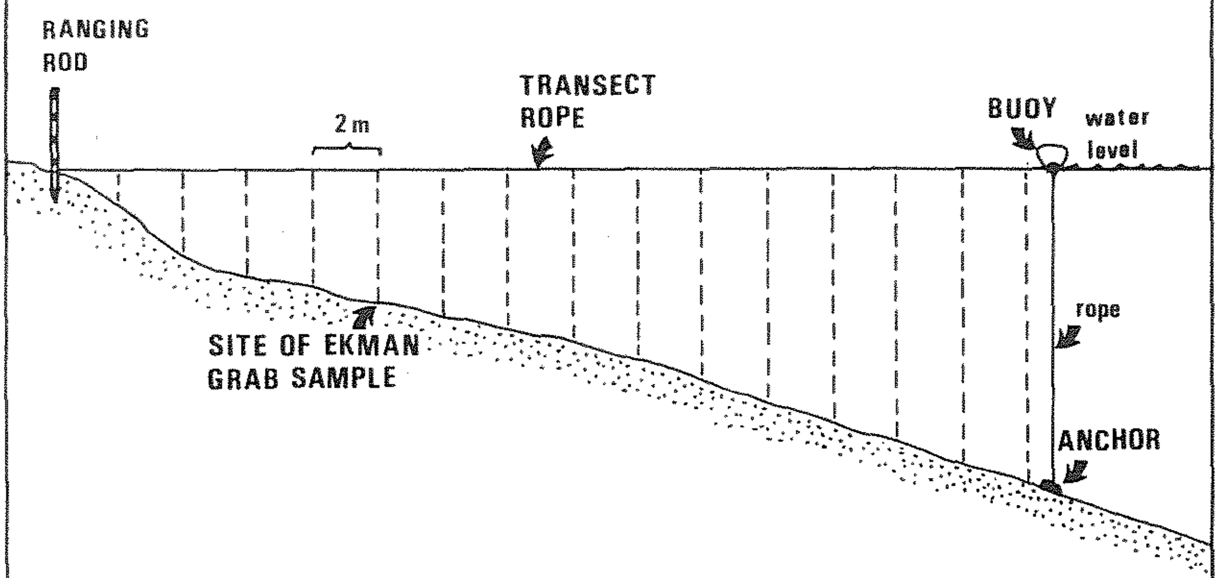
Three methods were used to assess the distribution of aquatic macrophytes in Loch Fleet; shore-based vegetation mapping in 1983 (c.f. Raven 1985), quadrat and grab samples located along transects perpendicular to the shore (July 1984 and September 1985) and sublittoral grab samples throughout the loch (July 1984 and September 1985).

2.1.1 1984-85 transects

In July 1984 the littoral vegetation along eleven transects located around the loch was sampled using 0.25 m x 0.25 m quadrats (Fig. 1). Three random quadrats were located at each of four depths (0.0 m, 0.5 m, 1.0 m and 1.5 m) and species cover was estimated to the nearest 10%, with an additional category (+) for < 5 per cent. The water was sufficiently clear to permit recognition of isoetid species but *Sphagnum* spp. were retrieved for drying and later identification. Filamentous algae and leafy liverworts were also recorded but only identified to genus level.

A systematic and easily replicated survey, which involved using a glass-bottomed bucket to view vegetation within quadrats located every 2 m along four 30 m long transects was planned for 1985. However, a high level of turbidity (secchi disc depth < 0.5 m) prevented this method

Figure 2 Sampling procedure for the 1985 transects



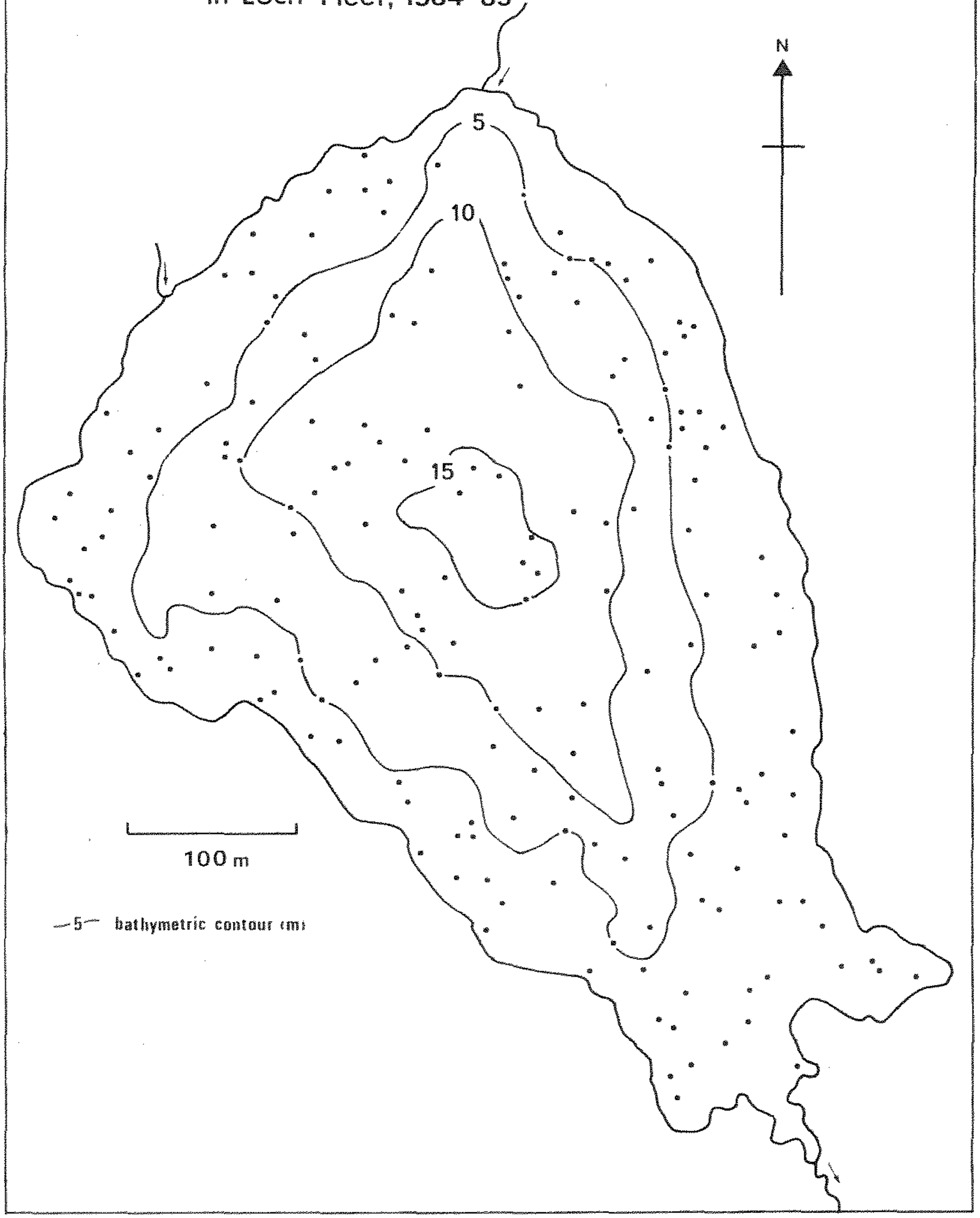
during the field visit of September 1985. As an alternative, Ekman grab samples were taken every 2 m along the transects, and these provided species presence/absence data. Three transects were located in embayments which were to be experimentally enclosed, the fourth acting as a control (Fig. 1). Each transect was established as follows: a ranging rod was driven into the shoreline at the current water level and this represented a reference marker; a rope tied to the ranging rod was then attached to a large temporary buoy which was firmly anchored about 35 m offshore; Ekman grab samples were then taken every 2 m along the transect rope which was perpendicular to the shore (Fig. 2). At each sample point along the 30 m transect water depth, substrate-type and a subjective assessment of plant species abundance (+, present; A, abundant; depending on the amount within the grab) were recorded. The shoreline reference markers and direction of each transect were defined by yellow canes for future sampling.

2.1.2. Sublittoral grab samples

More than 80 Ekman grab samples were taken during a sedimentological survey of the loch in July 1984 (Anderson and Battarbee 1985). Water depth, substrate and plant species were recorded and each site was accurately located by bearings from shore-based plane tables.

A further survey was conducted in September 1985 to

Figure 3 The locations of sublittoral Ekman grab samples in Loch Fleet, 1984-85



complete comprehensive sample coverage of the loch. To facilitate this, a sampling grid comprising 100 m x 100 m squares was established with reference to marker flags aligned around the shore. Grid coordinates in the loch were marked by temporary buoys. Five Ekman grab samples were randomly located within each complete grid square. Proportionately fewer samples were taken in incomplete squares near the shore. Water depth, substrate and plant data were recorded as before, but the location of each site was determined from compass bearings taken onto shore-based reference markers. Due to fog on one occasion and drifting by several temporary buoys, the intended pattern of sample sites was not fully achieved. However, overall, the 1984 and 1985 surveys provided nearly 200 sample points throughout the loch (Fig. 3).

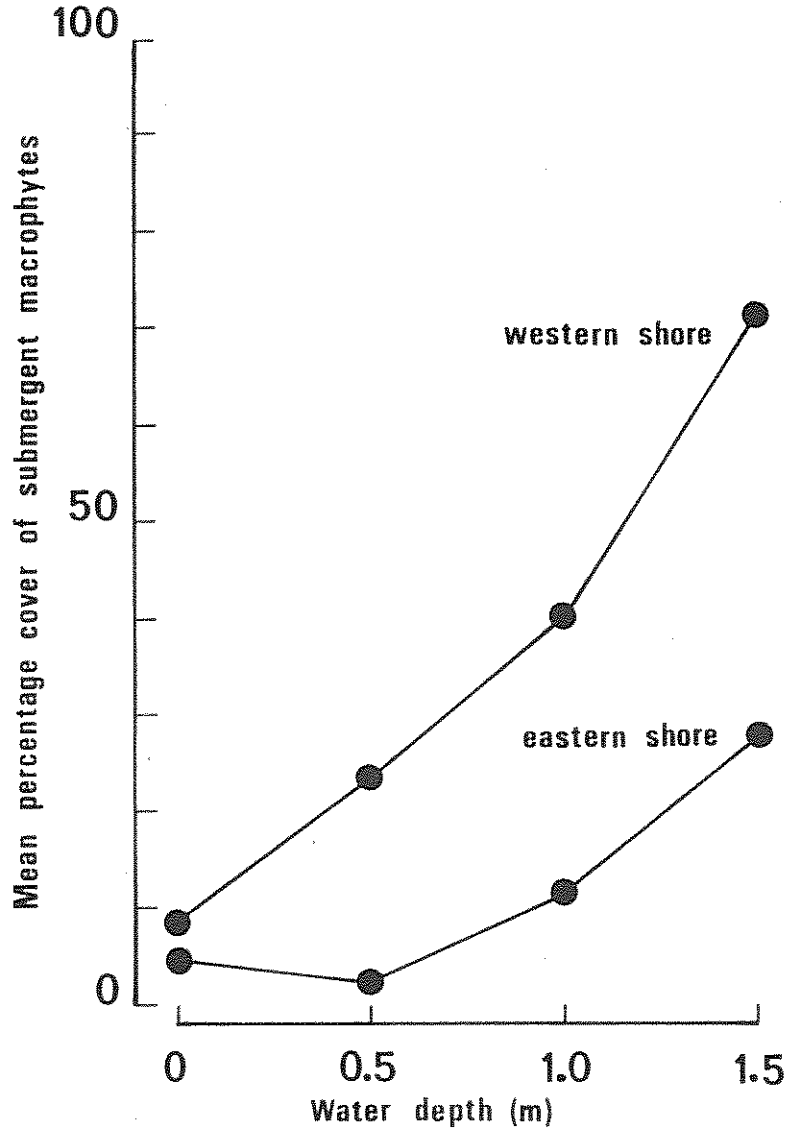
2.2 Sublittoral grab sampling in Round Loch of Glenhead, L. Skae, L. Harrow, L. Howie, L. Skerrow, L. Trool and L. Stroan.

A strictly limited and qualitative Ekman grab sample survey in seven other lochs was undertaken in association with limnological investigations in May and July 1985 (Flower et al. 1986). Consequently, the number and location of grabs was determined by the amount of time available at each loch (Appendix 1). Water depth, substrate and plant data were recorded and the position of each grab sample was annotated onto a large scale map.

2.3 Assessing short-term distribution changes of littoral macrophytes.

Thirty of the 31 lochs originally surveyed in 1983-84 were revisited in 1985. Changes in the distribution of littoral macrophytes were annotated onto photocopies of the vegetation maps compiled from the first visit (cf. Raven 1985).

FIGURE 4 The mean percentage cover of submergent macrophytes on the west and east shores of Loch Fleet



3. RESULTS

3.1 The aquatic macrophytes of Loch Fleet

Very few macrophyte species were found in Loch Fleet during 1983-85 (Table 1). The rocky shoreline restricted development of emergent vegetation which comprised *Carex rostrata* in two sheltered embayments on the western side of the loch. Submergent macrophytes were more abundant in littoral areas of the western shore where sand occurred more frequently than along the exposed, rocky eastern shoreline (Figure 4).

Table 1. Aquatic macrophytes recorded in Loch Fleet during 1983-85.

a) Emergent species †

Carex rostrata

b) Submergent species

Filamentous algae	:	(predominantly *Mougeotia spp.*).
Leafy liverworts	:	(predominantly *Jungermannia spp.*).
Mosses	:	*Sphagnum auriculatum*
		Sphagnum cuspidatum
		Fontinalis artipyretica
Isoetids	:	*Isoetes echinospora*
		Isoetes lacustris
		Littorella uniflora
		Lobelia dortmanna
Others	:	*Juncus bulbosus* var. *fluitans* (*J. fluitans*)
		Utricularia vulgaris

† *Juncus articulatus*, *J.acutifloris*, *Ranunculus flammula* and other marsh plants found along the shoreline are excluded from this list.

pH of L. Fleet in 1983-85 = 4.5 - 4.6

conductivity in 1983-85 = 47-60μS cm^{-1} at 18°C.

FIGURE 5 The depth distribution frequency of some submergent plant species in Loch Fleet 1984-85

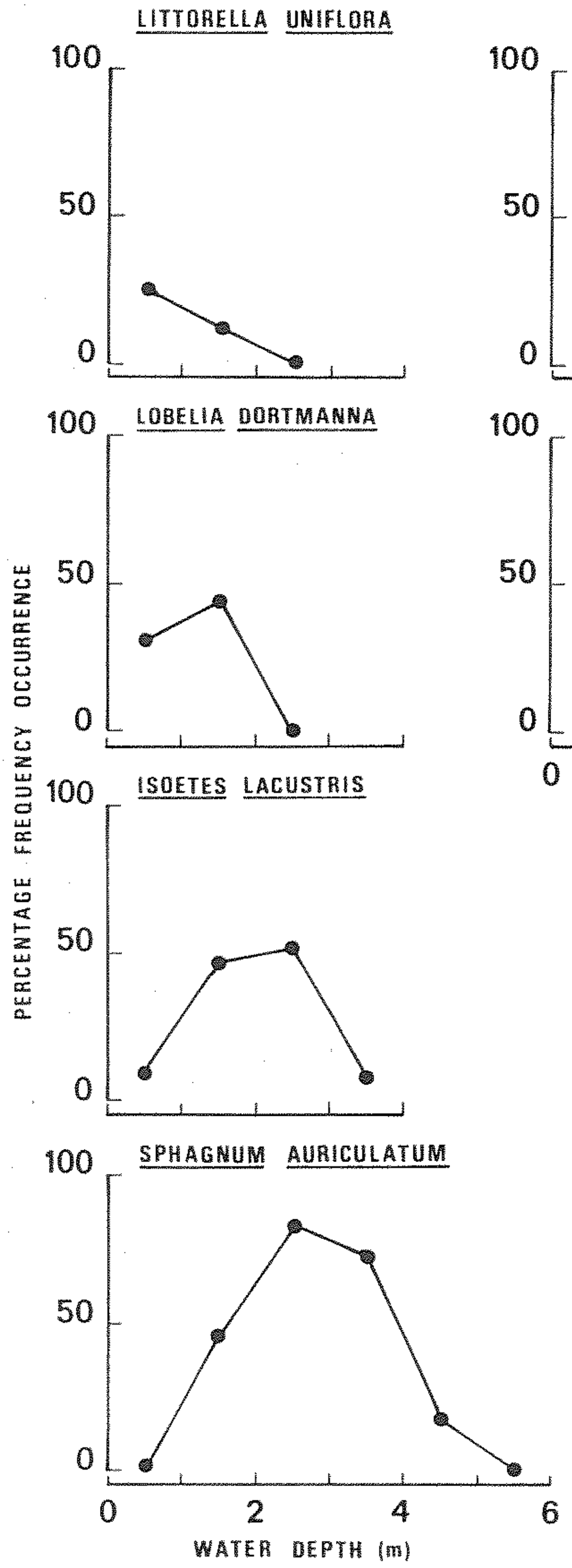


Figure 6 The distribution of *Isoetes lacustris* in Loch Fleet, 1984-85

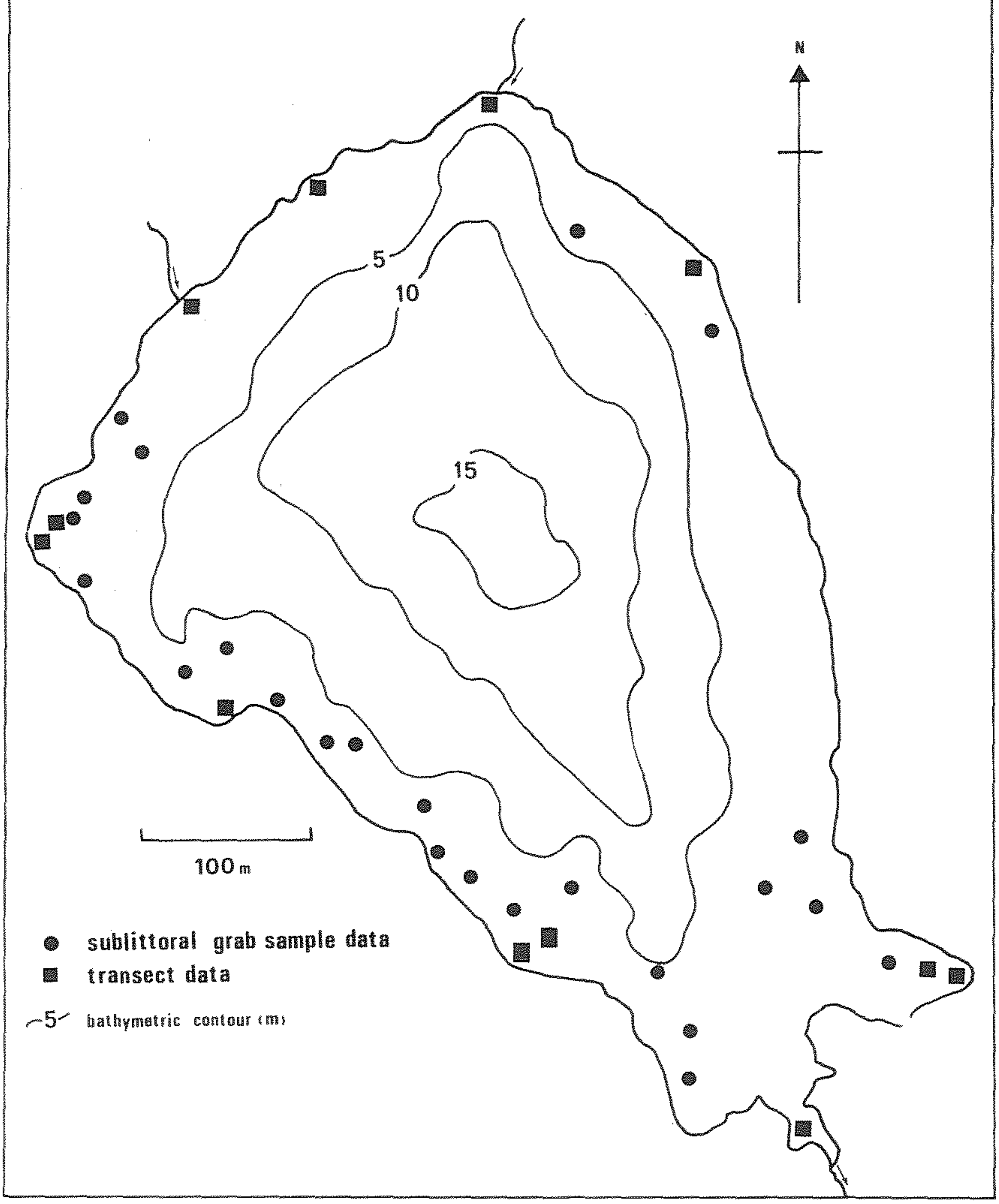
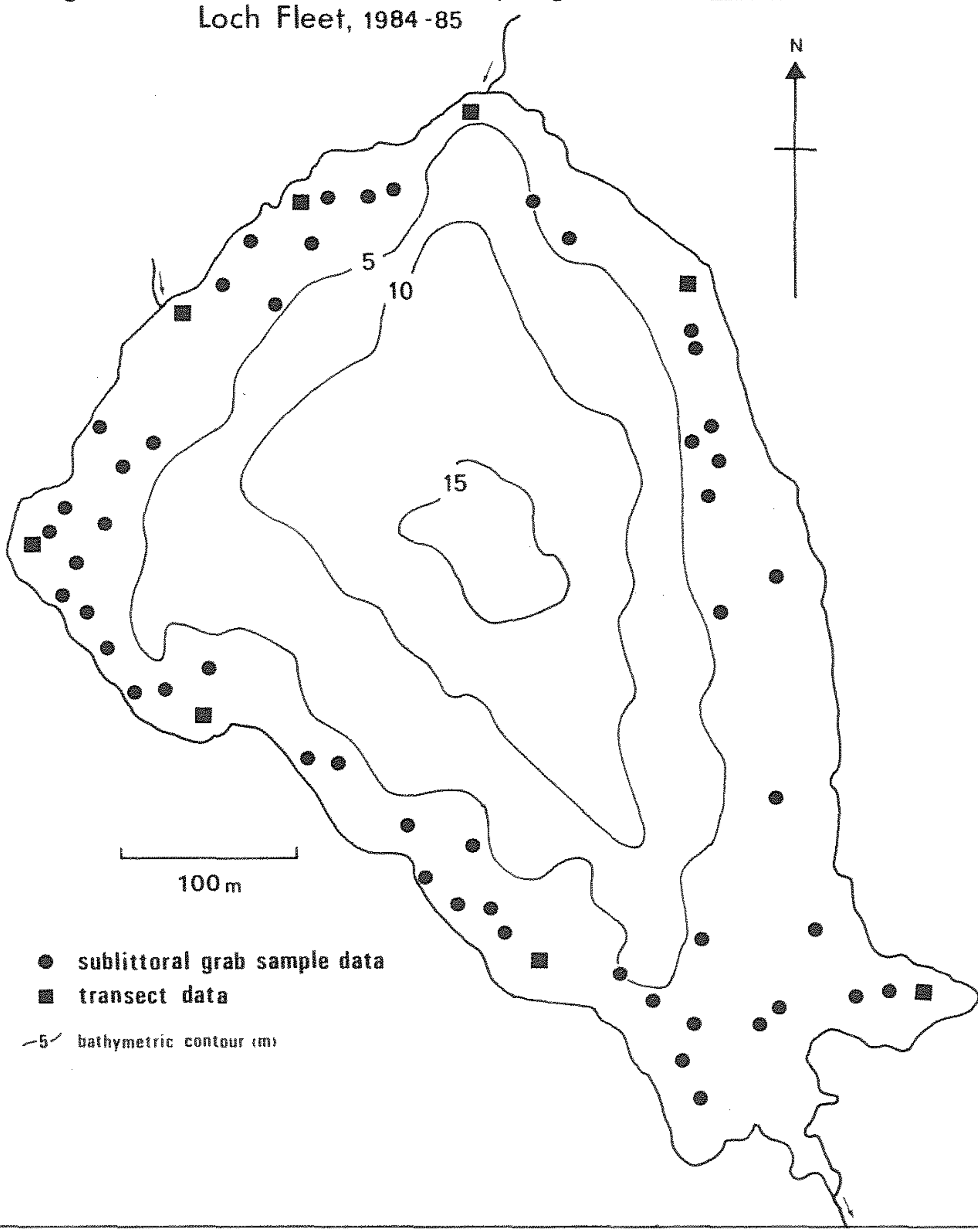


Figure 7 The distribution of Sphagnum auriculatum in Loch Fleet, 1984-85



A distinctive depth related zonation of macrophyte species was found (Fig. 5) although the full complement of Littorella uniflora → Lobelia dortmanna → Isoetes lacustris/Sphagnum spp. was largely confined to the west of the loch. Furthermore, Littorella and Lobelia were almost exclusively confined to inshore sandy substrate (Table 2).

Table 2. Sediments associated with the four main aquatic macrophytes in Loch Fleet.

Species	Percentage frequency recorded on:- Sands and gravels	Organic muds	n.
Littorella uniflora	97	3	37
Lobelia dortmanna	99	1	76
Isoetes lacustris	51	49	74
Sphagnum auriculatum	27	73	56*

* Ekman grab sample data only

Liverworts (mainly Jungermannia spp.) and filamentous algae (predominantly Mougeotia spp.) were also largely confined to shallow waters with algae frequently coating the underwater portion of Lobelia stems. Isoetes was most abundant further offshore (1.5 - 2.5 m) particularly on the west side of the loch (Fig. 6). Although Sphagnum was often retrieved in the same grab sample as Isoetes, it extended deeper than any other macrophyte and had the most widespread distribution (Fig. 7).

Despite considerable variation in morphology, which might have accounted for an erroneous identification of S. compactum and S. papillosum in the 1984 samples, only two species of Sphagnum were present. The bulky species S. auriculatum (synonymous with S. subsecundum) was dominant, occurring in all the Sphagnum samples and

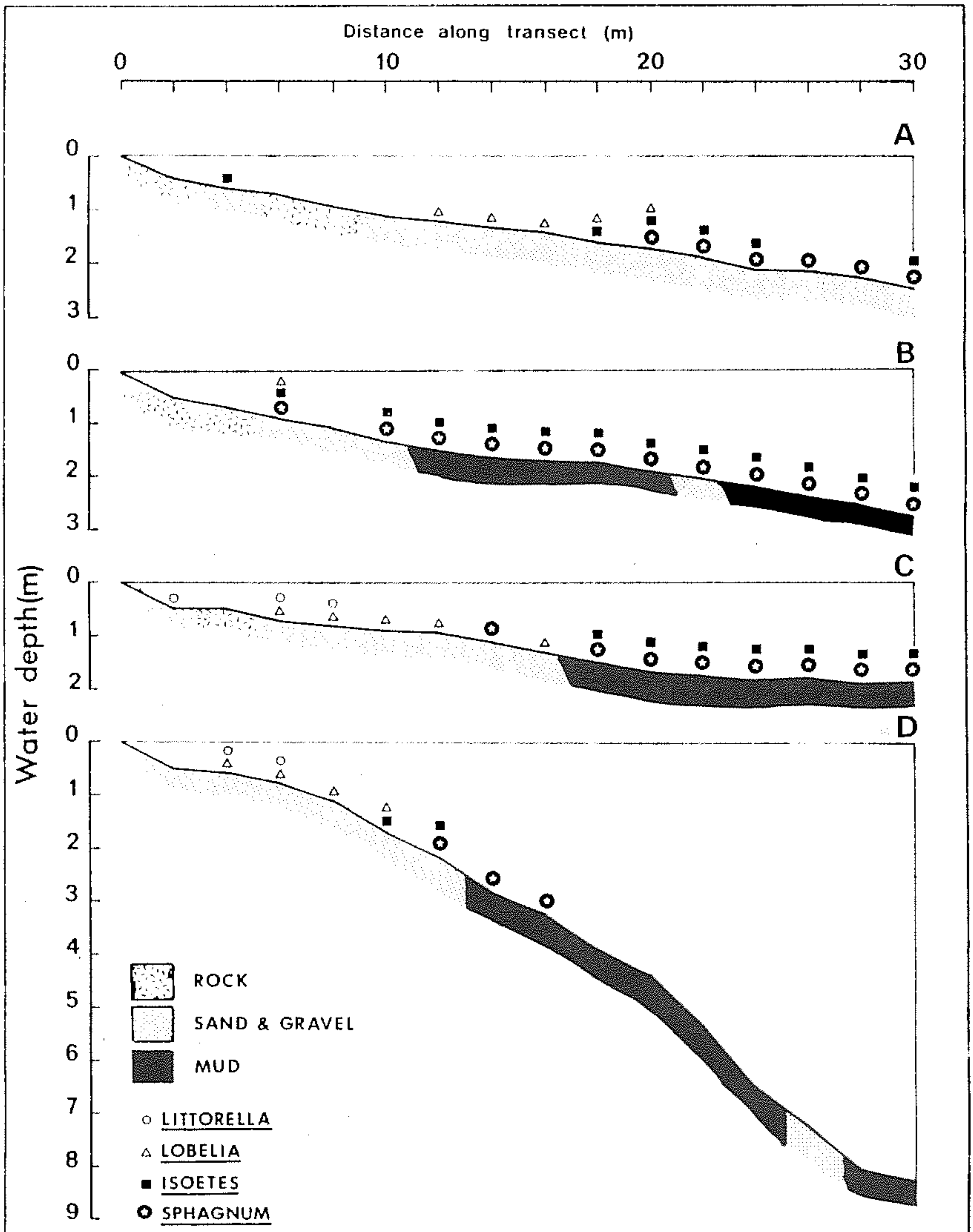


Figure 8 The depth distribution of 4 aquatic macrophytes along transects A-D in Loch Fleet, September 1985

growing prolifically in the north-west embayment. The more delicate and feathery S. cuspidatum was recorded in 25% of grab samples containing Sphagnum.

No living macrophytes were sampled below 5 m depth, and an abrupt vegetation cut-off point was exemplified along Transect D (Fig. 8). Inblown Molinia spp. debris had accumulated in a few shallow water sites. However, Sphagnum debris was found in deeper parts of the loch (Appendix 3).

3.2. The sublittoral vegetation of seven other Galloway lochs.

As in Loch Fleet, macrophyte growth was limited to water < 5 m deep (Appendix 2). Isoetes dominated the sublittoral vegetation in Round Loch of Glenhead (RLG), Loch Skae, Loch Harrow and Loch Howie (Table 3).

Table 3. The dominant sublittoral species recorded in seven Galloway lochs during 1985.

Loch	Dominant littoral species*	Dominant sublittoral species
RLG	Lobelia dortmanna	Isoetes lacustris
Loch Skae	Lobelia dortmanna	Isoetes lacustris
Loch Harrow	Lobelia dortmanna, Juncus fluitans	Isoetes lacustris, Juncus fluitans
Loch Howie	Lobelia dortmanna	Isoetes lacustris
Loch Skerrow	Lobelia dortmanna	?
Loch Trool	Juncus fluitans	Juncus fluitans, Sphagnum auriculatum
Loch Stroan	Schoenoplectus lacustris	Sphagnum auriculatum

* (Raven 1985).
? insufficient data due to rocky substrate.

Juncus bulbosus var. fluitans was the dominant sublittoral species in Loch Trool and was locally abundant in Loch Harrow. The rocky substrate at the northern end of Loch Skerrow severely restricted macrophyte growth but small quantities of *Sphagnum* were recovered in the grab samples. *Sphagnum* was present in three other lochs and was particularly abundant between 1.2 m and 2.0 m depth throughout Loch Stroan and between 3.0 m and 4.0 m depth on the northern side of Loch Trool (Appendix 2). The filamentous algae *Batrachospermum*, often found in *Sphagnum* pools (Prescott 1970), was locally abundant in Loch Trool.

Significant accumulations of *Molinia* debris were found in Round Loch of Glenhead while a thick carpet of *Quercus* leaves was found on the southern side of L. Trool. In both instances macrophyte growth was apparently inhibited by this debris.

3.3 Changes in the distribution of littoral macrophytes, 1983-85

Few changes in the distribution of littoral macrophytes were noted between 1983-84 and 1985. However, *Potamogeton natans* had increased in Loch Macaterick and Loch Skae, and there had been a noticeable proliferation of *Schoenoplectus lacustris* in Loch Mannoch and Loch Stroan (Appendix 4).

4. DISCUSSION

Water chemistry, and nutrient availability in particular, strongly influences the species composition of aquatic vegetation in lakes (Seddon 1967, 1972; Spence 1967). The vegetation of oligotrophic soft-water lakes is usually characterised by the isoetid species Littorella uniflora, Lobelia dortmanna and Isoetes lacustris, and the first two species often dominate exposed shores where emergent vegetation growth is prevented by excessive wave action (Spence 1964). Isoetids are physiologically adapted for nutrient-poor waters but inter-specific competition produces a downshore zonation: typically, Littorella and Lobelia dominate shallow (0 - 2 m) water while Isoetes is confined to deeper (2 - 4 m) areas (Kansanen and Nienni 1974; Sand-Jensen 1978). A similar pattern (Fig. 5) was frequently encountered during the 1983-85 Galloway study and has been reported from other oligotrophic lakes elsewhere in Galloway (West 1910; Spence 1964), the Lake District (Pearsall 1920) and Denmark (Sand-Jensen and Søndergaard 1979).

In strongly acidic conditions (pH < 4.0), however, Juncus fluitans and/or Sphagnum spp. dominate the vegetation, often to the exclusion of other species (van Dam and Kooyman-van-Blokland 1978; Roelofs 1983). These species have a competitive advantage over isoetids because they can utilise the dissolved carbon dioxide present at low pH values (Roelofs et al. 1984; Wetzel et al. 1984).

In The Netherlands, a significant decline in previously dominant isoetid plant communities and a concomitant increase of _Juncus fluitans_ and/or _Sphagnum_ since the 1950's has been attributed to water acidification (Roelofs 1983; Roelofs _et al._ 1984). Recent increased growth of _Sphagnum_ has also been reported in acidified lakes in Sweden (Grähn _et al._ 1974; Grähn 1977) and the United States (Hendrey and Vertucci 1980). It has been suggested that extensive growth of _Sphagnum_ may prevent nutrient exchange between sediment and water causing "oligotrophication" and that the high cation exchange capacity of the living tissue might exacerbate water acidity and reduce bacterial decomposition of dead plant material (Grähn _et al._ 1974). It has also been suggested that, by reducing floristic and structural diversity, extensive mats of _Sphagnum_ provide an impoverished habitat for aquatic invertebrates (Kenlan _et al._ 1984). However, in Loch Fleet _Sphagnum_ supported as many epiphytic diatoms as _Isoetes lacustris_ (N. Varley, unpublished data).

The increase of sublittoral _Sphagnum_ in acidified lakes in Sweden, the Netherlands and United States has been evaluated by comparing contemporary field surveys with historical data. Historical data for Galloway lochs are also available for comparative studies (West 1910; Spence 1964). It is clear in Galloway that _Sphagnum_ was restricted to small peaty pools and shallow water in the sheltered bays of a few oligotrophic lochs. However, during his 1905 survey, West recorded the "uncommon" occurrence of _Sphagnum_ growing between 2 and 8 feet below the surface at the southern end of Loch Grannoch. In contrast, <u>Sphagnum</u> was recorded in five out of eight oligotrophic lochs sampled in 1985 (Table 4).

Table 4. The presence of sublittoral <u>Sphagnum</u> in some Galloway lochs during 1985.

Loch	Altitude (m)	Catchment Geology	Mean pH	Range of conductivity	Sublittoral Sphagnum record
Fleet	340	Granite	4.5	47-60	Abundant
RLG	295	Granite	4.7	32-47	Absent
Skae	263	Shales	5.9	59-66	Absent
Harrow	247	Slates	4.8	30-40	Rare
Howie	232	Shales	5.3	68-74	Absent
Skerrow	127	Granite	5.1	49-68	Rare
Trool	75	Slates	5.0	31-48	Locally abundant
Stroan	70	Granite	4.8	48-80	Abundant

pH and conductivity (μScm^{-1}) data provided by R. Flower.

Unfortunately, West could not use a boat for his survey of Loch Fleet so the presence of <u>Sphagnum</u> in 1905 cannot be ruled out. However, changes in the relative abundance of <u>Sphagnum</u> and <u>Isoetes</u> occur in sediment cores taken from Loch Fleet (Stevenson, unpublished data). Although it is not possible to differentiate <u>Sphagnum</u> originating in the catchment from that in the lake, the pollen data suggest a significant decline of <u>Isoetes</u> and a concomitant increase in <u>Sphagnum</u>, probably associated with sediment input since afforestation in 1963. The presence abundance of <u>Sphagnum</u> suggests a rapid proliferation during the past 20 years. Since West made a thorough survey of the submergent vegetation in Loch Harrow, Loch Skerrow, Loch Trool and Loch Stroan, it is clear that <u>Sphagnum</u> has established in each of these sites since 1905.

In Sweden and the United States *Sphagnum* has apparently spread from the littoral into sublittoral areas, extending to depths of 18 m in places (Hendry and Vertucci 1980; Wetzel *et al.* 1984). There is no evidence for such a process in Galloway since *Sphagnum* is mainly confined to deeper water (> 2m) while isoetids still dominate further inshore (Fig. 5). Moreover, aquatic macrophyte growth is apparently limited to depths less than 5 m despite exceptional water clarity (secchi disc depth > 6 m) in some lochs.

In 1985 *Sphagnum* was restricted to lochs with a mean pH of 5.1 or less. However, its distribution was not consistent with contemporary pH (Table 5). For example, it was absent from the Round Loch of Glenhead (pH 4.7) which has been acidified since c. 1880 (Flower & Battarbee, 1983) but was abundant in Loch Fleet (pH 4.7) which has been acidified only very recently (Flower & Battarbee, in preparation). Furthermore, the 1905 record of *Sphagnum* in Loch Grannoch coincides with a reconstructed water pH of 5.6 (Battarbee & Flower 1985).

Increased sediment input associated with pre-afforestation ploughing may contribute to an increase in *Sphagnum* by smothering isoetids in the sublittoral zone and introducing *Sphagnum* from the catchment. For example, *Sphagnum* is absent from Round Loch of Glenhead which has an unafforested catchment. However, it does not occur in Loch

Skae or Loch Howie where catchment afforestation is 100% although pH is at least 5.3 (Table 5).

Table 5. A comparison between the dominant sublittoral species of eight Galloway lochs recorded in 1905 and 1985.

	Dominant sublittoral species		Contemporary pH	Afforestation*
Loch	1905	1985		
Fleet	*Isoetes* ?	*Sphagnum*	4.5@	40%
RLG	*Isoetes* ?	*Isoetes*	4.7@	0%
Skae	*Isoetes* (J)	*Isoetes*	5.9	100%
Harrow	*Isoetes* (J)	*Isoetes* (J)	4.8	100%
Howie	*Isoetes* (J)	*Isoetes*	5.3	100%
Skerrow	*Isoetes*	?	5.1	60%
Trool	*Isoetes* (J)	*J. fluitans* (S)	5.0	60%
Stroan	*Isoetes*	*Sphagnum*	4.8	70%

* percentage of shoreline afforested in 1985
N.B. None of the catchments were commercially afforested in 1905.
? insufficient data
(J) *Juncus fluitans* also abundant
(S) *Sphagnum* also abundant
@ known to have been acidified

Acidified lochs in the catchment may have contributed to a change in water chemistry and the subsequent appearance of *Sphagnum* in Loch Trool and Loch Stroan. Both lochs are at relatively low altitudes (< 75 m) and receive water from acidic upland lochs. Water from five upland lochs, including Loch Valley and Round Loch of Glenhead which have been acidified from pH ca. 5.3 - 5.5 in the late 19th century to pH 4.7 in the 1970's (Battarbee & Flower 1985), flows into Loch Trool. The River Dee flows through Loch Stroan carrying water from Loch Dee (pH 5.3), Loch Skerrow (pH 5.1) and Loch Grannoch (pH 4.6). Until liming was carried out in 1981-82, Loch Dee was an acidified water body and Loch Grannoch has been acidified from pH ca. 5.6 since 1920

(Battarbee & Flower 1985).

Parts of the Loch Fleet catchment will be limed in 1986. Since *Sphagnum* has disappeared from a number of acidified lakes in Sweden after liming (Brown 1985) changes in the relative abundance of *Sphagnum* and isoetids in Loch Fleet will be monitored with great interest during 1986-87.

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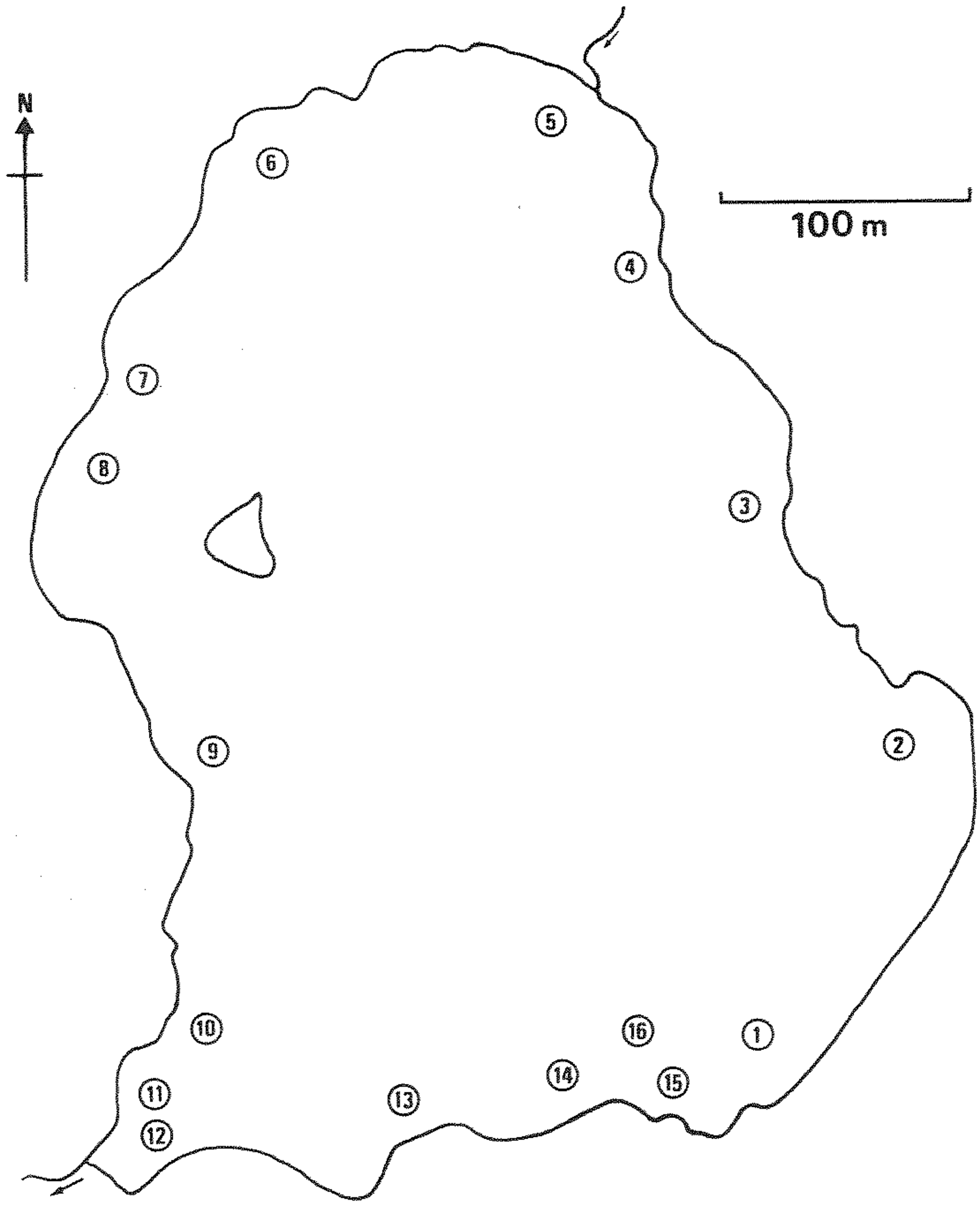
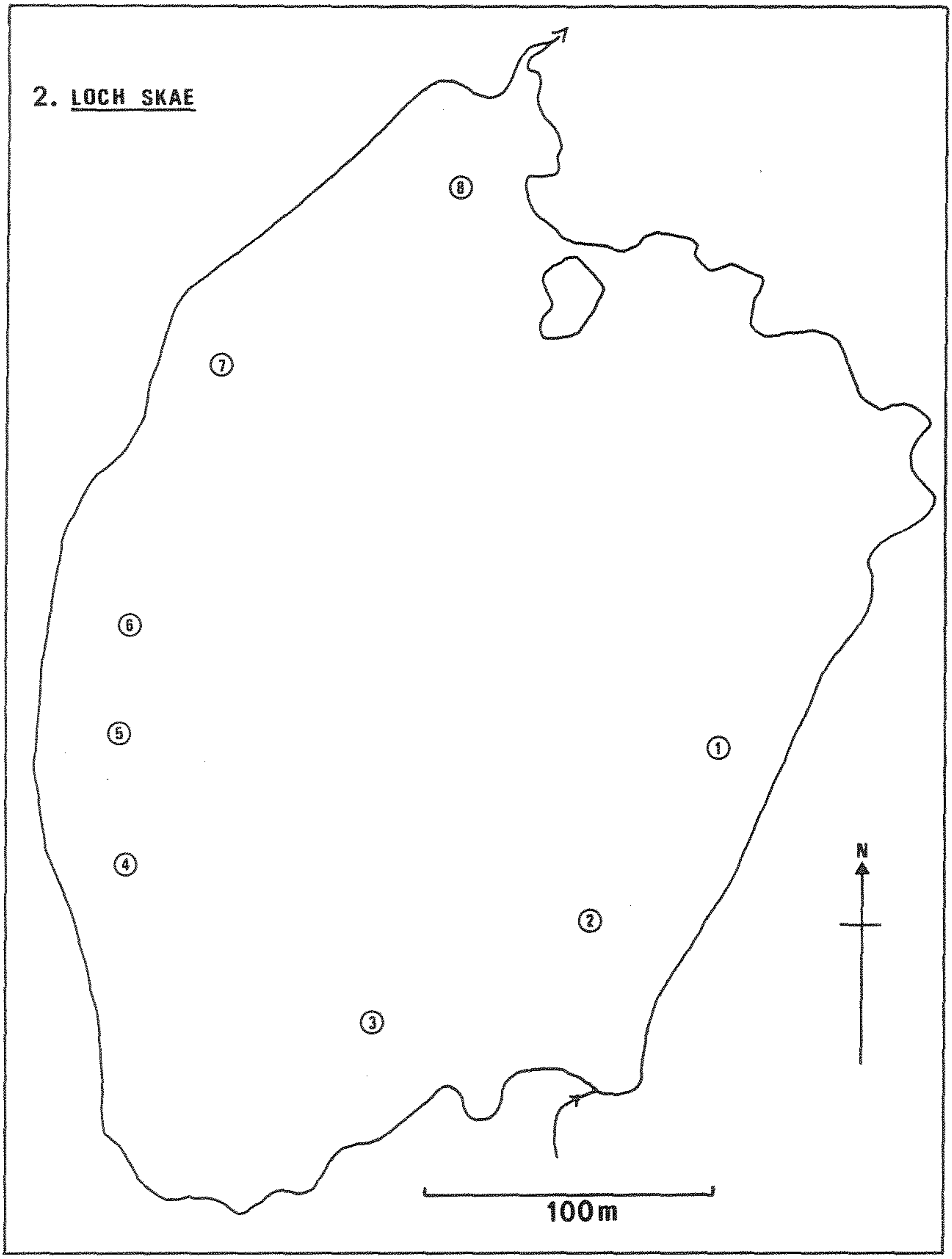
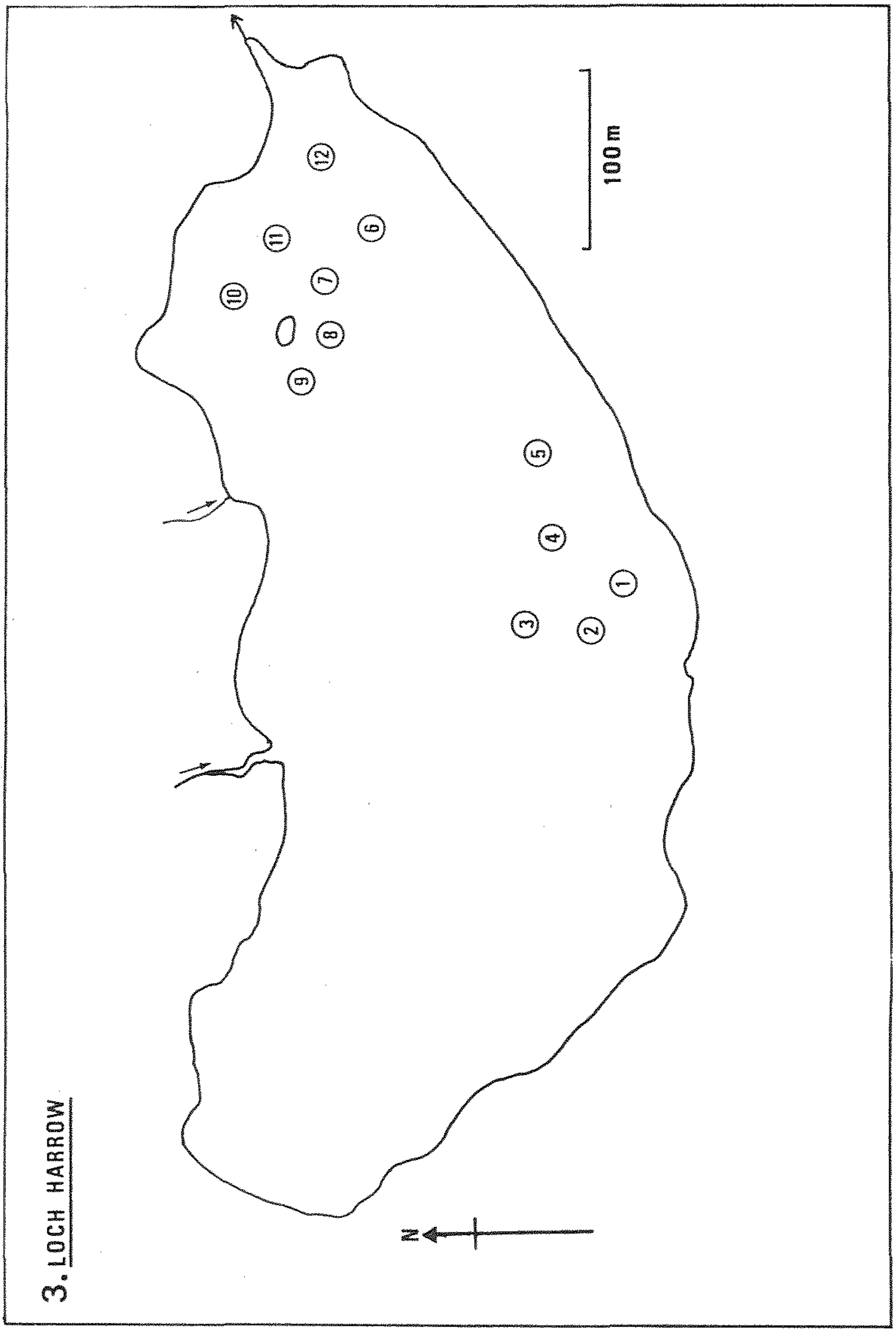
APPENDIX 1 EKMAN GRAB SAMPLE SITES IN SEVEN GALLOWAY LOCHS SURVEYED IN 1985

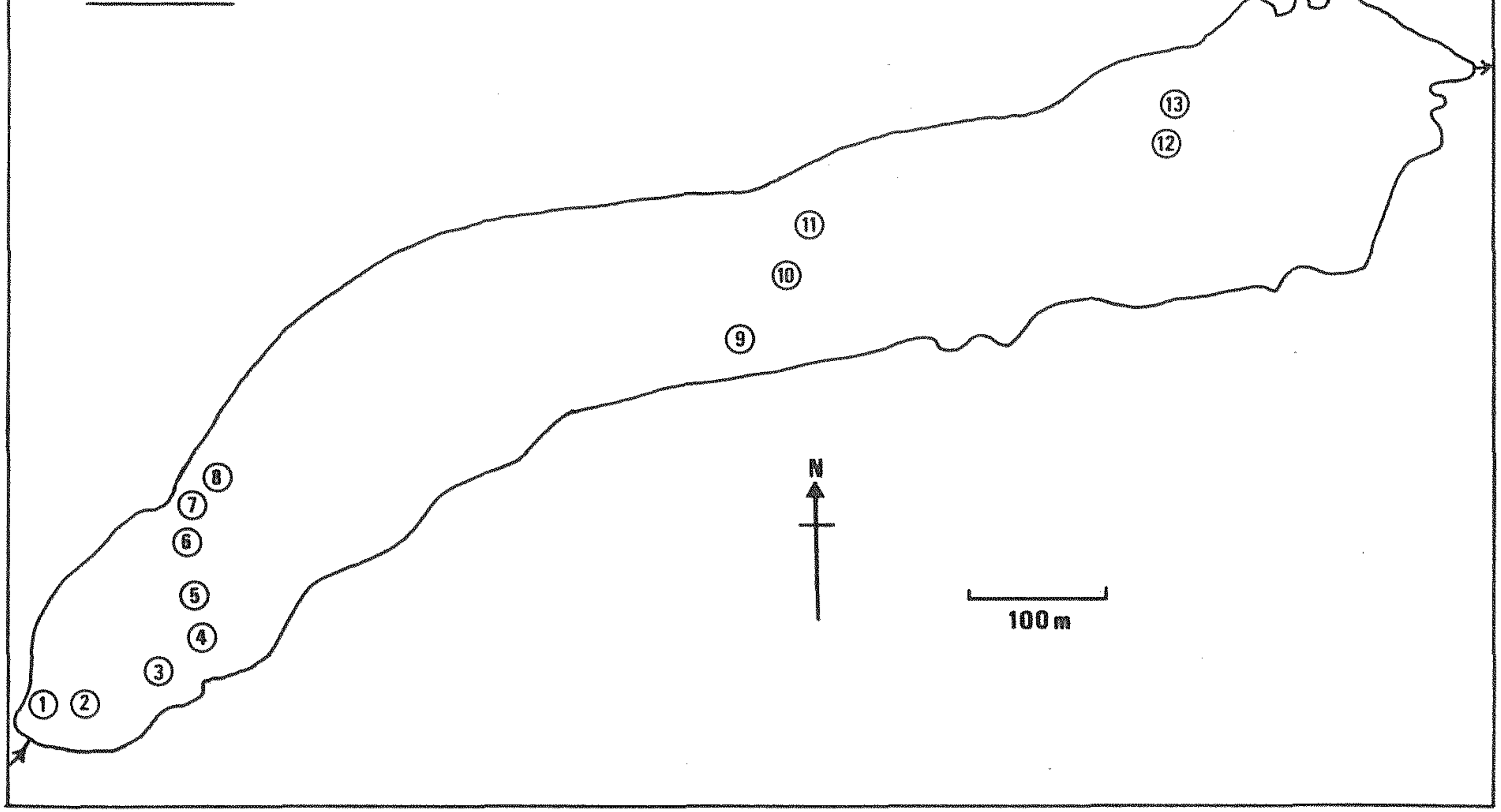
1. ROUND LOCH OF GLENHEAD

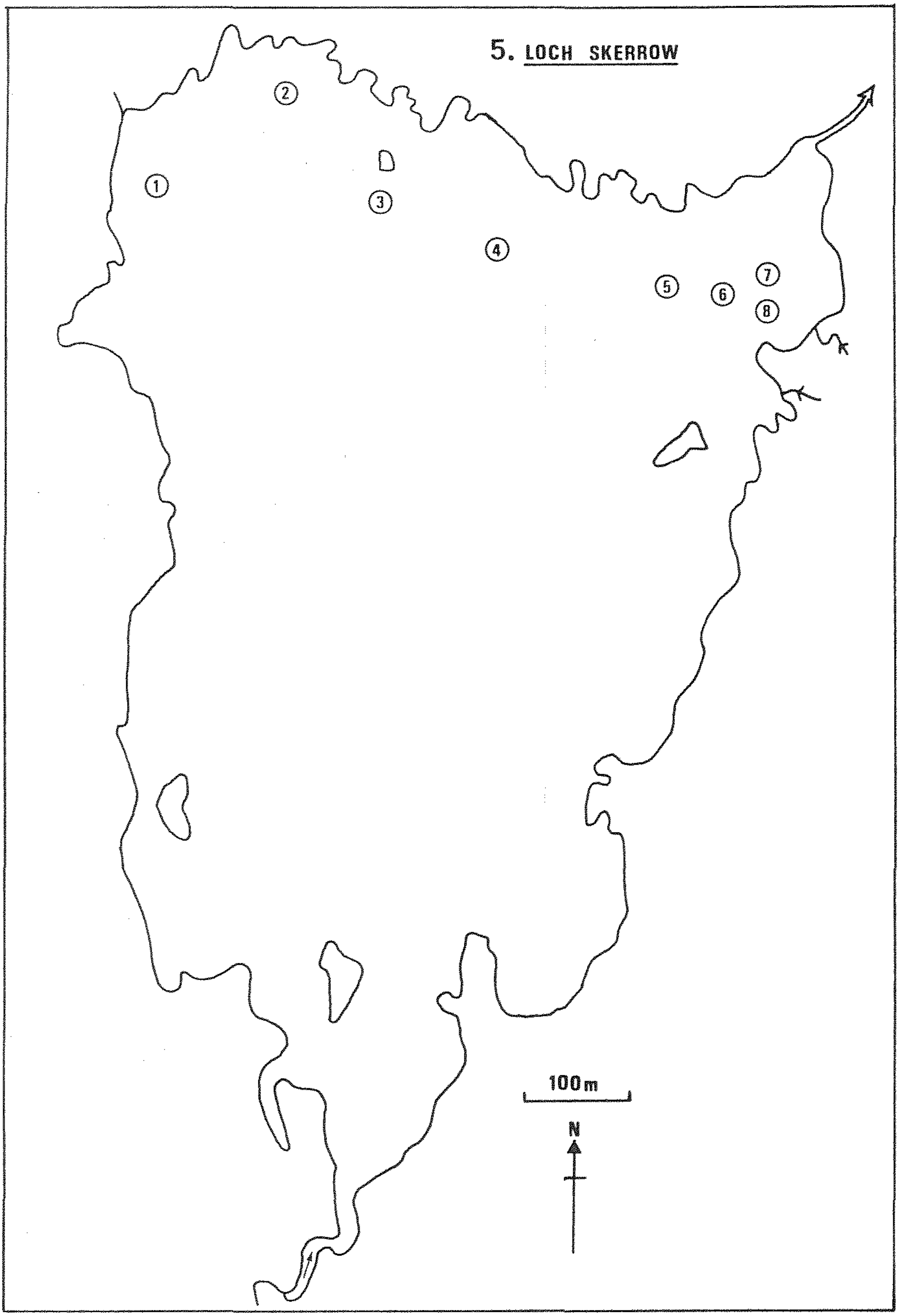


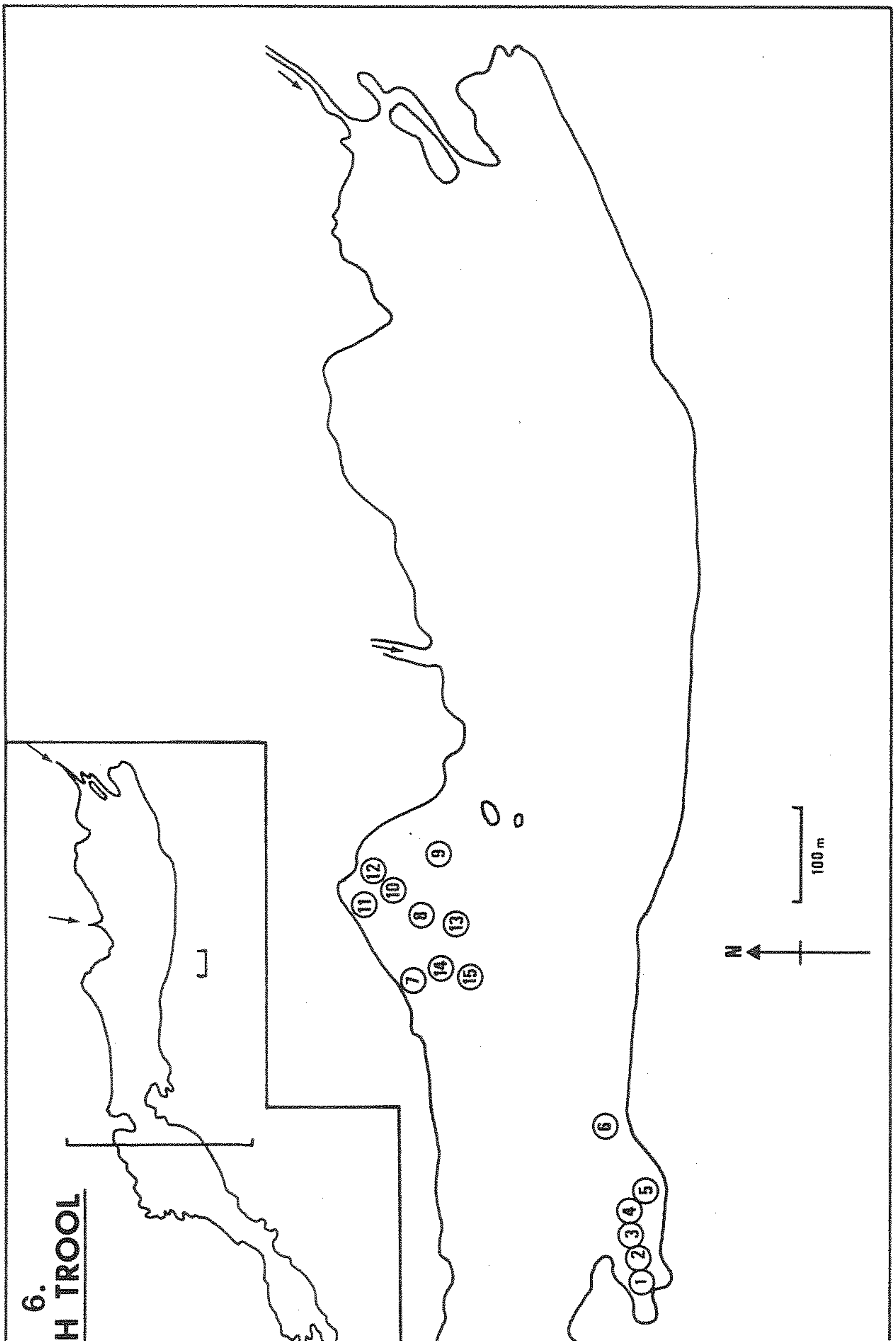

2. LOCH SKAE
1
2
3
4
5
6
7
8
N
100m


3. LOCH HARROW
100 m
N
1
2
3
4
5
6
7
8
9
10
11
12

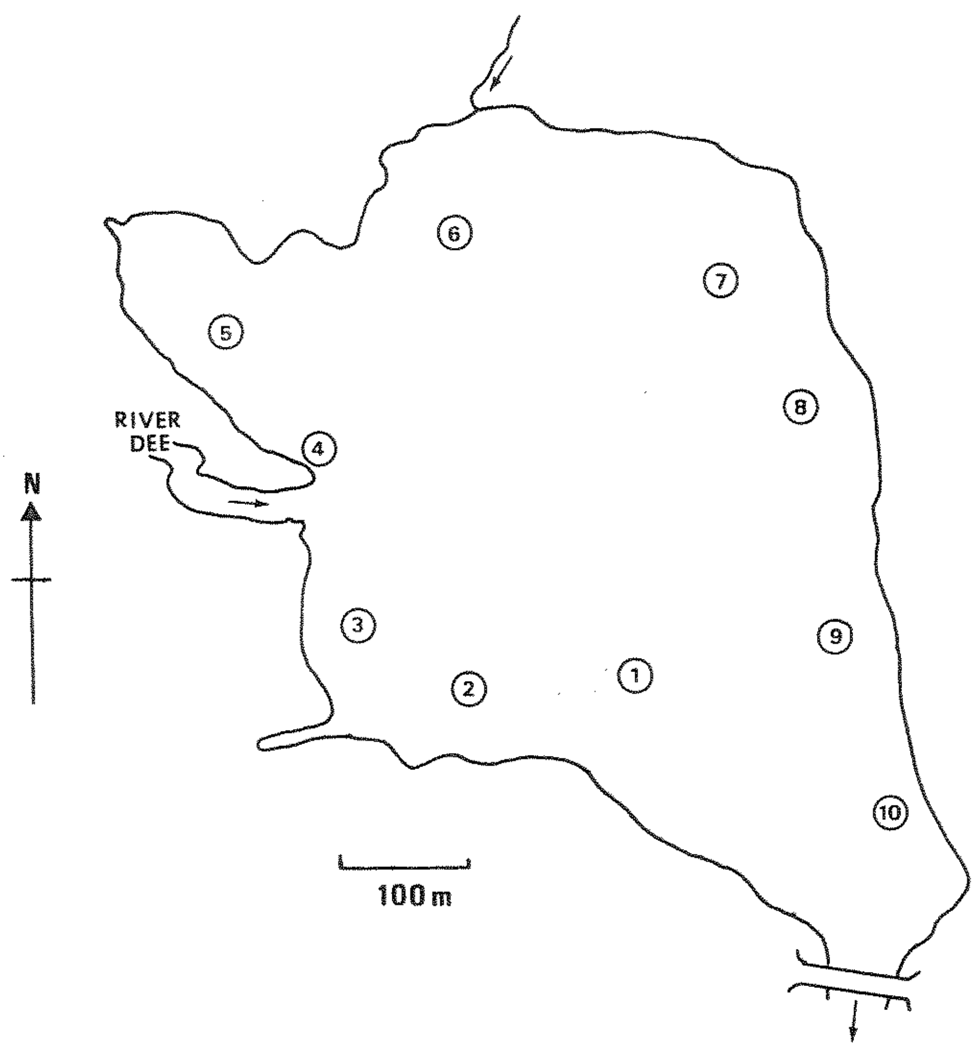
4. LOCH HOWIE




5. LOCH SKERROW
1
2
3
4
5
6
7
8
100m
N


6.
LOCH TROOL
100 m
N
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

7. LOCH STROAN



APPENDIX 2
Ekman grab sample data from seven Galloway lochs visited in 1985

ROUND LOCH OF GLENHEAD NATIONAL GRID REFERENCE: NX 450804

DATE OF SURVEY: 24 May 1985 NUMBER OF EKMAN SAMPLES TAKEN: 16

SECCHI DISC DEPTH: not taken

	Sample site (see map)															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
G; gravel S; sand M; mud	M	M	M	G	G	M	M	M	M	M	M	M	M	M	S	M
DEPTH (m)	2.5	2.8	3.0	1.7	1.1	4.0	2.5	1.1	2.2	1.8	2.8	2.0	1.5	1.8	1.1	5.0
Isotes lacustris	A	A		A	A		A	A	A				A	A	A	
Lobelia dortmanna					A			A								
Molinia debris	A		A							A		A				

LOCH SKAE NATIONAL GRID REFERENCE: NX 710837

DATE OF SURVEY: July 1985 NUMBER OF EKMAN SAMPLES TAKEN: 8

SECCHI DISC DEPTH: 5.5 m

	Sample site (see map)							
SUBSTRATE	1	2	3	4	5	6	7	8
M; muds	M	M	M	M	M	M	M	M
DEPTH (m)	3.0	1.2	1.5	2.2	2.0	2.5	2.0	1.5
Callitriche hamulata					+	A		
Isoetes lacustris	A		+	A	A	A	A	+
Juncus fluitans			A					
Littorella uniflora		A						A
Lobelia dortmanna		A	A				A	A

No _Molinia_ debris sampled

LOCH HARROW NATIONAL GRID REFERENCE: NX527867

DATE OF SURVEY: 14 July 1985 NUMBER OF EKMAN SAMPLES TAKEN: 12

SECCHI DISC DEPTH: 5.8 m

	Sample site (see map)											
	1	2	3	4	5	6	7	8	9	10	11	12
M; mud	M	M	M	M	M	M	M	M	M	M	M	M
DEPTH (m)	3.0	2.5	4.5	3.5	2.5	2.5	1.5	2.0	2.5	1.5	2.0	1.5
Sphagnum auriculatum						+						
Isoetes lacustris					A			A	A		A	A
Juncus fluitans	A	A		A	+						+	+
Littorella uniflora								+		+	+	
Lobelia dortmanna								+			+	
Utricularia minor	+			+	+	+						

No _Molinia_ debris sampled

LOCH HOWIE NATIONAL GRID REFERENCE: NX697834

DATE OF SURVEY: July 1985 NUMBER OF EKMAN SAMPLES TAKEN: 13

SECCHI DISC DEPTH: 6.3 m

	Sample site (see map)												
	1	2	3	4	5	6	7	8	9	10	11	12	13
M; mud	M	M	M	M	M	M	M	M	M	M	M	M	M
DEPTH (m)	1.0	2.5	1.2	4.5	8.0	8.5	5.0	3.0	1.8	2.0	1.8	7.5	2.5
Isoetes lacustris	A			A			A	A	+	A	+		A
Littorella uniflora									A		A		
Lobelia dortmanna	+	+	A						A		A		

No _Molinia_ debris sampled

N.B. _Sphagnum_ growing on S.W. shore (1984 survey).

LOCH SKERROW NATIONAL GRID REFERENCE: NX 606682

DATE OF SURVEY: July 1985 NUMBER OF EKMAN SAMPLES TAKEN: 8

SECCHI DISC DEPTH: 1.4 m

	Sample site (see map)							
	1	2	3	4	5	6	7	8
R; rock S; sand M; muds	R	R	R	S	M	S	S	S
DEPTH (m)	2.0	2.0	1.5	3.0	2.0	1.5	0.5	1.0
Fontinalis antipyretica						+	+	+
Sphagnum auriculatum	+			+	+			
Callitriche hamulata		+	+					
Isoetes lacustris						+		
Lobelia dortmanna						A	+	+

No *Molinia* debris sampled

LOCH TROOL NATIONAL GRID REFERENCE: NX 412798

DATE OF SURVEY:17 July 1985 NUMBER OF EKMAN SAMPLES TAKEN: 15

SECCHI DISC DEPTH: 2.6 m (N.B. adverse weather conditions)

	Sample site (see map)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
R; rock S; sand M; mud	S	S	M	M	M	M	R	M	M	M	M	R	M	M	M
DEPTH (m)	1.0	1.2	2.0	2.2	3.1	9.0	3.0	3.0	3.2	2.0	1.0	1.0	4.0	3.0	3.0
Sphagnum auriculatum								A					A		A
Isoetes lacustris					A			+						A	+
Juncus fluitans		+						A	A	A		+	A		
Lobelia dortmanna											A	A			
Utricularia vulgaris													+		+
(*Batrachospermum sp.*)					+		+						+	+	+
Oak leaf debris		A	A	A		A					A				
Molinia debris		A									A				

LOCH STROAN   NATIONAL GRID REFERENCE: NX 644704

DATE OF SURVEY: 18 July 1985   NUMBER OF EKMAN SAMPLES TAKEN: 10

SECCHI DISC DEPTH: 1.5 m

	Sample site (see map)									
	1	2	3	4	5	6	7	8	9	10
M; mud	M	M	M	M	M	M	M	M	M	M
DEPTH (m)	2.5	1.5	1.2	1.2	1.0	1.2	2.0	2.0	2.2	2.0
Sphagnum auriculatum			A	A		A	A	A	A	A
Sphagnum cuspidatum					A					
Juncus fluitans				+						

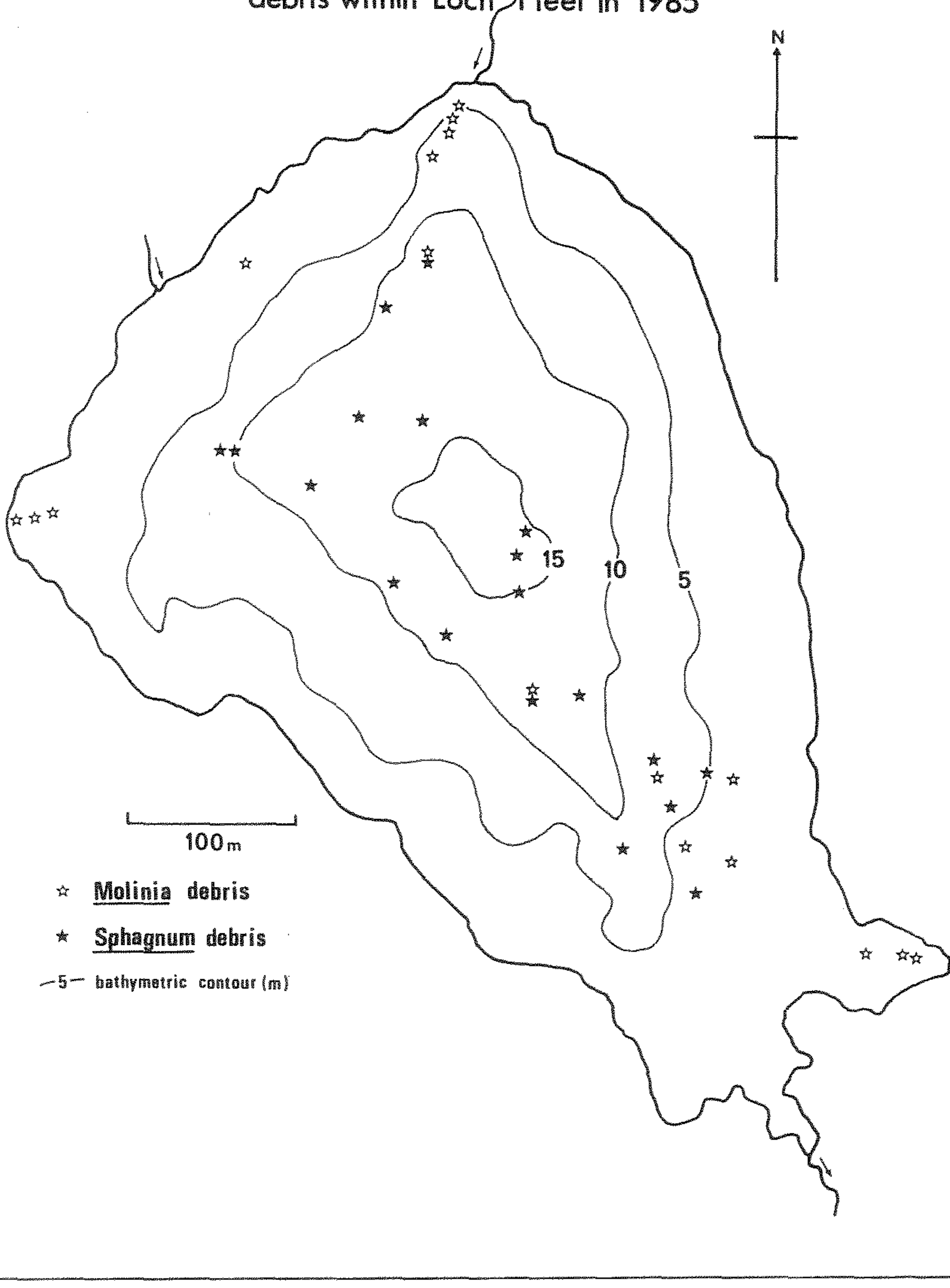
No *Molinia* debris sampled

Abundance of macrophytes assessed as biomass present in each grab sample:

+ present in small quantity

A abundant

APPENDIX 3 The distribution of *Molinia* and *Sphagnum* debris within Loch Fleet in 1985



APPENDIX 4

Changes in the littoral macrophyte vegetation of 30 Galloway lochs between 1983 and 1985.

Loch	Change(s) observed between 1983 and 1985	Grid reference.
L. Macaterick:	New stand of Potamogeton natans	NX 437917.
L. Riecawr:	New stand of Sparganium angustifolium	NX 440937.
L. Skae:	New stand of Potamogeton natans	NX 708835.
L. Finlas:	New record; Ranunculus tripartitus	NX 468977.
L. Urr:	New stand of Polygonum amphibium	NX 762844.
L. Mannoch:	Increase of Schoenoplectus lacustris	NX 664600.
L. Skerrow:	New stand of Nymphaea alba	NX 603684.
L. Fern:	New stand of Myriophyllum alterniflorum, disappearance of Nymphaea alba stand	NX 863626.
L. Arthur:	New records; Isoetes lacustris, Potamogeton praelongus and Ranunculus aquatilis (strandline).	
L. Stroan:	New stand of Nyphaea alba	NX 642706.
	Increase of Schoenoplectus lacustris	NX 647705.
L. Woodhall:	Increase of Nymphaea alba	NX 663686.

There were no changes in the littoral vegetation of 18 other lochs previously visited and mapped in 1983-84 (cf. Raven 1985).

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No. 12 Battarbee, R.W. and Renberg, I. 1985 Royal Society Surface Water Acidification Project (SWAP) Paleeolimnology Programme. 18 pp.

No. 13 Raven, P.J. 1986 Occurrence of Sphagnum moss in the sublittoral of several Galloway lochs, with particular reference to Loch Fleet.

For copies or further information, please contact Dr R. W. Battarbee, Palaeoecology Research Unit, Department of Geography, University College London, 26 Bedford Way, London WC1H OAP.